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**Challenges for an Aquaculture Enterprise on its way towards
Sustainable Management**
A Case Study of a Shrimp Farm in Northeast Brazil

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Summary

Background and Aim

In the late 1980's aquaculture became a viable alternative to fisheries, to such an extent that it became the world's fastest growing food production sector. Shrimp is one of the most valuable aquaculture products currently undergoing rapid expansion in Asian and Latin American countries. Brazil is a small production country compared to leading countries such as Thailand and Ecuador, but it has one of the highest growth rates of shrimp farming.

Problems related to shrimp farming became generally known due to environmental and disease factors in important production countries. The necessity for a sustainable development of shrimp farming has been widely agreed on.

The goal of this work is two-fold, first to provide insights of how a single shrimp farm can contribute to development of a sustainable system and how it may improve and monitor its management on the way towards sustainability. Secondly, this research project will analyze the management requirements for sustainable shrimp production, including stakeholders' opinions. Ultimately, A shrimp farm (single case study) is analyzed on its way to identify and implement sustainable practices. The case study farm is analyzed according to its production results and socio-economical impacts. Finally, possible ways and scope of action for the improvement of sustainability at firm-level are suggested.

Methods and Data

The first part is the analysis of secondary literature to create a framework for the integration of sustainability into the performance management. Demands on shrimp farming are evaluated by stakeholders' opinions which are investigated through expert interviews and a Delphi study. Using the method of qualitative system dynamics approach, the requirements are outlined as a network for a shrimp farm. Furthermore key factors of this set of requirements are examined by using statistical methods. The data source for this purpose are production data of the case study (shrimp farm). Based on the financial statement of the farm, simulations were conducted. For the monitoring of the performance, a balanced scorecard - including sustainability aspects - is proposed.

Results and Conclusions

The analysis of the stakeholders' opinions indicates requirements including environmental-, social-, and management aspects. The main requirements stated by experts and stakeholders are traceability, control and monitoring of applied additives, control of effluents, efficient use of resources, and involvement of local employees. These requirements are summarized in a proposition as a label for shrimp production. Experts' opinions are useful guidelines due to their forecasting character. For this reason shrimp farms that want to develop towards sustainable management should care about a continuous involvement of stakeholders. Insights into such involvements can be used to build a farms' network, illustrating interactions. Technological developments within the shrimp industry can change the understanding of what is considered as sustainable management. The continuous evaluation of new technologies to subsequently reduce or even eliminate negative impacts is one of the main challenges.

Analyzing the production data of the case study, allows for important correlations between production variables such as survival rate and productivity. In order to reduce negative environmental impacts and improve production, farms should focus on efficiency improvements (eco-efficiency), such as the feed conversion ratio. Efficiency improvements are necessary. The analysis showed that it is possible to have good production results without using medical

feed. Such cycles should be used as learning cases. Tests should be conducted with production cycles not applying medical feed, but alternative products.

For shrimp farm management to move towards sustainability the economical aspect of the business also has to be considered. As the results demonstrated - the widely used indicator to evaluate a productivity of farm level is kg per ha and cycle has to be replaced by a time considering indicator kg per ha and day. This would avoid wrong conclusions about what can be classified as good or poor production results. As a consequence, the best economical indicator to compare different production cycles would be net margin per ha and day.

Shrimp farmers have to become familiar with socio-economical aspects of their activity. The most desirable activities include the improvements of educational possibilities for local labor (also in management positions), and improvements in employees housing facilities. Many impacts in the socio-economic field are rather qualitative. They include activities such as health-education programs and the co-sponsoring of the educational institutions. These activities are difficult to evaluate but nevertheless may be strong and sustainable.

It is important to monitor the results of management efforts in order to ensure that the farm is moving in the direction 'towards' sustainability. For this reason, farms should implement a monitoring tool, comparing indicators over time (and/or if possible with benchmarks). It is useful to integrate such indicators in a balanced scorecard, including 'soft factors' for sustainable management. Progress reports should be worked out periodically based on sustainability monitoring. Such reports can serve, for instance, for a third-party certification. Such certifications are also a valuable measure to improve credibility and to communicate the added value.

On deciding on different strategies towards sustainability, a simulation tool can give important indications. Such a tool should base on an actualized financial statement of the farm and consider the environment where the farm acts. Simulation of a sustainable operation showed lower financial returns and value of the enterprise than a corresponding standard case. This is mainly caused by higher costs which are not entirely compensated by the market. For the interpretation of the result, long-term effects such as possible lower risk have to be considered.

From the applied methodology (analysis of secondary literature, conducting expert interviews, Delphi study and the qualitative system dynamics approach) it can be concluded that it was an appropriate way to get an overview of important requirements. In relation to the expert interviews, it would have been more efficient to debate the topic in an interactive forum.

The case study as a research strategy and the application of statistical methods turned out to be a valuable method of analyzing interactions of enterprises data. As a restriction, the difficulties in data availability, data preparation and therefore data quality has to be considered. This has to be taken into account in the interpretation of the findings.

The balanced scorecard and the simulation tool are adequate instruments for the purpose of the study. They provide indicators for a shrimp farm on its way towards sustainable management.

Zusammenfassung

Hintergrund und Ziele

In den späten achtziger Jahren wurden Aquakulturen (kontrollierte Herstellung von Lebensmitteln im Wasser) eine wichtige Alternative zur Fischerei. Heute sind Aquakulturen weltweit der am schnellsten wachsende Sektor der Lebensmittelproduktion. Wertmässig gehören Crevetten zu den wichtigsten Produkten aus Aquakulturen. Das Wachstum von Crevettenfarmen erfolgt hauptsächlich in asiatischen und südamerikanischen Ländern. Verglichen mit Thailand und Ecuador ist Brasilien (bis anhin) ein unbedeutendes Produktionsland, weist jedoch weltweit eine der höchsten Wachstumsraten auf.

Durch Krankheitseinbrüche und Kollapse von Ökosystemen in wichtigen Produktionsländern sind die Probleme im Zusammenhang mit Crevettenfarmen einer breiten Bevölkerung bekannt geworden. Eine nachhaltigere Weiterentwicklung von Crevettenfarmen wird allgemein gefordert.

Die vorliegende Arbeit soll Erkenntnisse liefern, welchen Beitrag einzelne Crevettenfarmen zu einer derartigen Entwicklung leisten können und wie sie ihre Unternehmensführung auf dem Weg zu einer nachhaltigen Produktion verbessern und überwachen können. Das Ziel der Forschungsarbeit ist die Bestimmung der notwendigen Anforderungen für eine nachhaltige Crevettenproduktion unter spezieller Berücksichtigung von unternehmensinternen und externen Anspruchsgruppen. Als Erfahrungsobjekt wird eine Crevettenfarm im Rahmen einer Einzelfallstudie untersucht. Abschliessend sollen mögliche Wege zur Verbesserung der Nachhaltigkeit auf Stufe Unternehmung vorgeschlagen werden.

Methoden und Daten

Basierend auf einer Literaturanalyse zur Theorie der Nachhaltigkeit und Performance wird ein Konzept entwickelt, welches die Aspekte der Nachhaltigkeit und Performance verknüpft. Als erstes werden die Anforderungen an eine Crevettenfarm ausgearbeitet. Dazu werden Experteninterviews und eine Delphi-Umfrage mit ausgewählten Anspruchsgruppen durchgeführt. Im weiteren werden die Anforderungen in einem Netzwerk durch die Anwendung des „qualitative system dynamics approach“ skizziert. Anschliessend werden die Schlüsselfaktoren unter Anwendung von Methoden der multivariaten Statistik untersucht. Datenquelle für die statistischen Untersuchungen bilden die Produktionsdaten der beobachteten Farm (Fallstudie). Aufgrund der Daten aus der Buchhaltung wird zudem ein stochastisches Simulationsmodell erarbeitet. Für die Überwachung der Unternehmensleistung wird eine um die Aspekte der Nachhaltigkeit erweiterte Balanced Scorecard vorgeschlagen, welche die in der Arbeit gewonnenen Erkenntnisse umfasst.

Resultate und Schlussfolgerungen

Die in der Delphi Umfrage erarbeiteten Anforderungen umfassen ökologische-, soziale- und führungsbezogene Aspekte. Hauptsächliche Anforderungen – welche sowohl von Experten als auch den Anspruchsgruppen genannt werden – beziehen sich zum Beispiel auf Rückverfolgbarkeit, Kontrolle und Aufzeichnung von eingesetzten Hilfsstoffen, Kontrolle des Abwassers, effizienter Einsatz von Ressourcen, sowie der Einbezug von lokalen Arbeitskräften. Diese wurden in einem Vorschlag für ein Label zur nachhaltigen Crevettenproduktion zusammengefasst. Expertenmeinungen stellen durch ihren vorhersagenden Charakter eine brauchbare und wertvolle Leitplanke bei der Ausarbeitung solcher Kriterien dar. Darum sollte die Unternehmensführung die Interessen von Anspruchsgruppen kontinuierlich bei ihren Entscheidungen berücksichtigen. Erkenntnisse aus diesem Prozess können für ein unternehmenseigenes Netzwerk verwendet werden. Produktionstechnische Neuerungen können die Beurteilung betreffend Nachhaltigkeit von Produktionsstrategien rasch ändern. Eine wesentliche Heraus-

forderung für die Unternehmensleitung besteht darin, neue Technologien ständig bezüglich der Vermeidung oder Reduktion von negativen Auswirkungen zu evaluieren und gegebenenfalls zu implementieren.

Durch die statistische Analyse der Produktionsdaten konnten wichtige Zusammenhänge verifiziert werden. Zur Reduktion der ökologischen Auswirkungen sollte sich das Management auf die Verbesserung der (Öko)-Effizienz – wie z.B. die Futterverwertung und Wasserrezirkulation – konzentrieren. Solche Effizienzsteigerungen sind notwendig. Weiter konnte gezeigt werden, dass auch ohne Einsatz von Medizinalfutter gute Produktionsresultate erzielt werden können. Es besteht ein Bedarf für weitere gezielte Untersuchungen zum vollständigen Verzicht auf Medizinalfutter.

Bei der ökonomischen Analyse von Produktionszyklen ist es wichtig, geeignete Indikatoren anzuwenden. Die traditionelle Kennzahl besteht aus einer als Quantität pro Fläche und Produktions-Zyklus ausgedrückten Produktivität. Wie in der Datenanalyse gezeigt werden konnte, muss diese durch eine die Zyklusdauer berücksichtigende Kennzahl (kg/ha/Tag) ersetzt werden. Crevettenfarmen müssen zudem beachten, dass hohe Mengen-Produktivitäten keine Garantie für wirtschaftlich Zyklen sind. Deshalb wurde zur ökonomischen Analyse der Gewinn pro Fläche und Zeit betrachtet (Gewinn/ha/Tag). Durch diese Anpassung können Crevettenfarmer falsche Rückschlüsse eliminieren und somit den für erhöhte Effizienz und Gewinn wichtigen Lernprozess wesentlich unterstützen.

Crevettenfarmer sollten sich zudem vermehrt mit den sozio-ökonomischen Aspekten ihrer Aktivitäten vertraut machen. Die von den Anspruchsgruppen geforderten Anstrengungen beinhalten Verbesserungen der Ausbildungsmöglichkeiten, die Integration von lokalen Mitarbeitern (auch und gerade in Führungsaufgaben) und die Verbesserung der Gesundheit, Ernährung und Wohnsituation der Mitarbeiter. Viele der betrachteten sozio-ökonomischen Anstrengungen führen zu Resultaten rein qualitativer Art. Diese wurden in der Fallstudie durch Aktivitäten wie Gesundheitsprogramm, Umweltsensibilisierung oder finanzielle Unterstützung von Ausbildungsstätten erzielt.

Nur durch ein funktionierendes Controlling von Resultaten kann sichergestellt werden, dass die Anstrengungen des Managements auch tatsächlich in Richtung Nachhaltigkeit führen. Aus diesem Grund sollten die Unternehmen ein Instrument einführen, das es ihnen erlaubt, mittels Indikatoren die zeitliche Entwicklung zu erkennen und wo möglich mit Benchmarks zu vergleichen. Es ist hilfreich, solche Indikatoren mittels einer Balanced Scorecard aufzuzeichnen und dabei auch weiche Faktoren für die nachhaltige Bewirtschaftung zu integrieren (Sustainable Balanced Scorecard). Basierend auf dieser „Nachhaltigkeits-Überwachung“ sollten periodische Zwischenberichte erstellt werden. Solche Berichte können bei einer Zertifizierung von Nutzen sein. Externe Zertifizierungen sind zudem eine wertvolle Massnahme, um die Glaubwürdigkeit zu unterstützen oder einen Mehrwert des Produktes zu kommunizieren.

Es ist wichtig, verschiedene Strategien zur Nachhaltigkeit mit einem Simulations-Werkzeug zu analysieren. Ein solches Werkzeug sollte auf Erfahrungswerten (aus der Produktion und dem internen Finanzcontrolling), sowie auf Planungswerten (erwartete Veränderungen der Umwelt) basieren. Die in der Fallstudie analysierten Nachhaltigkeits-Strategien führten zu tieferem Gewinn und demzufolge geringerem Unternehmenswert. Dies kann hauptsächlich dadurch erklärt werden, dass der angenommene Mehrerlös die entstandenen Kosten nicht deckte. Zur Interpretation solcher Simulationen müssen allerdings die zu erwartenden Langzeit-Effekte wie stabilere Produktion, höhere Mitarbeiterzufriedenheit und geringeres Risiko berücksichtigt werden.

Die verwendeten Methoden (Studium der Sekundärliteratur, Experten-Befragungen, Delphi-Studie und ‚qualitative system dynamics approach‘) stellten eine angemessene Form dar, um

einen Überblick über die wichtigen Anforderungen von Stakeholdern zu erlangen. Bei den Experten-Befragungen wäre es jedoch effizienter gewesen, die erarbeiteten Punkte in einer interaktiven Form zu debattieren.

Die Durchführung der Forschungsarbeit anhand der Fallstudie und die Anwendung von statischen Analysen stellte sich als geeignete Methode zur Analyse der Wechselwirkungen heraus. Als Einschränkung muss auf die Mängel bei der Datenverfügbarkeit, Datenaufbereitung und daraus folgend in der Datenqualität hingewiesen werden. Dies muss bei der Interpretation der Resultate berücksichtigt werden.

Die um die Aspekte der Nachhaltigkeit erweiterte Balanced Scorecard und das Simulations-Modell sind geeignete Instrumente betreffend den Forschungszielen. Sie stellen Indikatoren für eine Crevettenfarm auf ihrem Weg in Richtung Nachhaltigkeit dar.

Resumo

Segundo plano e objetivo

No final dos anos 1980, a aquacultura começou a ser uma alternativa, apropriada, à pesca marinha, de tal forma que se transformou no setor que mais cresceu na produção de alimentos. O Camarão é um dos produtos mais valiosos da aquacultura, e está em processo de rápida expansão em países da Ásia e América Latina. O Brasil ainda é, um país com uma baixa produção, se comparado com os países líderes, tais como Tailândia e Equador. Porém, o Brasil tem uma das taxas mais elevadas referente ao crescimento deste cultivo.

Problemas ligados à produção de camarão, se tornaram conhecidos, pelo colapso no meio ambiente e as doenças deste indivíduo, nos principais países de produção. A necessidade de que este cultivo, tem que ser elaborado de uma forma sustentável, é uma percepção geral.

Este trabalho tem como objetivo providenciar conhecimentos aos carcinicultores, de como podem contribuir para um desenvolvimento na direção da sustentabilidade. Isso inclui também, a elaboração de indicações para melhorar e monitorar o manejo das fazendas. A meta desta pesquisa inclui a análise dos requerimentos no manejo de uma produção sustentável, incluindo opiniões e interesses de vários grupos de pessoas diretamente ou indiretamente envolvidos (ingl. 'stakeholders' opinions'). Por estes motivos, uma fazenda real (ingl.: 'case study') foi analisada referente aos resultados da produção e os impactos sociais. Finalmente, diferentes estratégias, para melhorar a sustentabilidade de uma fazenda, deverão ser sugeridos, considerando diferentes exigências.

Método e Dados

O ponto inicial é o estudo de literatura secundária, para criar um contexto com a integração de sustentabilidade no manejo do desempenho. Requerimentos - elaborados por especialistas - referente as fazendas de camarão foram avaliados pelos vários grupos envolvidos, usando a técnica 'Delphi study' e entrevistas. Usando o método 'qualitative system dynamics approach', os mesmos foram relatados e interligados em uma rede de interferências (ingl: 'network') do ponto de vista de uma fazenda. Além disso, fatores importantes foram examinados, usando métodos estatísticos com dados proveniente do 'case study'. Baseando-se em dados contábeis desta fazenda, um modelo para simulações foi elaborado. Pelo monitoramento do desempenho uma 'balanced scorecard' (incluindo aspectos de sustentabilidade) foi sugerido.

Resultados e conclusões

A análise das opiniões dos 'stakeholders' indica que os requerimentos podem ser divididos nos aspectos ecológicos, sociais e econômicos. Os mais importantes, indicados pelos especialistas e 'stakeholders' inclui: controle de doenças, uso eficiente de recursos, controle dos insumos aplicados, e melhorar a situação da mão-de-obra (local). Estes requerimentos foram somados e elaborado uma sugestão para ser criado um 'selo de produção sustentável de camarão'. As opiniões dos especialistas são de utilidade, por terem um caráter preventivo. Por este motivo, fazendas que querem caminhar na direção da sustentabilidade, deveriam envolver opiniões de stakeholders continuamente em seus decisões (p.ex. escalar reuniões, discussões públicos etc.). Os reconhecimentos destes envolvimento podem ser usados para elaborar o 'network' da fazenda, ilustrando as interações. O Desenvolvimento técnico pode mudar o entendimento sobre o que deve ser considerado um manejo sustentável. Então, um dos maiores desvios, é a constante avaliação de novas tecnologia para diminuir ou eliminar os impactos negativos do cultivo de camarão na natureza.

Analisando os dados da produção do 'case study', correlações importantes entre fatores de produção foram verificados - tais como sobrevivência e produtividade. Para reduzir os impactos negativos da carcinicultura no meio ambiente e para otimizar a produtividade, as fazendas deveriam focalizar sua atenção em melhorar a eficiência (eco-eficiência), tal como a TCA (taxa da conversão alimentar). Melhoramentos significativos de eficiência podem ser exigidos e esperados de uma indústria tão recente como a carcinicultura.

O gerenciamento de uma fazenda de camarão, deveria também considerar os aspectos econômicos do empreendimento. Por isso, é importante a escolha certa do indicador para comparar diferentes cultivos. O tradicional indicador e valor comparado é uma produtividade apresentada, em quantidade por área e cultivo (kg/ha/ciclo). Como foi mostrado na análise dos dados, este indicador tem que ser substituído por um, que leva em conta o tempo de um cultivo (kg/ha/dia). Esta mudança eliminaria conclusões falsas sobre o que é um resultado bom ou ruim. Como consequência, o melhor indicador para comparar cultivos, no aspecto econômico, é o dinheiro que se ganha por área e tempo (lucro líquido/ha/dia).

Carcinicultores deveriam se familiarizar com os aspectos socio-econômicos da sua empresa. As atividades mais desejadas são: o melhoramento das possibilidades educacionais, o envolvimento da mão-de-obra local (inclusive no gerenciamento) e os melhoramentos da situação diária dos funcionários tais como saúde, alimentação e moradia.

Para verificar se a fazenda está na direção do manejo sustentável, é importante monitorar os resultados dos esforços. Isto é, fazendas deveriam implementar uma ferramenta de monitoramento, comparando indicadores durante anos ou/e com os melhores do ramo (ingl. 'benchmark'). Neste aspecto é válido integrar estes indicadores em uma 'balanced scorecard', incluindo fatores suaves (ingl.: 'soft factors') para um manejo sustentável. Baseando-se no monitoramento da sustentabilidade, relatórios sobre o progresso podem ser elaborados periodicamente. Estes relatórios serão uma base para uma certificação através de um órgão independente. Estas certificações tem duas funções principais: assegurar credibilidade perante os 'stakeholders' e comunicar um valor agregado para os clientes.

O modelo elaborado para fazer simulações, é um bom indicador para decidir sobre estratégias referente a sustentabilidade. Para o sucesso deste modelo, é fundamental basear-se em informações contábeis atuais e reais da fazenda, e levar em conta os fatores ambientais. Essa simulação de uma estratégia sustentável, deu um resultado financeiro e um valor da empresa, menor; este resultado foi causado, principalmente, pelos custos mais altos, que não foram completamente compensados pelo mercado, na situação desta simulação. Para interpretar este resultado, os efeitos a longo prazo, como uma possível produção mais estável, deveriam ser considerados.

Considerando a metodologia aplicada nesta pesquisa, (analisando a literatura secundária, conduzindo entrevistas com especialistas, 'Delphi study' e 'qualitative system dynamics approach') pode ser concluído que foi uma forma adequada para conceber uma visão geral do assunto. Referente às entrevistas com os especialistas, teria sido mais eficiente, discutir o assunto de uma forma interativa.

Escolhendo uma fazenda como estratégia de pesquisa e também a aplicação de métodos estatísticos, pode ser considerado um procedimento valioso para analisar as interações de fatores envolvidos na produção de camarão. Como restrição deveria ser considerado as dificuldades na disponibilidade de dados, a preparação dos mesmos e por este motivo, a sua qualidade. Este aspecto deveria ser levado em conta na interpretação dos resultados.

O 'balanced scorecard' é também um modelo para fazer simulações, são instrumentos adequados para o objetivo da pesquisa. Os mesmos providenciam indicadores a serem seguidos por uma fazenda no caminho da sustentabilidade.

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List of Abbreviations

ABCC	Associação Brasileira de Criadores de Camarão
ANOVA	Analysis of variation between groups
ASA	American Soybean Association
BDO	Biological Oxygen Demand
BSI	British Standards Institution
CBI	Center for Promotion of Imports from developing countries
CC	Core Competencies or Core Capabilities
CCRF	Code of Conduct for Responsible Fisheries
CE	Ceará
CEPAA	Council on Economic Priorities Accreditation Agency
CFROI	Cash Flow Return on Investment
CL	Company Level
CR	Concentration Ratio
CSD	Commission on Sustainable Development
CSF	Critical Success Factors
CTO	Capital Turn Over
CVA	Cash Value Added
DCF	Discounted Free Cash Flow
DIN	Dissolved Inorganic Nitrogen concentration
EBIT	Earnings Before Interest and Tax
EFQM	European Foundation for Quality Management
EIA	Environmental Impact Assessment
ETHOS	Institute of Business and Social Responsibility (Association of companies)
EVA	Economic Value Added
FAO	Food and Agriculture Organization of the United Nations
FCF	Free Cash Flow
FCR	Feed Conversion Ratio
GAA	Global Aquaculture Alliance
GDP	Gross Domestic Product
GRI	Global Reporting Initiative
ha	Hectare
HACCP	Hazard Analysis and Critical Control Point
hp	Horse power
HPV	Hepatopancreatic Parvo-like Virus (shrimp viral disease)
IBGE	Instituto Brasileiro de Geografia e Estatística
ICM	Integrated Coastal Management
IDEC	Instituto Brasileiro de Defesa do Consumidor
IDEMA	Instituto de Desenvolvimento Econômico e Meio Ambiente do RN
IEP	Instituto de Estudos e Pesquisas
ISO	International Organization for Standardization
IHHNV	Infectious Hypodermal and Hematopoietic Necrosis Virus (shrimp viral disease)
INMET	Instituto Nacional de Meteorologia
KMF	Key Management Factors
LIFDC	Low Income Food Deficit Countries
MT	Metric tons

MVA	Market Value Added
MSC	Marine Stewardship Council
NE	Northeast
NGO	Non-governmental organization
NHP	Necrotizing Hepatopancreatitis (shrimp bacterial disease)
NL	National Level
OECD	Organization for economic co-operation and development
P/B	Price-to-Book-Ratio
P/CF	Price-Cash Flow-Ratio
P/E	Price-Earnings-Ratio
PL	Post-larvae
RENOA	Return on Net Operating Assets
RN	Rio Grande do Norte
ROCE	Return on Capital Employed
ROE	Return on Equity
ROIC	Return on Invested Capital
ROI	Return on Investment
ROS	Return on Sales
SA	Social Accountability
SA8000	Social Accountability 8000 (international standard for social accountability)
SAI	Social Accountability International
SIGMA	Sustainability: Integrated Guidelines for Management
SITC	Standard International Trade Classification
SL	Sector Level
SMC	Safe minimum standard
SP	São Paulo
Std. Dev	Standard deviation
TQM	Total Quality Management
tsd.	Thousand
TSV	Taura Syndrome Virus (shrimp viral disease)
UEC	Union Européen des Experts Comptable Economiques et Financiers
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
vs	versus
WACC	Weighted average cost of capital
WBCSD	World Business Council for Sustainable Development
WCED	World Commission on Environment and Development
WRI	World Resource Institute
WSSV	White Spot Syndrome Virus (shrimp viral disease)
WWF	World Wildlife Fund
YHV	Yellow-Head Virus (shrimp viral disease)

A QUESTION FOCUS AND THEORETICAL BACKGROUND

1 Introduction and Overview

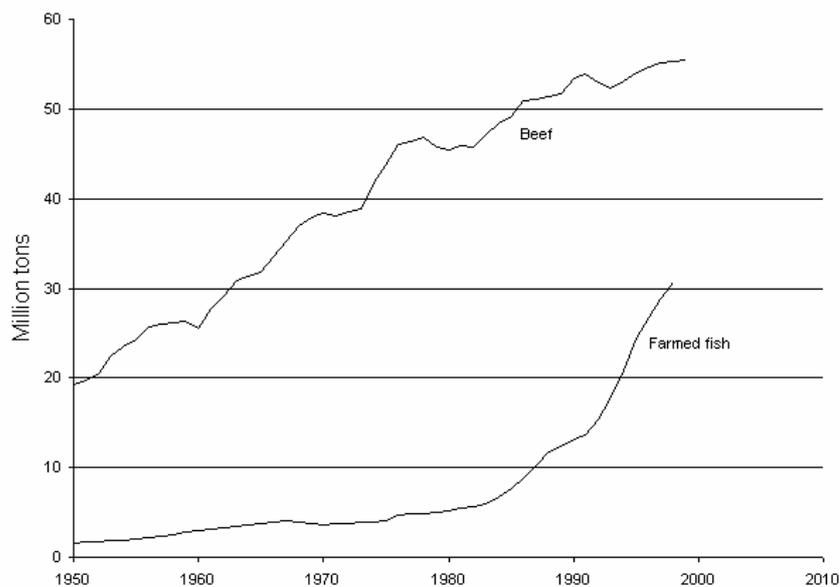
This chapter gives a ‘big picture’ of the content of the research project. The first part includes a description of the initial position of aquaculture¹ in general and shrimp farming in particular. An overview of the consumption and production trends is also presented, along with an outline of the relevance of the topic. The second part focuses on the goals, main question and additional research questions. The last part of the introduction gives an overview of the design and methodology used in the research process. More detailed information about the methods will be given at the beginning of each chapter.

1.1 Aquaculture and shrimp farming

From ancient times, fishing has been a major source of food for humanity and a provider of employment and economic benefits to those engaged in this activity (FAO 1995). With increased knowledge and dynamic market-development of fisheries, it has been realized that aquatic resources, although renewable, are not infinite. There was a consensus of various authors in the 1980’s that fisheries resources could no longer sustain such rapid exploitation, and capture fisheries would not be able to meet the growing demand (FAO 1995; Chamberlain and Rosenthal 1995; Williams 1997).

As a consequence aquaculture has become another dimension in volume and value. According to Williams (1997, p. 6) aquaculture has become the world’s fastest growing food production sector (see Figure 1).

Figure 1: World Aquacultural and Beef Production, 1950 - 2000



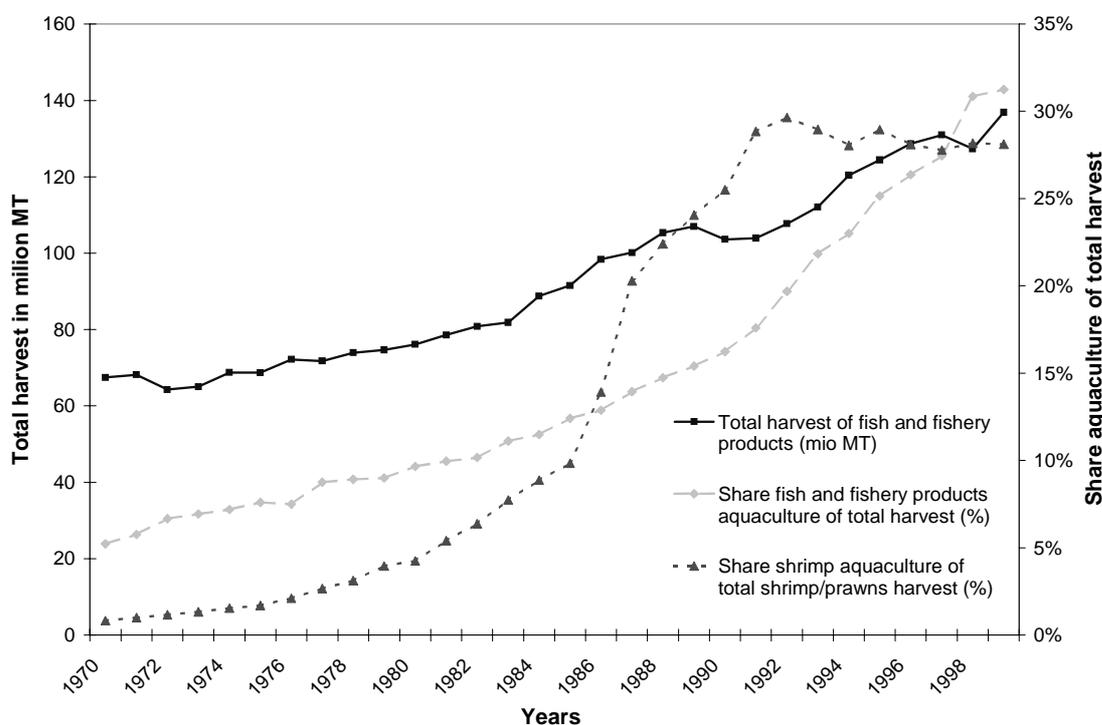
Source: *Worldwatch 2000*

¹ Farming of aquatic organisms, including fish, mollusks, crustaceans and aquatic plants (FAO 1999).

Figure 2 shows the total harvest of aquatic products and the share of aquaculture production. From the total harvest of aquatic products (1970: 67,5 million MT; 1999: 136,9 million MT) the share of products from aquaculture raised form 5,2% in 1970 to over 30% in 1999 (FAO 2000).

The clear dotted line represents the share of aquaculture products from total harvest of fish and fishery products. The total production of shrimp (1970: 1,09 million MT and 1999: 4,02 million MT) almost quadruplicated in this timeframe. The share of aquaculture shrimp of the total shrimp harvest raised from 0,8% in 1970 to 28,1% in 1999 (see dark dotted line in Figure 2). Shrimp is one of the most valuable aquaculture products. In 1999 shrimp aquaculture accounts for 2.6% of the total aquaculture production. In terms of values shrimp aquaculture accounts for 12.5% of the total aquaculture production (FAO 2000).

Figure 2: Total harvest and share of aquaculture production



Source: FAO 2000, *Aquaculture production quantities 1970-1999 and Total production 1950-1999*

According to Boyd and Clay (1998, p. 43) shrimp farming became profitable during the 1970s and has dramatically increased through-out the tropical world (“blue revolution”). The number of shrimp farms along tropical coastlines has increased rapidly since 1980. The eastern hemisphere with the leading countries Thailand, China and Vietnam produced 87% of the world farmed shrimp production in 2000. In the same year, Ecuador was still the most important producer in terms of metric tons in the western hemisphere (Rosenberry 2001), but Mexico and Brazil had the highest growth rate of shrimp farms in 2000 (Rosenberry 2000, p. 5). Table 1 shows the production countries in Asia and Latin America and their increase in production between 1990 and 1999.

Table 1: Shrimp Farming production countries

Asia	1990 (tsd MT)	1999 (tsd MT)	growth	Latin America and Caribbean	1990 (tsd MT)	1999 (tsd MT)	growth
Thailand	119.5	230.0	92%	Ecuador	76.4	119.7	57%
China	184.8	170.8	-8%	Mexico	4.4	29.1	566%
Vietnam	31.0	131.8	325%	Brazil	1.7	16.8	885%
Indonesia	107.3	119.1	11%	Honduras	3.3	8.0	145%
Others	127.1	256.7	102%	Others	15.0	34.8	132%
Total	569.7	908.5	59%	Total	100.8	208.4	107%
% of global shrimp farming	85%	80%			15%	18%	
Total shrimp farming worldwide	673.2	1'130.7	68%				

Source: FAO 2000, *Aquaculture production quantities 1970-1999*

Demand and consumption trends

The global demand of aquaculture products is increasing. As world population continues to grow, food- and protein supply has to respond to increased demand. The per capita fish and fishery products consumption also increases with increasing income. In 1997 the per capita consumption in developing countries was 9 kg vs. 27 kg in developed countries (FAO 1997, cited in Williams (1997, p. 5)). Consequently, aquaculture has to meet the higher demand resulting from population growth and increasing incomes, and simultaneously ensure that fish and seafood is available to the lower income groups in developing countries (Williams 1997, p. 6). According to Edwards (1992, p. 144) preferences for seafood have strengthened in response to medical evidence that seafood promotes nutrition and health.

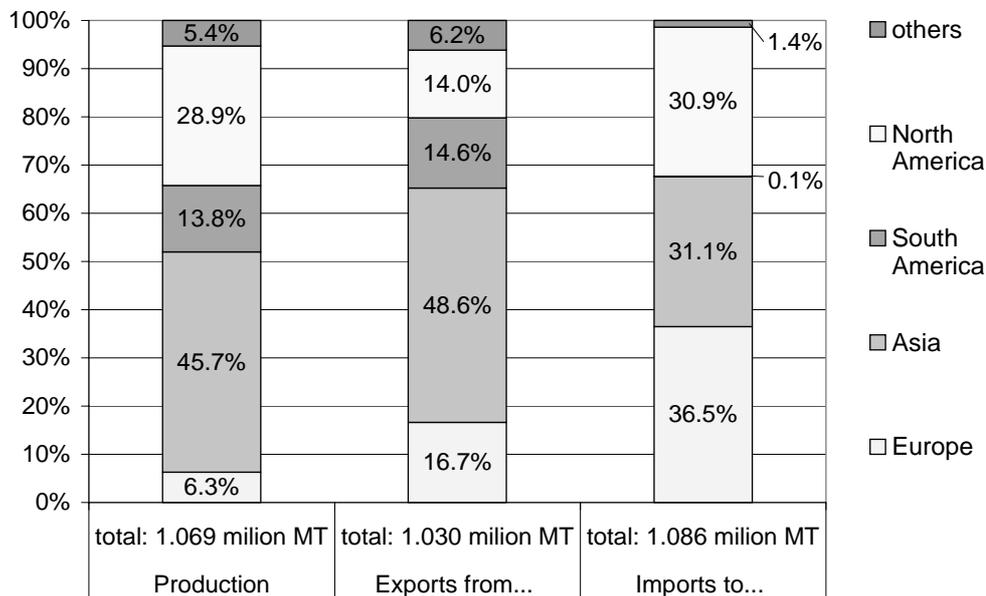
Nearly 40% of the world's food fish production is traded internationally, making fish one of the most traded food staples. The developed countries have become net importers of fish and developing countries net exporters (Delgado and Courbois 1997, cited in Williams 1997, p. 6). In 1999 the share of all imports to developed countries was 91% and 78% of all exports came from developing countries (FAO 2000, *Commodities production and trade 1976-1999*). The rapid expansion of shrimp and salmon culture are primarily export-oriented (Shang and Tisdell 1997, p. 136). Figure 3 gives an overview of world trading areas in 1999, including the production, imports and exports of the total quantities of SITC Group 'Shrimps, Prawns, frozen'² (wild catch and aquaculture).

Asia is the major shrimp producer and exporter continent. Thailand is the major producer with 12% of the world production and the most significant exporter with 12.3% of the world total exports. The major importer of the Asian countries is Japan with 22.8% of the world total imports. Japan has the highest shrimp per capita consumption of any nation (ca.12.5 kg per capita). North America is also a net importer of shrimp and the United States are the most important buyers accounting for 25.8% of world total imports. In 2000 the per capita consumption of shrimp in the US was 1.36 kg and this figure has doubled in the last decade, making shrimp one of the most popular seafoods in the US. The main exporter in the North American continent is Mexico. Ecuador is the major producer and exporter in the South American continent with 8.8% of total production and 9.1% of total exports. Denmark is the major European exporter of shrimp (4% of total exports). Among European countries Spain is

² SITC = Standard International Trade Classification, used for classification of groups in trade activities.

the major producer (2.3% of worldwide production) and the most significant importer of shrimp with 8.5% of total imports.

Figure 3: Shrimp Production – Exports and Imports in 1999



Source: FAO 2000, *Commodities production and trade 1976-1999*

Shrimp has undergone a change during the last decade and is no longer exclusively a luxury but is becoming a commodity good. The demand has increased steadily, mainly in European countries as well as in the United States. With the globalization and an increase of international trading aquaculture production has become an issue that is discussed not only by people directly involved, but consumer groups are increasingly interested in production methods and impacts. Such knowledge becomes an important issue for the consumer that has a co-responsibility for their consumption (Backhaus and Hoffmann 2001).

1.2 Relevance of the topic

In many tropical nations with emerging economies, shrimp farming is a major industry that provides economic opportunities for many people (Boyd, et al. 2001, p. 238). In common with most human economical activities shrimp farming requires resources and has an effect on the environment and local communities in which it is conducted (Clay 2001). The most common and most direct impacts in the literature and in the public can be classified into environmental and social impacts, which can be rather positive or negative.

The environmental impacts are described by Bardach 1997, Barg and Phillips 1997, Hargreaves 1997, Dierberg and Kiattisimkul 1996, and Stewart 1997. The general issues concerning environmental impacts of shrimp farming revolve around possible destruction of mangroves, water pollution problems, effect of wild shrimp larvae capture on ‘artisan-style’ fisheries, and limited access to public wetlands (Bailey 1988, Gautier 2000, Stanley 2000). Further points relate to the use of critical inputs, such as large amounts of fish meal as aqua feed, chemical additives and antibiotics. Shrimp pond effluents are often rich in organic matter, that results in high biological oxygen depletion in receiving waters (Boyd 1999).

The impacts of shrimp farming on social structures of rather poor, underdeveloped communities along tropical coastlines has both positive and negative aspects. Social and socio-

economical aspects are described by Bailey 1988, Bailey 1997, Michielsens 2001, and Various 1997.

Against this background FAO declared its aim to promote and support a responsible fishery production. The idea of sustainability for the development of responsible fishery production is crucial.

“Sustainable development is the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and the continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable” (FAO, 1997)

It was recorded at the Bangkok FAO Technical Consultation on Policies for Sustainable Shrimp Culture in 1997 (FAO 1997) that “... sustainable shrimp culture is practiced and is a desirable and achievable goal which should be pursued ...”. The 1995 Kyoto Declaration established a global Code of Conduct for Responsible Fisheries (CCRF) (that is based on the sustainability definition above), and this CCRF was recognized as an appropriate framework for the development of additional codes/guidelines applicable to shrimp culture (FAO 1997). A few month later at the Ad-hoc-expert meeting in Rome (FAO 1998) indicators and criteria for sustainable shrimp culture were also elaborated. The meeting stressed that these criteria and indicators related only to the national level and did not encompass farm-level and local-level indicators. Based on this FAO-guidelines Global Aquaculture Alliance (GAA) elaborated “Codes of Practice for Responsible Shrimp Farming” under the direction of Claude E. Boyd (Boyd 1999). This document compiles a series of nine recommended practices for the shrimp farming industry. The purpose of the Codes is to provide a framework for environmentally and socially responsible shrimp farming that is voluntary, proactive, and standardized (Boyd 1999). These voluntary Codes are important because most countries with shrimp farming do not have an established regulatory apparatus to monitor and enforce environmental and social standards (Boyd, et al. 2001, p. 238). Unfortunately none of the codes were developed with the involvement of other stakeholders, particularly those groups that are likely to be most affected by shrimp production (Boyd, et al. 2001, p 255).

There are additional efforts for the development of standards and codes of conduct to realize a product differentiation on the market. The Marine Stewardship Council (MSC) was set up in 1996 by the World Wildlife Fund (WWF) and Unilever. The purpose of this Council is to raise industrial awareness for sustainable fisheries and aquaculture in particular, and to ensure that the world’s fisheries are sustainable, well managed and able to provide consumers with fish in the long-term (Aerni 2001, p. 16). Another project realized is the certification and market launch of organic shrimp, certified by Naturland³. These products have been launched on some specific European markets. The consumer pattern of the European market is different than the US-market and characterized by high standards concerning health-, quality-, and convenience-standards (CBI, et al. 1998, p. 1). The awareness concerning sustainable production is part of these requirements. In this context, voluntary eco-labeling is considered to be a cost-effective way of supplying consumers with the relevant product information that may influence their purchasing and consumption decisions (Schmidt 1997).

³ Naturland - Association for Organic Agriculture was established in 1982 in Germany (Naturland 2000)

⇒ The discussion about sustainability or non-sustainability of shrimp farming is controversial. It is often a confrontational debate between extreme environmentalists and extreme growth economists (Phillips and Barg 1997, p. 65). The exchange of reliable information is becoming an increasingly essential part of improving a sustainable development on all levels. Against this background the research project will focus on the possibilities based on the perspective of a single shrimp farmer.

1.3 Aims and research questions

Professional shrimp farming is still a relatively new industry, and relatively little knowledge exists about the process and the impacts of shrimp farming compared with other agricultural activities. Based on this fact it is important to get a ‘big picture’ and a holistic perspective of shrimp farming and its crucial factors on the way towards more sustainable management. This study develops this overview including stakeholders’ opinions. Based on quantifiable analysis and simulations within the case study conclusions for the management of a shrimp farm will be drawn.

The present study focus on sustainability requirements and on the performance of a single shrimp farm. It gives an idea of what measurements / actions have to be done by shrimp farmers developing their business. The study is a contribution for better understanding, and increased clarity for responsible decision-making for involved stakeholders of a shrimp farm. The goal of this project is to analyze the management requirements for competitive and sustainable shrimp production, including stakeholders’ opinions. One company (single case study) is analyzed on its way to identify and implement better practices. Methods and scope of action for the improvement of sustainability on the firm-level will be presented.

1.3.1 Question focus

Based on the question focus of the possibilities of a single shrimp farm on its way towards sustainable management the need of action (requirements) must be defined. Furthermore the challenges for the management has to be analyzed. For this purpose Key Management Factors (KMF) have to be defined and analyzed on the farm level. Based on this analysis various strategies towards sustainable management can be simulated and recommendations can be developed.

1.3.2 Research questions

The research questions are divided into one main research question with related additional research questions.

Main research question

What are the recommendations for a single shrimp farm on its way towards sustainable management?
--

Most of sustainability definitions are referred at a global or sector level. There are few publications writing about the role of a single farm. A shrimp farmer needs to know what are the crucial factors in his management that he has to focus on. With spots and detailed analysis of management procedures this KMF will be analyzed and monitored in the case study.

Additional research questions

What is an adequate concept to evaluate the performance of a shrimp farm on the way towards sustainable management?

The theoretical and methodological part focus on this research question. Tools for sustainability performance evaluation generally include analysis of indicators. The definition of these indicators are crucial. It is supposed that every subsystem (shrimp farm) contributes to a system on a higher level (shrimp sector).

What are the requirements for sustainable shrimp farming based on selected stakeholders' opinions?

This research question will be worked out in part B. The first focus in this part will elaborate the existing requirements from literature. The second part will focus on experts representing stakeholder groups in Brazil. The last part will focus on conscientious consumers and experts along the trade chain. This results in a single, all encompassing set of requirements for a sustainable managed shrimp farm.

What Key Management Factors for sustainable shrimp farming can be deduced from the requirements and theoretical cognitions?

The KMF result from requirements is outlined as a network. They will be measured and analyzed based on case study data.

How can the Key Management Factors be measured? What conclusions can be drawn from these analysis?

The data will be analyzed mainly with statistical methods. The results of the analysis will be evaluated economically. The simulations show economic effects on the enterprise based on changes of KMF.

What tools are required to monitor the performance of a shrimp farm on its way towards sustainable management?

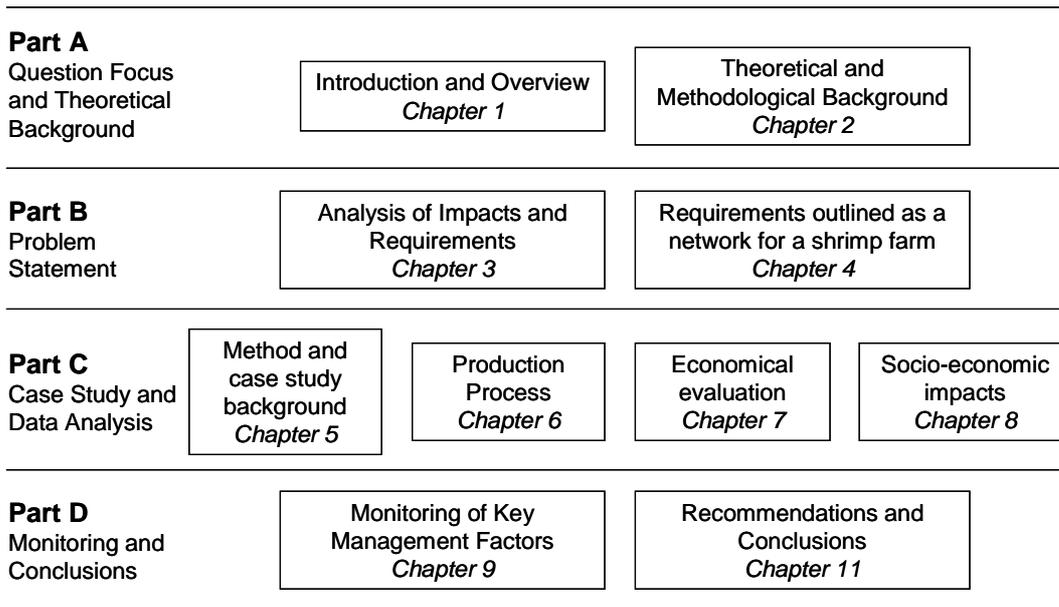
A monitoring and controlling tool can be used to measure the development of a company towards sustainable management. This monitoring tool is an adequate tool for performance measurement on the way to 'better practices' in relation to a more sustainable operation.

Specific aims, which are based on the methodological work are shown and explained in chapter 1.4.

1.4 Structure, research design and methodology

This chapter gives a summary of the structure and general methodology used in the study. It also gives an overview of the methods applied to find an answer to the questions listed in chapter 1.3.2. A more detailed description of the methods used will take place at the beginning of each chapter. Figure 4 shows the parts and chapters of this thesis. It is a key to the structure of the procedure and is conversion of the research process shown in Figure 6.

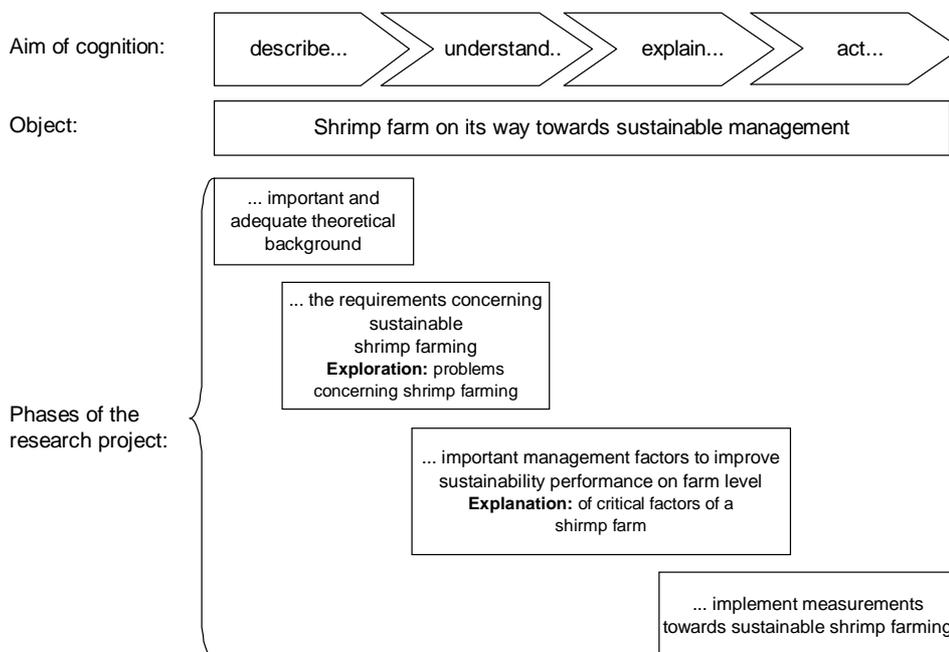
Figure 4: Structure



1.4.1 Research design an methodological procedure

Specific aims of the research design are shown in Figure 5. The first part includes a description of theoretical and methodological background to measure sustainability performance on the firm level and the description and understanding of requirements concerning sustainable shrimp farming. Special focus will be on understanding and explaining of KMF and their influence. Explanation and action take place in the last part talking about action and conversion on firm level. The case study is the object of the entire research process.

Figure 5: Specific aims and research design



Source: Own illustration according to Theler (2001, p. 52)

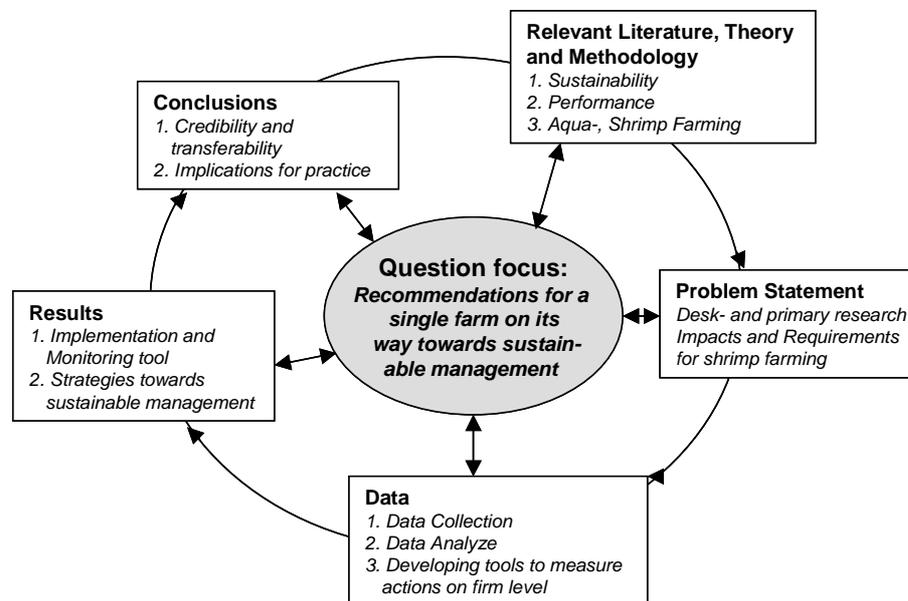
This research is a business management project, which is part of social science. Enterprises are categorized as social systems with interactions with their environment (Sachs and Hauser 2002, p. 23). The project is a multistage procedure. As professional shrimp farming is still a new industry the problem statement is more of an explorative step.

The second part – understanding and explaining of KMF of a shrimp farm – is an explanative process. The data of the case study will be tested and analyzed according to the requirements defined in the explorative section. Object is the case study. According to Yin (1994, p. 1) “(The case study is) the preferred strategy when ‘how’ or ‘why’ questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context”.

Figure 6 shows the steps of the research process following Ulrich (2001, p. 45). The question focus is the central idea of the research process. In the applied research, the question focus is commonly a practice-relevant issue (Ulrich 2001, p. 29). It is illustrated as the initial step of the process. This figure also shows that the research process is an iterative process. The process of the problem solution (question focus) has to involve continuously the practical experiences (Ulrich 2001, p. 46). The experiences on the shrimp farm (in the management of the shrimp farm) have to be continuously involved during the research process.

Contrary to basic research the applied research focuses its question on the necessities and experiences of the practice. Applied research deals with complex situations of people acting in their realities. The construction of models and rules is a common way to explain complex situation in action research. Therefore the system which will be depicted in the model has to be delimited. The term ‘framework’ is often used in business management. It is a tool to articulate problem statements, and to simplify complexity (Sachs and Hauser 2002, p. 45)⁴.

Figure 6: Steps of the Research process



Source: Adapted from Marshall & Rossmann, 1995; cited in Moser 1998

As is common in applied research, various methods will be used in the study. The exploration of important factors concerning a shrimp farm will be detected though desk-research, expert

⁴ According to Sachs and Hauser (2002, p. 45) the framework has three features: 1) is useful for analysis - “what should be focused on?”, 2) permits critic - “what is the relevance of the analyzed topic?” and 3) is used for designing - “what could be changed to improve the situation?”.

interviews, and a Delphi study. Based on the analysis a 'network' will be built (simple and conceptual model) to explain the complex system of the company in its reality. This visual model will help to give a holistic view of the company. The underlying method is a 'qualitative system dynamics approach'. This approach allows combination of different perspectives, and qualitative and quantitative analysis. The system approach frames the problem statement and results in the definition of KMF.

The KMF will be analyzed in 'spots'. Different methods for the information procurement and the explanation of these spots will be used. The spots (quantitative analysis of management factors) will be empirical data analysis within the case. The case study is a shrimp farm situated in the northeast of Brazil, in a region with an intense rate of growth of shrimp industry in recent years.

Table 2 shows the different parts, chapters, research questions, methods and sources of information and data.

Table 2: Chapters, research questions, methods and data source

	Main Part	Chapter	Research questions	Method	Data source
A	Question Focus and Theoretical Background	1 Introduction and Overview			
		2 Theoretical and Methodological Background	What is an adequate concept to evaluate the performance of a shrimp farm on the way towards sustainable management?	Analysis of Literature	Secondary data
B	Problem Statement	3 Analysis of Impacts and Requirements	What are the requirements for sustainable shrimp farming based on selected stakeholders' opinions?	Analysis of Literature Expert Interviews Delphi Study	Secondary data Primary data
		4 Requirements outlined as a network for a shrimp farm	What Key Management Factors for sustainable shrimp farming can be deduced from the requirements and theoretical cognitions?	Qualitative System Dynamics Approach	Primary data (Interviews)
C	Case Study and Data Analysis	5 Case study method and background of Data Analysis	How can the Key Management Factors be measured? What conclusions can be drawn from these analysis?		Secondary data Primary data
		6 Production Process		Statistical Methods	Primary data
		7 Economical evaluation of production correlations		Statistical Methods	Primary data
		8 Socio-economic impact of a shrimp farm		Statistical Methods	Primary data
D	Monitoring and Conclusions	9 Monitoring of Key Management Factors	What tools are required to monitor the performance of a shrimp farm on its way towards sustainable management?	Financial Simulation	Primary data (Results Part C)
		10 Conclusions	What are the recommendations for a single shrimp farm on its way towards sustainable management?		

2 Theoretical and Methodological Background

The Golden Rule is that there are no golden rules.

George Bernard Shaw, *Maxims for Revolutionists*

At the beginning of this chapter some important issues considering the research question will be discussed. Definitions, theory based explications, citations and detailed analysis of the theories and concepts will take place in the following sub-chapters. In the first part (chapter 2.1) issues relevant to sustainability will be illustrated. The second part (chapter 2.2) focus on performance theories and methods. The conclusions of the topic relevant issues and methods applied in the research will be drawn in the last part of chapter 2.

Research Question:

What is an adequate concept to evaluate the performance of a shrimp farm on the way towards sustainable management?

... adequate concept ...

Starting point of the research is a practice-relevant problem which is characteristic for ‘applied research’⁵. To find possible solutions for this problem theoretical and methodological procedures will be analyzed and approaches will be applied to find solutions. The theory will give a background and ideas to develop methods and tools in the thesis.

... performance of a shrimp farm ...

The relevant research object is a single shrimp farm and its activities. A farm is the key actor in the development of the shrimp sector. A farm also has various functions such as provider of goods and services, user of resources, etc. Many decisions take place on this level and impact the economical, ecological and social environment of the farm. The farm’s activities further contribute to the development of the whole sector and its image. As shrimp farming is a relatively new business, experiences made on a pilot farm can be used as lessons to learn for other farms.

... on the way towards ...

Sustainability is not a theory but a concept. There is no universally agreed upon definition of the concept of sustainability. It is supposed that sustainability is rather a relative concept than an absolute. That means that defining sustainability and sustainability goals is delicate and “... the so-called ‘goals’ of sustainability cannot be unique and defined once and for all; rather, sustainability should be viewed as a dynamic process in which the targets have to be continuously checked and improved, or as a philosophy that permanently tends towards improvements.” (Callens and Tyteca 1999, p. 42). Also Kane (1999, p. 28) explains in her conclusions that it must be made “... the leap from debating sustainability to implementing strategies to move towards it”.

... sustainable management ...

This indicates that the focus of sustainability is set on the corporate level. The concept of sustainable development transposed to the business level is described among others by Dyllick

⁵ Applied research is explained in Ulrich (2001, p. 19 ff).

and Hockerts (2002). Also Kane (1999, p. 29) concludes that “It is time to re-examine the connections between environmental sustainability and people’s livelihoods, ... begin to forge new tools which allow us to monitor and care for all the layers.” The underlying perception considers sustainability as part of business and indicates the importance of corporate sustainability (see chapter 2.1.3).

2.1 Sustainability concepts and methods

Sustainability is not a theory but a concept and there is no universally agreed definition of the concept of sustainability. According to various authors (Perman, et al. 1996, p. 51; Sikor and Norgaard 1999, p. 49) there is no consensus on the precise or operational meaning of sustainable development. Rigby, et al. (2001, p. 464) argue that one “can only assess sustainability after the fact; it is a prediction problem more than a definition problem.”

Sustainability can be understood as a normative and dynamic concept (Dorenbos Theler and Hediger 1999, p. 130), which involves trade-offs among social, ecological and economic objectives (Hediger 2000a, p. 481). The term ‘dynamic’ relates to the factor time and/or changes in the environment. What was considered as ‘sustainable’ twenty years ago is not necessarily considered as sustainable today. Or what is considered as sustainable in the developed world may not be considered as sustainable in the developing world. A good way to find out what kind of objectives are desired and what combination of these objectives are possible can be elaborated through a participative stakeholder approach. Such an approach is based on constructivist understanding. Constructivism assumes that there are no general principles for objective knowledge (see further literature in Dorenbos Theler 2001, p. 76). Bergner (1996, p. 82 ff) describes in this context the perception of the human being, that does not perceive the true reality, but that human being constructs their own world that fits to what is perceived. Based on this mind-set sustainability is a way and not a state.

The general acceptance of sustainability will not be discussed. It is taken for granted that sustainable development is an important issue⁶.

2.1.1 Beginnings of sustainability concerns

The definition of sustainability is often based on a discussion of what sustainability does not include. The basic and initial motive behind the sustainability discussion is the perception that the current manner of living is not sustainable (Kane 1999, p. 15). According to Kane (1999, p. 16) the roots of sustainability debate can be found in several places. One of this places is basic resource management, decisions of how to manage renewable resources. The field of natural resource economics often focuses on the optimal use of resources to ensure availability far into the future. Other more generally focuses, are beyond strict economic sustainability. These approaches focus on conservation issues (for protecting the services provided by nature) and resource protection with its aesthetic and spiritual benefits.

According to Perman, et al. (1999, p. 50) sustainability arguments are generally based on an ethical principle. For instance that ecological diversity is believed to be an important objective in its own right. Seen from an economic point of view this ecological objective can be interpreted as the behavior should be organized “so as to avoid serious ecological disruption, to make economic activity be consistent with ecological diversity” (Perman, et al. 1999, p. 50). It is hard to know the absolute level of economic activities to be consistent with ecological diversity.

⁶ For further explications see also Perman, et al. (1996, p. 53).

2.1.1.1 From ‘Limits to Growth’ to ‘Sustainable Development’

Environment and the adverse consequences of human impact on the natural environment is one of the main concerns that the Club of Rome expressed in its first Report ‘Limits to Growth’ (Meadows, et al. 1972). The world was presented as a networked system (Von Weizsäcker, et al. 1997, p. 11), where simulations on computer models predicted collapse of the whole system, provided that the resource demand pattern does not change dramatically. According to Kane (1999, p. 16) this report focused exclusively on physical ecological limits to economic growth. Other authors - for instance Paul Ekins 1993 cited in Kane (1999) - argue that limits to growth may also be social and/or a consequence of repercussions of societal conflicts resulting from environmental degradation and inequitable distribution of resources or wealth. Another report of the Club of Rome was the Factor Four (Von Weizsäcker, et al. 1997), citing examples for doubling wealth and halving resource use.

Based on the growing awareness of environmental issues the concept of ‘sustainable development’⁷ has been developed. In 1987 the World Commission on Environment and Development (WCED) also known as the Brundtland Commission⁸, provided a working definition of ‘sustainable development’. This definition is one of the earliest, simplest, and most widely accepted definitions of sustainability (WCED 1987, p. 43).

“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs”

This definition is broad and may have many different interpretations. According to Hediger (1999, p. 1121) the definition has evolved from different development paradigms, encompasses economic, social and ecological perspectives, and contains within it the key concepts of equity, needs and limitations.

As explained in Kane (1999, p. 17) “the interpretation of sustainability, hinges on underlying assumptions of what is important for the continued existence and happiness of the human species, and the possibility for substitution of those things which contribute to our welfare.” As aforementioned this definition is based on an “ethical imperative of equity within and between generations” (Hediger 2000a, p. 481). ‘Substitution’ is an important term in the sustainability discussion. According to Costanza (1991, p. 9) “Most economists view natural and manmade capital as substitutes rather than complements. Consequently, neither factor can be limiting. Only if factors are complementary can one be limiting. Ecological economists see manmade and natural capital as fundamentally complementary and therefore emphasize the importance of limiting factors and changes in the pattern of scarcity.” The question of substitutability will be discussed further in chapter 2.1.3.4, p. 28.

2.1.1.2 Three aspects of sustainability

According to Munasinghe (1993, p. 1) the concept of sustainable development can be characterized by the experience of several decades of development efforts. “In the 1950s and 1960s, the focus of economic progress was on growth and increases in output, based mainly on the concepts of economic efficiency. By the early 1970s, the large and growing numbers of poor in the developing world ... led to greater efforts to directly improve income distribution. The development paradigm shifted towards equitable growth, where social ... objectives were recognized as distinct from and as important as economic efficiency.” (Munasinghe 1993, p. 1). Later, the protection of the environment became the third major objective of development. In the early 1980s it was recognized that environmental degradation was a major barrier to

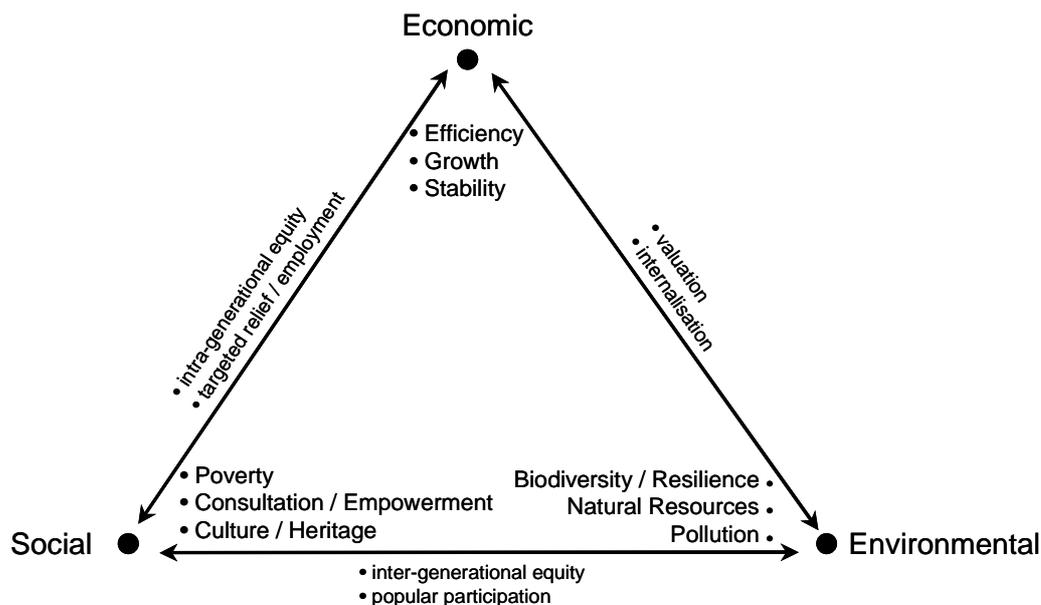
⁷ The terms ‘sustainability’ and ‘sustainable development’ are used interchangeably in the literature.

⁸ The Brundtland Commission is named after the past WCED’s chair, Gro Harlem Brundtland.

development. This was also the underlying idea by implementing the term ‘sustainable development’ (see 2.1.1.1).

A more precise definition of sustainable development involves “a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and the institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations” (WCED 1987). This definition is an extension of the ecologically-based concept to the socio-economic context of development (Adams 1990 cited in Hediger 1999, p. 1120). These three aspects – economy, environment, and society – are traditionally the three perspectives defining sustainability. The objectives of development involve the three dimensions as shown in Figure 7. According to Hediger (2000a, p. 481) the concept of sustainable development “...involves trade-offs among social, ecological and economic objectives, and is required to sustain the integrity of the overall system.” Also Leung and El-Gayar (1997, p. 168) state the tradeoffs among the conflicting goals of various development plans and policies. The trade-offs reflect the possible conflicts of objectives among three perspectives. The conflicts are a contrast to the harmony-objective WCED definition, whereas a conflict-solving approach through democratic participation is required.

Figure 7: Trade-offs among the three main objectives of sustainable development



Source: Munasinghe 1993

Based on the three aspects shown in Figure 7 Munasinghe (1993, p. 3) describes three approaches for sustainable development:

- **Economic approach:** is based on the concept of maximum flow of income that could be generated while at least maintaining the stock of assets which yield these benefits. The problems related to this approach such as substitutability of capitals, valuing assets will be illustrated further on in chapter 2.1.2.1
- **Ecological approach:** focuses on the stability of biological and physical system. The emphasis is on preserving the resilience⁹ and dynamic ability of such systems to adapt to change.

⁹ Resilience is the capability of a system to respond to adverse factors and to restore its functionality (illustrated in Dorenbos Theler (2001, p. 78)).

- **Socio-cultural approach:** this approach seeks to maintain the stability of social and cultural systems, including the reduction of destructive conflicts. As shown in Figure 7 intra-generational equity (especially elimination of poverty), and inter-generational equity (rights of future generations) are important aspects of this approach.

These approaches refer to a global sustainable development. The three aspects of sustainability (economic, environmental and social) are also represented in micro-focused approaches. ‘Corporate sustainability’ and ‘Corporate environmental responsibility’ generally focus on how “economic sectors or business contribute to this (sustainable development) objective” (Atkinson 2000, p. 235). This approach will be illustrated in chapter 2.1.3. The combination of indicators of economic, social and environmental concerns, presented in heterogeneous units is also called the ‘triple bottom-line’ approach and stands for a comprehensive value adding in all three dimensions (Atkinson 2000, p. 239; Bieker, et al. 2001, p. 16).

Köhn (1999, p. 97) focus on hierarchy, change and sustainability and argues that “there is no need to distinguish between different kinds of sustainability, for example, environmental, social and economic ... environmental sustainability has to include social sustainability ... economic sustainability is part of social sustainability.” Based on this argumentation is the assumption economic, social and environmental aspects cannot be analyzed separately.

According to Hediger (1999, p. 1121) the discussion about trade-offs lead to exclusive concepts of ‘weak’ and ‘strong’ sustainability and divides economists and environmentalists. Weak sustainability is a value principle, which requires that the total value of aggregate economic activity and environmental quality should be maintained over time (Hediger 1999, p. 1127). A stronger form of weak sustainability (very weak) is represented by Robert Solow where production capacity of an economy is maintained intact, such as to enable constant consumption per capita through time (Solow 1974 1986, Turner 1994, cited in Hediger 1999, p. 1123). The environmental economists Costanza, Daly and Pearce are representatives for strong sustainability concept. It is a physical principle with a minimum necessary condition of total stock of natural capital to remain constant over time. A stronger form (very strong sustainability) stands for a stationary-state principle which requires limiting of human scale (Turner 1994, cited in Hediger 1999, 1123).

2.1.2 Sustainability concepts

2.1.2.1 Survey of sustainability concepts

According to Kane (1999, p. 18) the limits of growth arguments and the Brundtland definition of sustainability are focused on constraints. Such constraints are essential for the understanding of sustainability by economists. A definition of sustainable development requires a clear distinction between goals and constraints. It has to be defined 1) what do we want to sustain (goal) and 2) what can we sustain (constraints) (Hediger 2000a). Based on this concept the goal of sustainability focuses on the maximization of utility (consumption) without (for example) a declining stock of natural capital. The constraints depend on the capability and feasibility of the social, ecological and economic system to adjust to changes.

The authors Perman, et al. 1999, show various ways of how economists think about sustainability. They present six concepts reflecting different ways of thinking about sustainability. The concepts are listed in Table 3. It is important to consider that not all of the concepts are purely economic conceptualizations and are not necessarily mutually exclusive. Some of the concepts view sustainability as a constraint on economic behavior and none of the concepts explicitly specifies the duration of time over which sustainability is to operate (Perman, et al. 1999, p. 52).

Table 3: Concepts of sustainability

	A sustainable state is one in which ...					Development
	A	B	C	D	E	F
Concept	... utility (consumption) is non-declining through time	... resources are managed so as to maintain production opportunities for the future	... the natural capital stock is non-declining through time	... resources are managed so as to maintain a sustainable yield of resource services	... satisfies minimum conditions of ecosystem stability and resilience through time	Sustainable development as a capacity and consensus building
Issues of the concept:	Hartwick's rule ^{a)} Hartwick-Solow rule: non-declining consumption over time Pezzey purposed a concept of survivable development (minimum level),	Raise the question of use of renewable and non-renewable resources. Preservation of opportunities, also described in Brundtland report Initiates the question of substitution possibilities between capitals	Two ways of constant capital stock rule: Requires values on different elements of capital (common metrics) UNESCO definition: non-declining natural capital stock	Often used in biological models of renewable resource stocks (e.g. fisheries, forests). Concept of maximum sustainable yield ^{b)} Steady state economy ^{c)} . Progress in steady state is possible through efficiency improvement.	Interpreted from ecologists, sustainability within a system perspective Identify what kind of economic activities seem to be consistent with ecological sustainability (critical zone, resilience). Propose a set of indicators	Focus on the process. Environmental objectives cannot be separated from other social and political objectives. Human societies as part of ecosystems. Negotiation through consensus building Internalization of external costs
Advocates	John Pezzey John Hartwick Robert Solow	Robert Solow Talbot Page	Atkinson Pearce Barbier and Markandya	Daly (steady state economy)	Costanza ^{d)} Ciriacy-Wantrup Schaeffer	De Graaf
Criticism	No requirements for initial level of consumption. Minimum level is related to the environment (e.g. poverty line is culturally, rather than biologically determined)	Difficulties to define possible substitutions between various capitals.	Difficulties to define valid measures of capital depreciation, (particularly for natural capital) Natural capital is not homogeneous, no satisfactory method to measure total stock of natural capital.	Difficulties of interpretations because of heterogeneous elements as resources	Difficulties for an ex-ante evaluation of impact/changes of resilience of a system	Difficulties to identify carrying capacities of ecosystems and difficulties for pricing of environmental decline (external costs)
	Very weak sustainability	Weak sustainability	Strong sustainability	Very strong sustainability	Strong sustainability	-

^{a)} If the rents derived from non-renewable resource extraction are saved and then invested entirely in reproducible capital, then under certain conditions the levels of output and consumption will remain constant over time

^{b)} Highest feasible flow of services that can be maintained over time from an environmental system

^{c)} Constant stocks of physical wealth and constant population, each maintained at some chosen, desirable level by a low rate of throughput, so that longevity of people and durability of physical stocks are high (Daly 1974, quoted in Perman, et al. 1999, p. 62)

^{d)} Sustainability is a system "in which 1) human life can continue indefinitely, 2) human individuals can flourish, and 3) human cultures can develop; but in which effects of human activities remain within bounds, so as not to destroy the diversity, complexity, and function of the ecological life support system." (Costanza 1991, p. 8-9)

Source: According to Perman, et al. (1996, p. 52ff) and Hediger 1999

All concepts share a common theme in recognizing that future well-being is determined by what happens to wealth over time (Atkinson 2000, p. 236). Differences among concepts are a result of different visions about what a sustainable world can and should look like (Hediger 1999, p. 1123). Concepts A and B are focusing on utility, consumption and production opportunities. Concepts C, D and E focus on management of resources and natural capital stock.

Most of the concepts described above are based on the allocation of capitals, management of resources and shift of utility. All concepts rather describe a ‘top-down’ perspective where all factors (e.g. biodiversity, environmental pollution, social equity, poverty, etc.) are forced into the same framework, which can be an economic allocation model. Development of these kinds of models require a broad data base and interdisciplinary knowledge. The understanding of different kinds of capital and formal analytical proceedings is important for these sustainability concepts. These concepts will be further discussed in chapter 2.1.2.2. Concept E of Table 3 describes sustainable development as a capacity and consensus building, and is a rather participative approach. This kind of approach will be illustrated in chapter 2.1.2.3.

Concluding the discussion about sustainability concepts Bieker, et al. (2001, p.15) argue that sustainability involves three central principles:

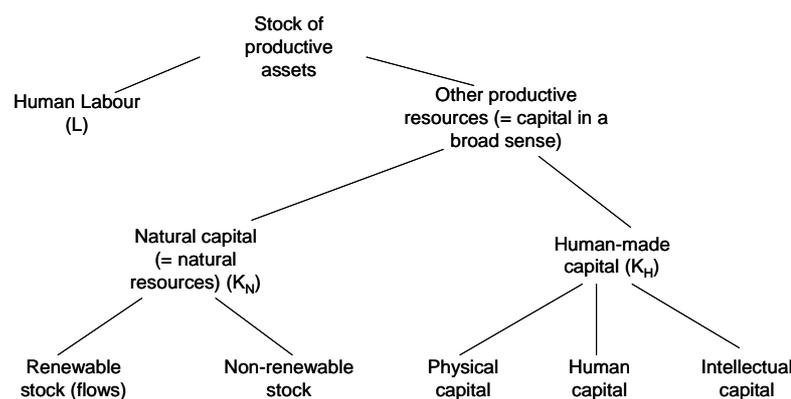
- Principle of maintenance of capital: This principle is generally accepted for economic understanding but much less for the ecological and social capital. The central idea is to live from revenues and not from assets (see 2.1.2.2).
- Principle of a permanent sustainable development: This principle shows the importance of the integration of short- and long-term aspects in the development. It requires to focus on a long-term development.
- Principle of the integration of three aspects: ecological, social and economical aspects, this principle is known as the ‘magic triangle’ or on the business level as ‘triple bottom line’ (see. 2.1.1.2).

A further principle that is not explicitly stated by Bieker, et al. (2001) is equity, that is a central point in the Brundtland definition.

2.1.2.2 Formal analysis of sustainability

The formal analysis of sustainability is capital based and represents a ‘top-down’ approach (Dorenbos Theler 2001, p. 100). The management of resources and capital as a constraint for economic activities are key issues in formal analysis. Perman, et al. (1999, p. 56) classifies the capital as shown in Figure 8.

Figure 8: Capital and Resources



Source: According to Perman, et al. 1999, p. 56

According to the above mentioned classification of capitals an economy’s production function can be written as shown in Equation 1.

Equation 1: Economy's production function

$$Q = Q (L, K_N, K_H)$$

Source: Perman, et al. 1999, p. 57

whereas:

Q	output
L	labor
K _N	natural capital
K _H	human-made capital

Q represents the output of the economy's production as a function of various stocks and capitals. Depending on the substitution possibilities between the resource categories the capital stock has to remain on a non-decreasing level (Perman, et al. 1999, p. 57). It can either be a single capital stock (for example the natural capital), or an aggregate value of capital assets that ensures the maintenance of productive opportunities.

According to Hediger (2000a, p. 484) the capitals described in chapter 2.1.2.1 are extended to the social context, whereas capitals are defined as shown in Table 4.

Table 4: Capital extension to social context

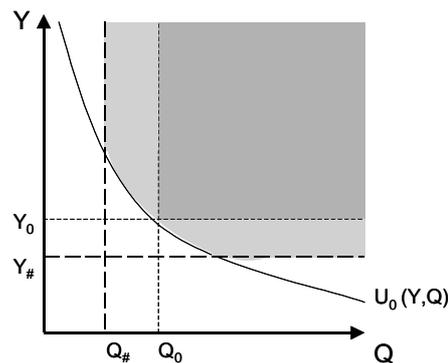
Capital	Consists
Economic capital	<ul style="list-style-type: none"> • Manufactured capital (machines, buildings) • Immaterial assets (knowledge, institutions, state of technology) • Natural resources (renewable and non-renewable resources) that are used for economic production processes
Ecological capital	<ul style="list-style-type: none"> • Total renewable resources (also part that is not used for economic processes – part that determines overall quality of ecosystem)
Natural capital	<ul style="list-style-type: none"> • Ecological capital • Non-renewable resources
Social capital	<ul style="list-style-type: none"> • All immaterial assets, also these assets that are not used for economic production processes

Source: According to Hediger 2000a, p. 483

Based on the classification of these capitals a social welfare function can be defined (Hediger 2000a). As constraints to this function are defined necessary conditions such as equity within and between generations, efficient use of scarce resources, and compliance with safe minimum standards¹⁰, such as critical ecological capitals and basic human needs. These conditions reflect the goal-conflicts (trade-offs) and some of the objectives shown in Figure 7.

This context is graphically shown in Figure 9. It is the concept of weak sustainability, which is defined in this case of non-decreasing social welfare (U_0), as a function of aggregate income (Y), environmental quality (Q). $Q_{\#}$ represents critical ecological capital and $Y_{\#}$ represents basic human needs. These are both safe minimum standards (critical limits) for the development. Q_0 and Y_0 are strong sustainability frontier respectively economic development frontier. The function U_0 is a weak sustainability frontier.

¹⁰ Safe minimum standard (SMC) is defined by Perman, et al. (1996, p. 186). The authors state it as a principle that would involve constraints on resource harvesting and use so that all risks to the survival of a renewable resource are eliminated. Furthermore are distinguished various versions of SMC.

Figure 9: Critical limits and possibilities for sustainable development

Source: Dorenbos Theler (2001, p. 89), according to Hediger 1999

The total shaded area represents the possibility space for weak sustainable development. The measurement of utility and social welfare is undisputable. There are no metrics defined and the perception of what is utility and aggregated utility can be very subjective depending on time and space. The economist Arrow Kenneth states that it may be impossible to devise a social welfare function that is positively related to individual choices; society might be unable to make up its collective mind as to what it wants (Pearce 1992, p. 18).

The achievements of the capital based understanding are top-down approaches. This formal analysis of top-down approaches defines the formal sustainability requirements. It is supposed that there exists the knowledge to define all critical limits and frontiers concerning economy, ecology and society. According to Callens and Tyteca (1999, p.43) the top-down approach starts “from the concept of environmental space, which would allow the measurement of sustainability, through the definition of an adequate distribution scheme of various components of environmental space among production systems. ... the measurement (of the top-down approach) is performed with respect to some global, predetermined level of sustainability.” Also Atkinson (2000, p. 237) argues that the problems involved with this approach are “... firstly, identifying critical assets and, secondly, determining thresholds are far from trivial and are at the frontier of interdisciplinary research.” Further Dyllick and Hockerts (2002, p. 19) point out that the complexity of the real world, where “non-substitutability, non-linearity, and irreversibility prevail ...” requires a more differentiated vision. Because if all capitals would be completely substitutable, “one could translate natural and social capital in monetary terms thus reducing the problems to the ‘mere’ task of profit maximization.” (Dyllick and Hockerts 2002, p. 19).

2.1.2.3 Participative understandings of sustainability

The approach of participation is described by various authors (Bass, et al. 1995; Uphoff 1992; Dorenbos Theler 2001). It is stamped by the central role of actors that are involved in the implementation of sustainability concepts. The success of the process of sustainable development depends on the involvement of key actors that implement the measures and realize institutional changes (Dorenbos Theler and Hediger 1999, p. 135). A participative approach allows an evaluation of values and norms of actors that are finally responsible for the implementation of measures towards sustainable development. The participative decision-making process is very important in this kind of understanding. According to Köhn, et al. (1999, p. 9) “sustainability can be understood as a process of regulatory decision-making. ... sustainability cannot be split into economic, social or environmental categories. On the contrary, sustainability is a unifying and guiding principle of social and social-environmental interaction. Therefore, sustainability cannot be an issue for a solely social or natural science. The call for

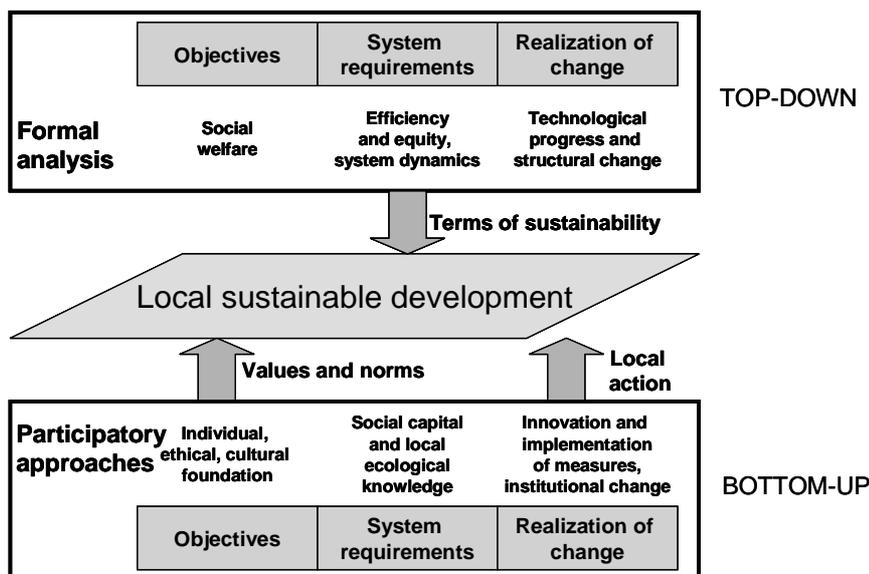
a post-normal science that relates science to decision-making within the social context requires designing a political economy of sustainability.” Schmidt (1997) argues that the awareness among all stakeholders for sustainability issues is important for a sustainable development.

Also Callens and Tyteca (1999, p.51) are convinced that the inclusion of actor’s knowledge is important “... it should be stressed that ... a sustainability frontier is by no means static; instead, it should evolve both with the improvement of the knowledge we have about the world we live in and with new goals we set for future generations.” This statement encourages a participative approach. The participative approach is promoted by other authors with regard to the implementation of sustainability concepts. The problem of implementation of sustainability concepts such as the Brundtland definition and the interpretation of current and future ‘needs’ is also risen by Redclif (1996) cited in Kane (1999, p. 18). He argues that the concept of needs is no longer based on survival but on accepted norms. Development itself contributes to the changing perception of what is a need. The difficulty in defining sustainability often comes to a disagreement on exactly what can or should be maintained (Kane 1999, p. 19).

Other advocates of participative approaches are Sikor and Norgaard (1999). They argue, writing about critical ecological and economical variables, that “the ‘objective’ information derived from the scientists’ models may be absolutely correct from a modern scientific perspective, but it will also quite likely be irrelevant or erroneous from the local perspective, from the perspective of the people whose actions may or may not need to change to promote sustainability. Thus framework selection, modeling, data collection, and parameter estimation need to be undertaken in collaboration with the people whose ecosystems and livelihoods are being modeled. “... we argue for an approach that recognizes sustainability as an on-going outcome of appropriate social processes” (Sikor and Norgaard 1999, p. 53).

Dorenbos Theler (2001) illustrates in her thesis the integration of the participative bottom-up approach and the formal analysis top-down approach (see Figure 10).

Figure 10: Integration of top-down and bottom-up approach



Source: According to Dorenbos Theler 2001

It is important to understand the participative approach not as a contradiction to the formal analysis approach, but as an integration. Top-down and bottom-up describe exclusively the perspective and the point of view.

2.1.3 Corporate sustainability

Initiated at the Earth Summit 1992 in Rio de Janeiro a group of concerned business leaders had formed the World Business Council for Sustainable Development (WBCSD). This coalition of actually 150 international companies share a commitment to sustainable development via the three pillars of economic growth, ecological balance and social progress. The WBCSD's mission is "to provide business leadership as a catalyst for change toward sustainable development, and to promote the role of eco-efficiency, innovation and corporate social responsibility." (WBCSD 2002). According to Dyllick (2002, p. 4) "numerous firms appoint corporate sustainability officers, publish sustainability reports (SustainAbility, 2000), and incorporate sustainability into their corporate communication strategies." The conviction of the importance of corporate sustainability¹¹ is mentioned by various authors. Callens and Tyteca (1999, p. 43) argues that "due to their central role in human activities and development, firms should play an important part in the attainment of sustainability goals."

Numerous activities and initiatives exist on firm level related to environmental- and social management. Bieker, et al. (2001, p. 13) describe changes and development of various management systems. Additional to the universally financial approaches have been implemented more standardized systems for the environmental- and social management. ISO-Standards¹², for quality- (9.001) and environmental- (14.001) management, and SA8000¹³ for social aspects are some examples for standardized systems. Against this background certification activities became widespread. Further approaches include various aspects, e.g. EFQM-Model for Business Excellence¹⁴. Bieker, et al. (2001, p. 13) amplify about the inefficiency of the parallel implementation of various management systems at the same time in the same firm. The authors emphasize the necessity of a more integrated management system. Callens and Tyteca (1999, p. 41) demand an integrated approach. They argue that "...efficiency with respect to economic, social and environmental resources is viewed as a necessary (but not sufficient) step towards sustainability."

2.1.3.1 Understanding corporate sustainability

According to Bieker, et al. (2001, p. 20) especially large-scale enterprises started to focus on sustainability concepts. Various enterprises profess sustainability as part of their corporate vision¹⁵. Based on the vision objectives, strategies and measures are deduced. The implementation of these strategies take place with specific sustainability management systems and its success is measured and evaluated with sustainability indicators (see 2.1.3.2). Bieker, et al. 2001 distinguish between *sustainability as a business objective* and *sustainability as a contribution of a firm to sustainability objectives of the society*. Both of these understandings are important for the implementation of corporate sustainability.

¹¹ In this context 'Sustainable development of firms' is used as a synonym for 'Corporate sustainability'.

¹² ISO stands for International Organization for Standardization, (<http://www.iso.ch/iso/en/ISOOnline.openerpage>).

¹³ SA8000 is a uniform, auditable standard for a third party verification system. SA8000 is based on the principles of 11 Conventions of the International Labor Organization (ILO), the Universal Declaration of Human Rights and the United Nations Convention on the Rights of the Child. The standard covers eight workplace conditions: child labor, forced labor, health and safety, freedom of association and the right to collective bargaining, discrimination, disciplinary practices, working hours and compensation. The ninth area covered by the standard is management systems, which stipulates necessary systems for ensuring ongoing conformance with requirements of the standard (<http://www.cepaa.org/publications/sa8000.htm>).

¹⁴ EFQM stands for European Foundation for Quality Management (<http://www.efqm.org>).

¹⁵ Bieker, et al. 2001 specify: Shell, BP, GM, Ford, Henkel, Novartis, Bristol-Myers Squibb, Novo Nordisk, Procter & Gamble, Unilever, ABB, Intel, Axel Springer Verlag, Volkswagen, Otto Versand, Swiss Re, Barclays Bank, and UBS.

The first understanding of sustainability (as a business objective) focus on the firm and its activities. Environmental and social circumstances that are relevant for the firm will be analyzed and appropriate measurements will be defined and implemented. The Starting point for these measurements is in the firm (Bieker, et al. 2001, p. 20).

Problems and challenges of the society are at the core of the second understanding of corporate sustainability (as a contribution to society goals). This second understanding is also explained by Atkinson (2000), his publication 'Measuring Corporate Sustainability' focuses on the question of how economic sectors or business can contribute to the national or international adopted goal of sustainable development. Atkinson (2000) argues that "one of the keys to understanding corporate sustainability is full cost accounting, that is, valuing pollution in corporate green accounts." He refers to the definition of 'full cost accounting' of the Canadian Institute of Chartered Accounts¹⁶. The central idea is "the integration of an entity's internal costs (including internal environmental costs) and the external costs of its activities." According to Atkinson (2000, p. 242) the "accounting for external costs may provide firms with an incentive to search for economic ways of decreasing these costs and thereby lead to a more socially beneficial use of environmental resources". The difficulties of the full cost accounting approach (outlined by Atkinson) is the necessity for valuing external costs that requires putting a price on 'goods' and 'bads' that lie outside of the market and thus cannot be estimated using familiar, tried and trusted, techniques. WBCSD (2002) is another example that classifies sustainability as a contribution to a higher level. The organization defines 'global outreach' as one of its aims¹⁷. Schmidheiny (1999, p. 137) states that a company with its economical activities is always producing impacts on the environment, and therefore can not be called 'sustainable'. The author focus on the contribution of companies to the economical development and social welfare.

Both understandings of sustainability as a firm's objective or as a contribution to society's objective are not exclusive and are important for corporate sustainability.

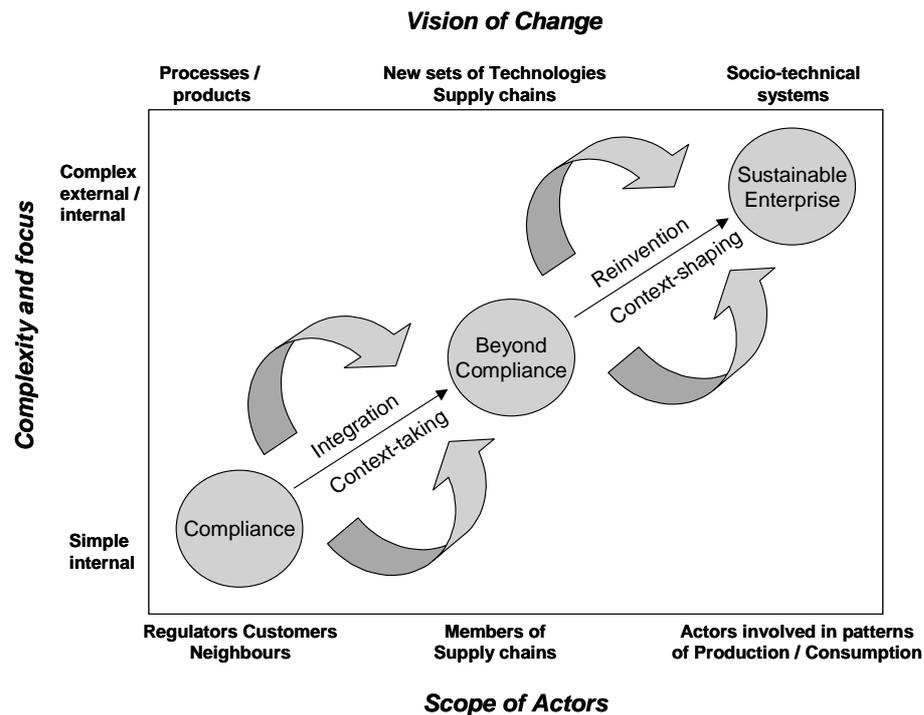
According to Hawken, et al. (1999) and Birkin (2001) initiatives in environmental programs indicate that humankind is actually participating in another industrial revolution, "a revolution to Natural Capitalism". These changes and concerns about sustainable development necessitate different mind-sets and sets of values that "lead to profound differences in the ways in which businesses are managed" (Birkin 2001, p. 47). According to Birkin (2001, p. 50ff) basic changes in knowledge, values and meanings, metrics, goals and management are needed. This perception shows the necessities of a holistic approach to achieve corporate sustainability. Senge (1996) argues that it is necessary to develop 'learning organizations' in order to manage in this new environment (Birkin 2001, p. 55).

Roome (2001) presents a framework for a sustainable enterprise shown in Figure 11. He argues that a sustainable firm is far beyond compliance of requirements of regulators, customers and members of the supply chain. A sustainable firm involves stakeholders that help to define the context of what sustainable enterprise is (context-shaping). As already mentioned in the participative understanding of sustainability (see 2.1.2.3) the stakeholders define values and norms. The context-shaping-process is also described by Dyllick, et al. (1997, p. 78). The authors differentiate between offensive and defensive strategic orientation, and strategies concerning the market and the society. The strategies concerning society include activities to modify the frame in which the competition occurs. This may include postulation and acceleration of the ecological transformation process (Dyllick, et al. 1997, p. 79).

¹⁶ <http://www.cica.ca>.

¹⁷ To contribute to a sustainable future for developing nations and nations in transition.

Figure 11: Framework for a sustainable enterprise



Source: Modified according to Roome 2001

According to Roome's framework the vision of change focus on a holistic socio-technical system. Which means that the management of a sustainable firm not only focus on the process and the final products but involves a holistic point of view of changes. Figure 11 shows the complexity of the system, according internal and external factors. The framework illustrates that corporate sustainability can be interpreted as a process (of integration and reinvention) rather than a state. This opinion is shared by various authors writing about corporate sustainability. Sikor and Norgaard (1999) for example argue that the "challenge of sustainability is to develop social processes that integrate diverse views of sustainability and create sufficient opportunities to satisfy future demands on resources." They also argue that to understand sustainability as an "on-going outcome of appropriate social processes", is different from a traditional concept, which requires an objective definition of the goal of sustainability (see chapter 2.1.2.1, p. 17).

2.1.3.2 Indicators for monitoring 'Sustainable Development'

The necessity to measure sustainable development started on a global/political level as a follow-up of the United Nations Conference on Environment and Development (UNCED). The Commission on Sustainable Development (CSD) was created to ensure monitoring and reporting on the implementation of the Earth Summit agreements (Agenda 21, the document produced at the UN Earth Summit 1992) (United Nations 1999). Standards and indicators of development have been used to monitor the progress of sustainable development (Rigby, et al. 2001, p. 464). The definition of indicators and its measurement in connection with a sustainable development is also one of the key priorities for OECD (OECD 2000, p. 5). The implementation of indicators (on all levels) is a necessary condition to monitor progress and development. On the level of corporate sustainability WBCSD (2002) specifies as one of its aim "to demonstrate business progress in environmental and resource management and corporate social responsibility ...".

Ranganathan (1998, p. 2) defines ‘sustainability indicator’ on firm level as “information used to measure and motivate progress toward sustainable goals ... includes information of a firm’s social, environmental, or economic performance.” Verfaillie and Bidwell (2000, p. 8) define indicators as “specific measures of an individual aspect that can be used to track and demonstrate performance.” They describe the role of a business specific indicator to “...monitor performance with measures which are transparent and verifiable, and therefore meaningful to business managers as well as to external stakeholders.”

The availability of data is often a crucial point. The set of indicators must incorporate ecological, social and ethical issues and information as well as economics. Several authors have suggested criteria for good indicators of sustainable development. According to Kane (1999, p. 27). These criteria include:

- **Applicability to scale and place / location:** It is important to define a measurable unit to be able to measure a progress where the indicators can be either broad and single indicators or indicator sets which seek to combine data on many phenomena. The definition of the reference framework is important for the applicability to place.
- **Appropriateness to their audience and to the layers of sustainability:** Concerning the appropriateness to the audience the definition of the timeliness is a critical issue. In connection with the layers of sustainability it is important to take the context into account. For example there should be indicators which address categories such as Environment, Health, Community, etc.

These requirements for criteria indicate the importance of the reference system. This is mentioned by various authors. According to Callens and Tyteca (1999, p. 43) the question whether an enterprise is sustainable or not can not be answered in absolute terms, because it depends on environmental factors such as the geographic and socio-demographic environment.

Ranganathan (1998, p. 2) requires that sustainability indicators must be comparable, complete, and credible. These requirements guarantee that it is possible to track performance over time and across firms. The application can also be across sectors and even countries and credible, so that business and others trust the indicators and make reliable decisions based on information reported.

Standardization movement is described by various authors. Several organizations¹⁸ “have independently undertaken to develop and bring about broad agreement on a core set of environmental performance metrics” (Ranganathan 1998, p. 3). Bieker, et al. (2001) also illustrate the example of standardized system concerning social management¹⁹. In addition to these voluntary reporting initiatives, public disclosure, and comparability are being driven by regulations (Ranganathan 1998, p. 3).

2.1.3.3 Measurement of corporate sustainability

As mentioned above the standards to evaluate corporate sustainability are generally focusing only on one aspect of sustainability. The most common known focus in this context is eco-efficiency. A WBCSD publication illustrates the functionality of measuring eco-efficiency (Verfaillie and Bidwell 2000). According to these authors eco-efficiency defined as shown in Equation 2.

¹⁸ Coalition for Environmentally Responsible Economies (CERES), the World Business Council for Sustainable Development (WBCSD), and the Canadian National Round Table on Environment and the Economy.

¹⁹ AccountAbility 2002, SAI 2002.

Equation 2: Eco-efficiency

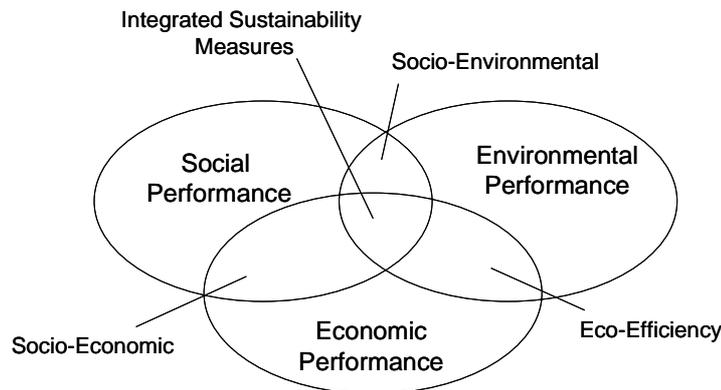
$$\frac{\text{Product or service value}}{\text{Environmental influence}}$$

Source: Verfaillie and Bidwell 2000

It calls for business to achieve higher value from lower inputs of materials and energy with reduced emissions. General applicable indicators for product/service value are quantity of goods or services produced or provided to customers or net sales. The environmental influence generally are energy consumption, materials consumption, water consumption, greenhouse gas emissions, ozone depleting substance emission. The term and interpretation of eco-efficiency is a rather technical definition. Externalities, by-products and other impacts of the companies' activities are not considered (Verfaillie and Bidwell 2000, p. 3). The authors list various possibilities to achieve or improve eco-efficiency. Reduction of material, energy intensity, dispersion of undesired substances, and enhancement of recyclability, maximization of renewable inputs, extend product life and increase service intensity.

Ranganathan (1998, p. 2) illustrates economic-, social-, and environmental performance with the corresponding overlapping parts. He shows eco-efficiency as an intersection of economic environmental performance (Figure 12). Further intersections described by Ranganathan 1998 are socio-economic and socio-environmental. The intersection of all three performances is called integrated sustainability measures.

Figure 12: Sustainability Measurement Schematic



Source: Ranganathan 1998

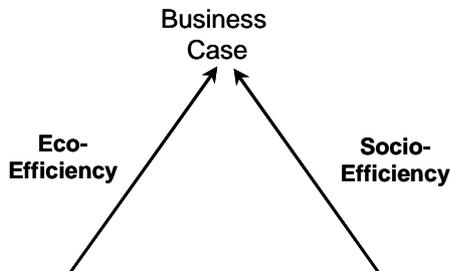
The socio-economic performance (according to Ranganathan 1998) includes employment creation, equitable distribution of wealth, investment in employee education, etc. Socio-environmental aspects focus on equity in access to natural resources, land tenure, and siting of high environmental impact industrial facilities. This definitions of the terms above combine the understanding of sustainability as 1) a political-ethical project (e.g. in the case of equitable distribution, equity in access) and 2) a strategic management project (e.g. in the case of eco-efficiency).

Against the background of the tension of political-ethical project and management project, Dyllick and Hockerts (2002, p. 19) define an extended framework for corporate sustainability. They argue that the implementation of sustainability concepts on the business-level focus primarily on the 'business case'. 'Efficiency' is a key word for this business case perspective, where firms ask how they can raise their economic sustainability by paying attention to social and environmental issues. This issue will be elaborated in the next chapter.

2.1.3.4 Efficiency as part of corporate sustainability

As already mentioned in chapter 2.1.3.3 efficiency is rather a technical term measuring output per input. Based on a business perspective the efficiency to reach economic sustainability has to be improved. This context is shown in Figure 13.

Figure 13: Sustainability in the business case



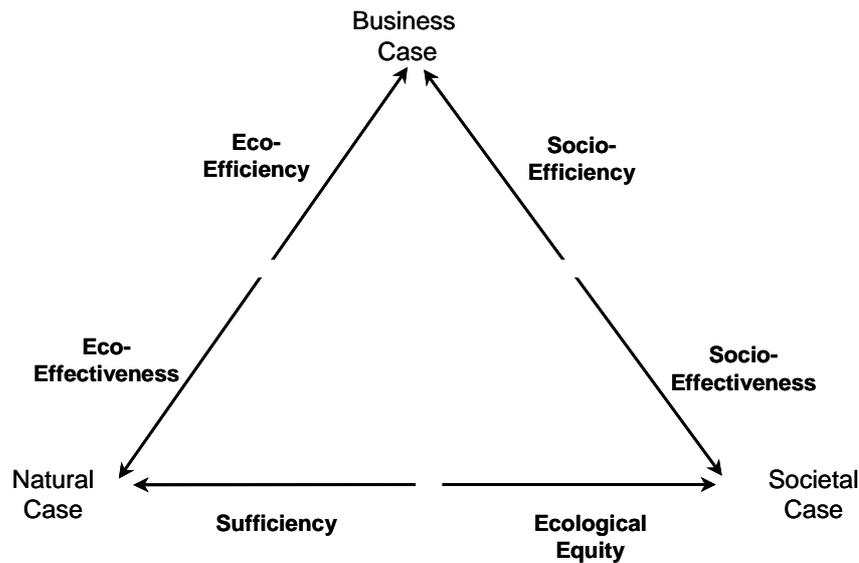
Source: Dyllick and Hockerts 2002

In the business case perspective corporate sustainability is reached with eco- and socio-efficiency. Eco-efficiency is widely accepted and widely used (see 2.1.3.3). Socio-efficiency describes the relationship between a firm's value added and its social impact. As a contrast to social impacts, environmental impacts are generally considered as negative ones. Social impacts can be either positive (e.g. creation of employment) or negative (e.g. work accidents, mobbing of employees). Depending on the type of impact socio-efficiency either tries to minimize negative social impacts or maximize positive social impacts in relation to the value added (Dyllick and Hockerts 2002, p. 21). The authors illustrate further that focusing on the business case is primarily increasing economic sustainability and natural and social capital benefit from win-win situations.

Dyllick (2002) and Callens and Tyteca (1999) illustrate that efficiency measurements are tools that only lead to relative improvements. Callens and Tyteca (1999, p. 43) write about "...investigating a set of necessary conditions that firms must fulfill in order to be sustainable. Necessary conditions are viewed as being efficient in the use of resources, in the pollutants released to the environment, in the social role played by firms as reflected by their rate of employment, the working conditions, and in the care taken with respect to future generations in the setting of long-term objectives. Since there are no benchmarks, for any of these characteristics, that would indicate from which level firms could be declared sustainable, the focus is on comparing the firms between themselves."

Efficiency is viewed as a necessary (but not sufficient) step towards sustainability (Callens and Tyteca 1999, p. 43; and Perman, et al. 1996, p. 51). The relative improvement can not be fully applied to ecological sustainability. Due to the problem of non-substitutability, non-linearity, and irreversibility (of the economic, natural, and social capital) absolute thresholds have to be considered (Dyllick and Hockerts 2002, p. 21). The authors postulate that to become truly sustainable a corporation has to address two more 'cases', additional to the 'business case'. Dyllick's framework for corporate sustainability with the three cases and the six criteria is shown in Figure 14. The differentiation between business, natural, and societal case becomes necessary, because the three capitals are not completely interchangeable in reality. These circumstances are considered in the perspective of the natural case where eco-effectiveness and sufficiency are required. Dyllick and Hockerts (2002, p. 26) describe the perspective of the social case, where socio-effectiveness and ecological equity are required. These two perspectives of natural and societal case are less known and less applied in the management practices, than the business case perspective.

Figure 14: Overview of six criteria of corporate sustainability



Source: Dyllick 2002

Dyllick and Hockerts (2002) follows that “firms aiming for corporate sustainability have to satisfy all six criteria outlined ...”. They argue that all businesses are guided by a set of political-ethical values that are part of the firm’s culture. “These (values) can require managers to act responsible without making an explicit calculation of the economic costs and benefits.” (Dyllick and Hockerts 2002, p. 28).

2.1.4 Conclusions of sustainability understandings for question focus

Sustainability is a widely used and applied concept with hundreds of different forms and interpretations. The definition and implementation of sustainability concepts is a major challenge. A common concept and understanding of what defines sustainability has to be found. Based on these findings, a way towards sustainability can be determined. Transparency is a necessary requirement to measure and evaluate sustainable management. What the presumptions, what the data base is, and how the data is evaluated all need to be determined. Against this background it also has to be defined to what system the sustainability evaluation refers.

2.1.4.1 Challenges of sustainability

Concerning to the system reference Bieker, et al. (2001) describe the transformation of the sustainability understanding from a political-ethical project towards a management project. This development is shown in Figure 15.

Figure 15: Various understanding of sustainability



¹ ISO: International Organization for Standardization;

² EFQM: European Foundation for Quality Management

³ GRI: Global Reporting Initiative

⁴ SIGMA: Sustainability: Integrated Guidelines for Management

Source: According to Bieker, et al. 2001

This development from a political-ethical project to a management project is not exclusive. It only shows a tendency of interpretation and on what level sustainability concepts are adopted and implemented. On one hand sustainability as a political-ethical project focuses on conceptual aspects and stands for a general attitude. On the other hand sustainability as a management project focuses on implementation aspects and concrete measures. Thus the ideas of sustainability as a political-ethical project may act as accelerators for standards and norms on the management level. This point of view leads to the next challenge of sustainability that can be understood either as a economical socio-political vision or as a firm's vision (described by Bieker, et al. 2001, p. 19). In the first case the definitions are rather vague. The aim is a general improvement of the quality of life and prevention of conflicts. This broad definition of aims results in various interpretations and concepts. Sustainability as firms' vision was already mentioned in chapter 2.1.3.1. The tendency of sustainability as part of firms vision (integrated approach) is also described by Ranganathan (1998, p. 8). He concludes that "Sustainability metrics, like any other metrics, will be most effective in driving change if they are integrated into business management systems. One way to ensure this happens is to make business and sustainability goals compatible." The two visions of sustainability as a sociopolitical or firms' vision are not exclusive, both of them are relevant for a sustainable development of a firm.

2.1.4.2 Sustainability concept applied in the research

Sustainability concerning shrimp farming was discussed in various studies and publications. In a comprehensive study of World Bank (1998) the feasibility of whether shrimp can be farmed sustainably or not was examined. It was argued that the question of sustainability can not be answered in absolute terms, because sustainability itself involves a wide range of different – and in some cases contradictory – elements, which are given greater or lesser weight according to cultural values and stage of development in any given country. This relates to a participative approach where the norms and values have to be defined by involved people (see Figure 10).

World Bank argues further that the question of sustainable shrimp farming may be answered in relative terms. "There is no technical reason why raising shrimp should not be as sustainable, or in some cases more sustainable than agriculture, fisheries, or other kinds of development. (...) It is impossible to say which of these (refers to the production system such as stocking density) is more sustainable without reference to local circumstances and the relative scarcity of different resources (land, water, material inputs, and skilled labor). (...) Efficient resource utilization is sometimes used as a practical criterion or objective for sustainability" (World Bank 1998, p. 8).

To evaluate sustainability of shrimp farming the environment / context of the farm has to be taken into account. This is especially important concerning side evaluation of new shrimp projects. Folke and Kautsky (1992) define aquaculture as an economic sub-system of overall ecosystem and focus on the relationship between these systems. Clay argues that "in most cases one pond built almost anywhere could be sustainable". The cumulative effect of many ponds in the same ecosystem may result in environmental and production problems.

The sustainability focus of the present study is on the business level, focusing on a single shrimp farm in a case study. According to this fact the central idea of corporate sustainability is applied (see chapter 2.1.3). The perspective of 'business case' (see Figure 13) is the main focus in the research. Additional aspects of 'natural case' and 'societal case' will be included (according to Figure 14). The recommendations deduced from the enterprises' analysis will focus on a further development of the farm towards sustainable management.

2.2 Performance

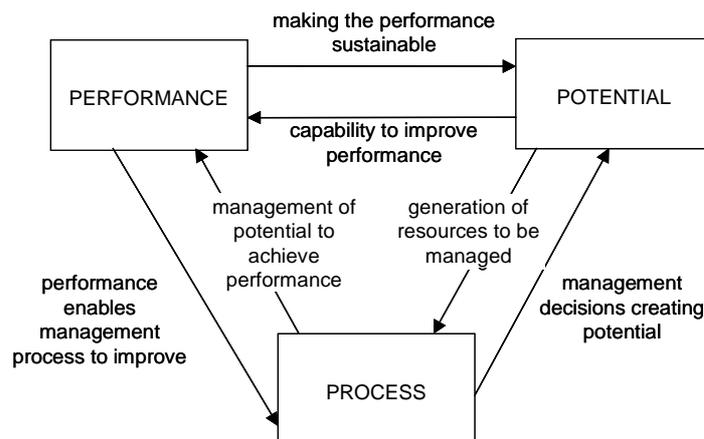
Similar to the sustainability term numerous definitions of performance exist in the literature. According to Lebas, cited in Hoffmann (1999, p. 7) “Performance is case specific and decision-maker specific”. Publications under the title ‘Performance Management’ and ‘Performance Measurement’ focus either on financial- and controlling aspects or include organizational-, quality-, and labor aspects. (Hoffmann 1999, p. 7). In a broad way performance is the „manner or quality of functioning” (Hoffmann 1999, p. 8). According to Brunner (1999, p. 11) performance management is a corporate management system which enables to transform and implement corporate strategies and aims in a permanent guiding system. Before determining performance measurement it needs to be defined what has to be measured. This is illustrated by Crowther, cited in Hoffmann (1999, p. 9) “appropriate measures cannot be selected until the purpose of evaluation has been determined. (...) the foundation of performance measurement is the identification of the reasons for the evaluation of performance.” Hoffmann illustrates five reasons why organizations and companies should measure their performance. The reasons are listed as five questions:

- Where has the organization been in the past? The reflection of the past allows to draw conclusions of the organizations’ development.
- What is the actual state of the organization? This measurement allows to draw conclusions on future potentials and activities which need to be improved.
- In which direction should the organization develop? This measurement should support to implement organizations’ objectives.
- How will the organization arrive there? Measurement can be the base for planning and budgeting.
- How will the organization make sure that it achieved its objectives? Measurement can help to give a feedback concerning the achievement of objectives.

As shown in the questions, performance measurements provide information for planning-, coordination-, and controlling tasks (Hoffmann 1999, p. 9). The increasing need for this kind of information is also due to stakeholders’ requirements. According to various authors, the performance is traditionally measured with financial measures and indicators. This issue will be discussed further in chapter 2.2.3.

2.2.1 Performance and competitiveness

Performance is often used in the context of measurement of competitiveness. Buckley, et al. (1998, p. 177) describe three categories of competitiveness measures. According to this categorization performance measures the outcome, potential measures the input and process measures the management of the operation (Buckley, et al. 1998, p. 178).

Figure 16: Interrelationship between measures of competitiveness

Source: Buckley, et al. 1998, p. 178

In the literature there exist numerous definitions of competitiveness. Based on these definitions, various methods for measurement of competitiveness were developed. Competitiveness is termed as a relative concept (Frohberg and Hartmann 1997, p. 5; Buckley, et al. 1998, p. 195). This means that competitiveness must be defined relative to a different point of time, to an existing comparator or to a defined counter-factual position. Analysis of competitiveness may differ with respect to the level of investigation. Generally used levels of analysis are national, industry, firm, or product level (Buckley, et al. 1998, p. 175). Buckley defines competitiveness of firms as “a firm is competitive if it can produce products and services of superior quality and lower costs than its domestic and international competitors. Competitiveness is synonymous with a firm’s long-run profit performance and its ability to compensate its employees and provide superior returns to its owners”.

According to Buckley, et al. (1998, p. 195) competitiveness includes efficiency²⁰ and effectiveness²¹. Efficiency and effectiveness are also required in the sustainability concept (see Figure 14, p. 29). This parallel will be explained further on in chapter 2.3.

According to the theoretical explication competitiveness can be understood as an umbrella term for performance. Performance is one part of competitiveness, traditionally used synonymous with financial performance. Financial performance is the most frequently used and widespread concept for performance measurement (Hoffmann 1999, p. 11-24).

2.2.2 Positioning of performance measurement within corporate management

The aspects illustrated in this chapter built a framework of what will be shown further in chapter 2.2.3 through chapter 2.2.5. It should help to integrate various measurement approaches in a general context of corporate management.

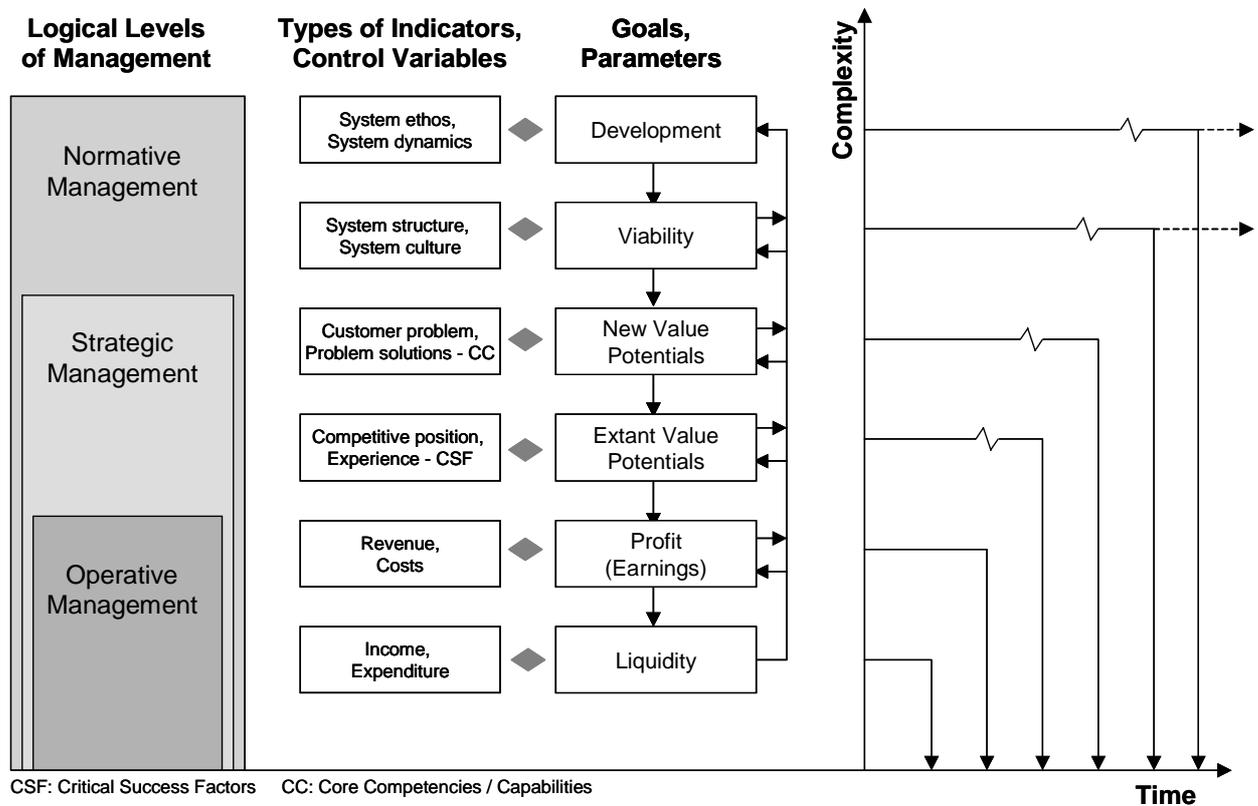
Based on the level of management, various indicators and parameters can be defined and according to this performance measurement will be chosen. The three logical levels of management are shown in Figure 17. On the operative level the performance is measured mainly by financial key figures. Schwaninger (1993), cited in Espejo and Schwaninger (1993, p. 49) argue that “traditional control models take their bearings largely or exclusively from the goal

²⁰ Efficiency deals with the question of optimal allocation of resources to achieve desired ends and reaching goals at the least possible cost.

²¹ Effectiveness deals with the question of having the right goals.

of ‘profit’.” They further argue that such models do not continue to meet the requirements of increasing complexity and turbulence of the environment. It is argued that a “system must govern itself with the help of control variables that may contradict each other because they belong to different logical levels: the levels of operational, strategic, and normative management” (Espejo, et al. 1996, p. 229). The authors state that the variables regulated at one level are the pre-control parameters for the next level below. This means for example that revenue and costs are control variables for profit, but not driving variables for profit. But profit has a pre-control function in relation to liquidity/solvency (Espejo, et al. 1996, p. 230). On the operational level bookkeeping provides the essential variables (control variables) for measurement of cash and profit results. But the attainment of operative goals requires preconditions that have to be created in advance (Espejo, et al. 1996, p. 230).

Figure 17: Three levels of corporate management



Source: Espejo and Schwaninger 1993, p. 50

On the strategic level methodologies of strategic management have been developed for example by Gälweiler (1990) and Porter (1999). Espejo and Schwaninger (1993, p. 51) postulate that value potential on a strategic level must be controlled separately from profit and solvency, on the basis of independent criteria. The authors argue that for instance “profit is not a strategic control variable, and consequently not a strategic aim either. Rather, its appearance or absence is a consequence of good or bad strategies” (Espejo and Schwaninger 1993, p. 52). The research which has led to variables of normative management are based on system theory and cybernetics (Espejo, et al. 1996, p. 235). These variables are used for the assessment of viability and the development of organizations. The normative management includes ‘Legitimacy’ which deals with the question of fulfilling the overall task, as defined by the larger whole (Espejo, et al. 1996, p. 239). This level becomes important in the context of sustainability which considers a long-term development. Arguments for sustainability are in general based on an ethical principle (see chapter 2.1.1, p. 14). Sustainability is directly linked with

the goals of development and the viability of a company. This context will be illustrated in chapter 2.3, p. 43.

2.2.3 Financial performance

Approaches to measure financial performance are discussed by Hostettler (1997, p. 231-250). He argues that these measures are required either to measure the achievement of objectives or to compare companies. Hostettler (1997, p. 33 ff) proposes the following table as a framework for financial measures.

Table 5: Framework for the financial performance measurement

	Ex-post (past-oriented)		Ex-ante (future-oriented)	
	Without public traded shares	With public traded shares	Without public traded shares	With public traded shares
Database: Economic Model	EVA Added Value CVA (CFROI) Economic Profit	MVA	EVA CVA Economic Profit DCF-Method	
Database: Accounting Model	ROI, ROS, ROE Earnings per share Margin key data Gross margin Business margin Net margin Growth key data Turnover per share Net profit per share	Market value Yield on shares Share price performance	Method considering earning-capacity value and net asset value Excess profit capitalization, e.g. UEC-method Sales- or Profit-multiples	P/E, P/B, P/CF-Ratio Dividend yield Direct company's comparison Technical analysis

Source: According to Hostettler (1997, p. 34)

whereas:

EVA	Economic Value Added	MVA	Market Value Added
CVA	Cash Value Added	DCF	Discounted Free Cash Flow method
CFROI	Cash Flow Return on Investment	P/E	Price-Earnings-Ratio
ROI	Return on Investment	P/B	Price-to-Book-Ratio
ROS	Return on Sales	P/CF	Price-Cash Flow-Ratio
ROE	Return on Equity	UEC	Method to evaluate the total value of a company ²²

Table 5 divides past-oriented (ex-post) and future-oriented (ex-ante) perspectives of performance measurement. Measures exist that are both past-oriented and future oriented. Economic Value Added is one of these measures that is “useful looking forward and looking backward” (Stern 1994 cited in Hostettler 1997, p. 34). The rows in Table 5 are divided into an economic and an accounting model. This division reflects the perspective of the owner (economic model) and of the creditor (accounting model). The creditor (based on accounting model) prefers to focus on balance-, and income statement of the company. He is generally more conservative in the evaluation about the performance of a company than the owner. The owner (based on the economic model) is interested in a shareholder-oriented measurement that reflects the potential and future prospects of the company. There exists an increasing interest and importance of the value based perspective (Hostettler 1997, p. 35-36). Accounting and economic performance measures will be further illustrated in the following chapters.

²² The method was developed by the Union Européen des Experts Comptable Economiques et Financiers (UEC).

2.2.3.1 Accounting measures

Measures such as turnover, profit, and ROI are widespread in companies as accounting measures. They are used as planning- and controlling-tools, can be aggregated, and are comparable. Many years of experience with these measures resulted in the development of a specific “accounting language” (Hoffmann 1999, p. 13). According to Seiler (1999) the ‘Du Pont-scheme’ is an accounting measure that is widely used in the practice. The scheme has been developed for the performance measurement of various divisions. It includes the key figures return on invested capital (ROIC) that is calculated as a product of return on sales (ROS) and capital turn over (CTO) (Seiler 1999, p. 37). Industry-specific measures exist for the key figures ROS and CTO. Copeland, et al. (1995, p. 74) argue that the main weakness of accounting approaches is to not consider the investment required to generate earnings nor its timing. The accounting approach generally only focus on this year’s or next year’s earnings. The negligence of investment- and financing risks and the negligence of the timeframe is also illustrated by (Hoffmann 1999, p. 14; and Brunner 1999, p. 12).

2.2.3.2 Economic measures

Economic measures focus on the shareholder value of a company and include the earning power. The most widespread method to value a company is the cash flow figure. Various methods of cash flows and cash flow calculations exist. The most common known measure is the discounted free cash flow method (DCF) that is based on the Free Cash Flow (FCF). The FCF is the increase of funds resulting from business activities reduced by funds that have been invested. The calculation of FCF is independent of how the investment has been financed (Seiler 1999, p. 493). The DCF considers the cash value of the net cash flow over time. In the DCF-method the performance is measured as the sum of discounted cash values of all net cash flows in the planning horizon and for further years a perpetuity (Seiler 1999, p. 494). The DCF is shown in Equation 3.

Equation 3: Discounted Free Cashflow (earning rate of total capital)

$$DCF = \sum_{t=1}^h FCF_t * \left(\frac{1}{1+i}\right)^t + \frac{FCF_h}{i} * \left(\frac{1}{1+i}\right)^h$$

Source: Seiler 1999, p. 494

whereas:

FCF_t	free cash flow of the period t (before interests)
h	planning horizon (number of years)
i	discount rate
$\frac{FCF_h}{i}$	value of perpetuity at the time h ²³

In contrast to the accounting measures the DCF-method values a business considering expected cash flow discounted at a rate that reflects the riskiness of cash flow²⁴ (Copeland, et al. 2000, p. 63). Hostettler (1997, p. 47) gives an overview of used alternatives to the DCF-method. These other approaches for value measuring are all based on a so called ‘super profit’. The most common are Economic Added Value (EVA), economic profit, added value and cash value added (CVA)²⁵.

²³ It is assumed that at the time h will still be generated free cash flow.

²⁴ For single projects (e.g. equipment investment) the discount rate reflects the risk. To evaluate the value of a company the discount rate reflects the risk and the pattern of finance of the company.

²⁵ The advocates of these approaches are: Stern Stewart & Co. for EVA; McKinsey & Company, Inc. for economic profit; London Business School for added value; and The Boston Consulting Group for the Cash Value Added.

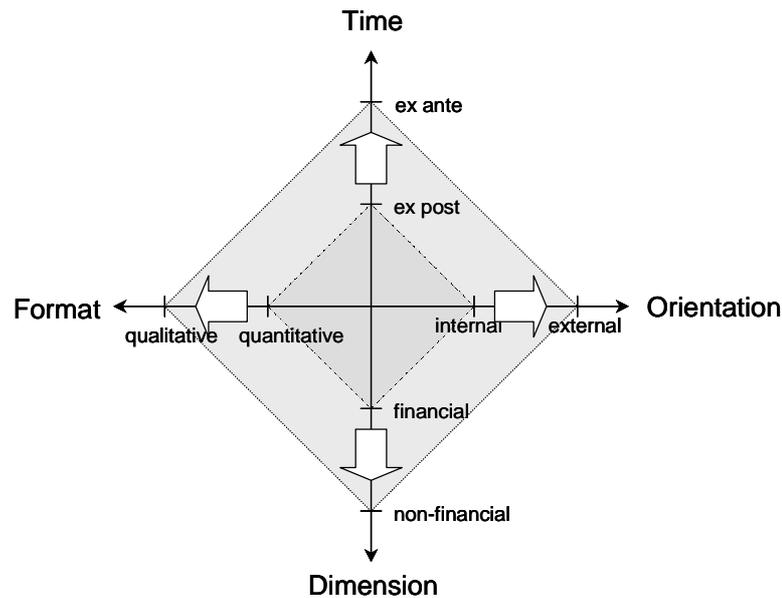
2.2.3.3 Performance measurement within the company (divisions, departments)

Analysis and measurement of profit, turnover and costs are central issues in the context of measuring performance on the operational level within a company (Hoffmann 1999, p. 15). On lower aggregation levels (sectors or divisions) these financial measures are adequate and efficient for the performance measurement e.g. of a production process. Keegean et al. 1989, cited in Hoffmann (1999, p. 15) state that “cost is a most important basis for performance measurement.” Additional to the knowledge about internal cost rates, the process costing also provides information about quality of the process and can facilitate internal communication (Hoffmann 1999, p. 16). The information based on process costing is a control variable for profit, whereas profit is pre-controlled by strategic decisions (see Figure 17, p. 33). Various authors (cited in Hoffmann 1999) warn that process costing does not provide all necessary information for performance measurement and distortion of information may take place. Brunner (1999, p. 12) argues that measures on operational level such as production costs, but also non-financial figures such as quality, and throughput time are generally output-oriented and are not sufficient for the management of the company, because the figures do not provide information about upstream and downstream process.

2.2.4 More-dimensional performance

Historically, performance measurement included measuring tangible things such as return on investment (ROI), cash flow, and cost of sales. “Attention and focus have shifted toward measuring intangibles such as quality, customer satisfaction, and safety. In the light of this transition, companies began investigating ways of incorporating both financial and non-financial performance in an effort to achieve optimal organizational well-being” (American Productivity & Quality Center 1999, p. 6). According to Figure 17, page 33 these extended value potentials pre-control goals on operative management level such as profit. The necessity of the transition to more-dimensional performance is shared by various authors. Hoffmann (1999, p. 17) argues that cost management and measurement of financial performance of a company is not sufficient to give an indication of the performance of various services and tasks in the company and about the creation of long-term value. This context is also illustrated in the Figure 17, p. 33 whereas financial performance, such as costs is pre-controlled by other types of indicators. Copeland, et al. (1995, p. 101) also argue that “companies must have two sets of goals: financial goals, which guide senior management, and inspirational non-financial goals, which motivate the performance of the entire organization.” Copeland, et al. (2000, p. 71) state that financial indicators like revenue growth and ROIC drive DCF values and can be used to set targets and track performance. Financial indicators, however, must be supplemented with strategic and operating value drivers that provide insights about where a company’s performance is heading.

In this context Müller-Stewens and Lechner (2001) write about the ‘enhancement to the system focus’. The authors argue that companies traditionally focused on ‘internal optimization’ to improve the cost-, and quality process. This step was normally reached with efficiency improvement. Müller-Stewens and Lechner discuss that for further development strategic management becomes more important, to answer questions considering the future position of the company, and how further improvements be generated. The shift from internal efficiency improvement steps to strategic development requires a change in the way of performance measurement, such as illustrated in Figure 18

Figure 18: Development in performance measurement

Source: Müller-Stewens 1992, p. 524

As mentioned above financial measures are central indicators for the performance of a company. Müller-Stewens and Lechner (2001) state that financial measures can be distorted, that they might not be reliable enough for corporate performance measurement, basically the performance at an early stage. In addition to creditors and investors there are more stakeholders with different demands on the company. To include these demands it is necessary to include additionally non-financial dimensions. Another important requirement of the performance measurement is that it provides information at an early stage. It is important to have early indications for the success of initiated changes. The inclusion of external stakeholders reflects the contact and the interaction that a company has with its environment. Müller-Stewens and Lechner (2001) argue further that some issues are pre-controlled by qualitative figures and can be 'weak signals' of what will finally result in quantitative figures. For example, the employees' unhappiness may result in less motivation and corporate identity and finally in declining results in the production process. This context is shown in Figure 17 where qualitative factors pre-control a quantitative factor such as profit (Espejo and Schwaninger 1993, p. 51).

Fopp and Rüttimann (1994) describe the development of the management requirements concerning various stakeholders. The authors apply these perceptions and develop an integrated accounting system. They describe the principle trends as:

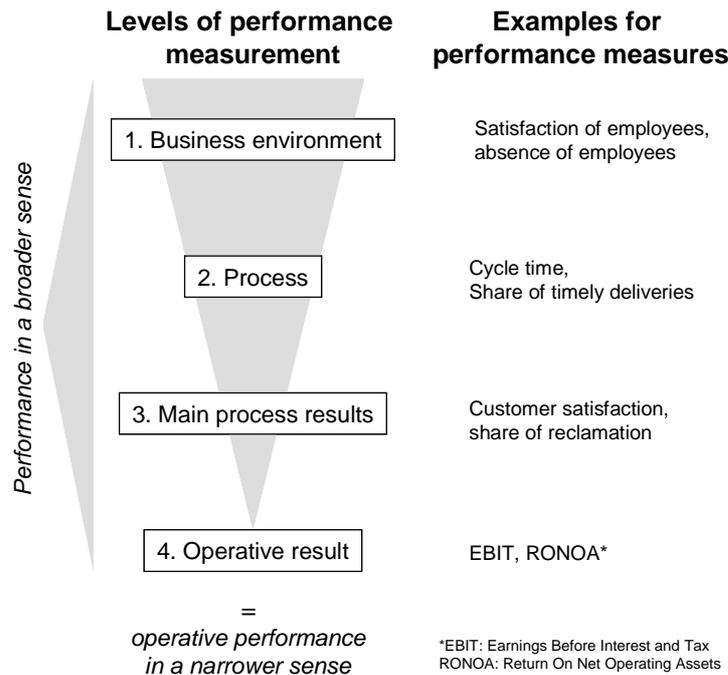
1. focus of the accounting system is not unilateral on the profit but needs a multilateral focus on further aims and
2. the management is not only cost oriented but an integrated management-responsibility focusing on total utility.

2.2.4.1 Levels of performance measurement

The focus on a more-dimensional performance measurement is described by Hoffmann (1999, p. 17-28). He argues that performance measures have to be more future-oriented and have to be adopted to a dynamic, turbulent, and shifting business environment. Increasing competitiveness intensity results in a higher complexity and increasing requirements for the management. Various tendencies in corporate management show the adaptation activities to the more complex and shifting business environment. The tendencies are increasing customer orienta-

tion in terms of a TQM-philosophy²⁶, increasing significance of lean production and process orientation, time as a competitiveness factor, concentration on core competencies and increasing importance of knowledge as a competitiveness factor (Hoffmann 1999, p. 18). There exists no adequate single figure to measure performance that efficiently incorporates all conditions. Various figures/indicators (financial and non-financial ones) can be applied in a more-dimensional performance measurement. Lebas 1994 cited in Hoffmann (1999) illustrates a causal model of the performance term. Based on this causal model Hoffmann (1999, p. 28) shows levels of the performance measurement as illustrated in Figure 19.

Figure 19: Levels of performance measurement



Source: Hoffmann (1999, p. 28)

Understanding the process of performance generation (illustrated in the levels) not only facilitates the identification of measures and therefore of corrective actions, it allows a “clear deployment of strategy at all levels of responsibility” (Lebas 1995, cited in Hoffmann 1999, p. 28).

2.2.4.2 Performance measurement and performance management

According to Hoffmann (1999, p. 29) performance management is more broadly defined than performance measurement. It includes techniques and instruments for the manager to plan, steer and improve the performance based on corporate objectives. Spangenberg 1994 cited in Hoffmann (1999) defines four elements of the performance management:

- Performance planning (define priorities)
- Managing performance (activities and guidance towards improvement)
- Performance measurement (considering efficiency and effectiveness, measurement of input, resource demand, and output)
- Rewarding performance²⁷

²⁶ TQM stands for Total Quality Management.

²⁷ “What is measured becomes visible, what is rewarded gets done.” (Brunner 1999, p. 12).

According to this list performance measurement is part of performance management. There exist interactions between management and measurement. Actions in the performance management can be chosen based on results of the performance measurement. Furthermore the performance management can define the measures for the performance measurement. Brunner (1999, P. 11) states that measurement and monitoring of key management factors are part of the performance management.

2.2.5 Approaches for performance management

The following description of the performance management approaches is based on Hoffmann (1999). Ashton 1997, cited in Hoffmann (1999, p. 37) identifies five requirements for a successful implementation of performance management approaches in companies. These requirements are: more-dimensional definition of performance, focusing on critical dimensions, integrated in the companies development, flexible and corporate specific. The three approaches that will be presented widely comply with the requirements defined by Ashton. All of the approaches with different historical basis have been adopted in the practice. The '**Tableau de Board approach**' was developed from engineers in production plants to improve the production process, and has French roots. The '**Balanced Scorecard approach**' is the result of a research project with a number of American companies to measure performance. The '**Intellectual capital approach**' resulted from a working group which dealt with the performance measurement of companies, whereas know-how is a central issue, and was first applied in Sweden.

2.2.5.1 Tableau de Board

A central idea of the tableau de board approach is that it supports decentralized decisions (Hoffmann 1999, p. 46). It supposes that managers focus on these figures within their scope that are critical for the success factors. The tableau de board approach is based on an operative model of the company whereas the company is described through critical success factors that are manageable but also external factors that can influence the business activities (Hoffmann 1999, p. 39-48). The use of tableau de board stimulates anticipative actions of the decision-maker. There is no universal presentation for a tableau. It is presented according to the goals and field of responsibility of the decision maker. It can also be divided in a short- and long-term tableau.

As there is no universal convention for the structure and the presentation of a tableau Hoffmann (1999, p. 42) describes three different groups of origin wherefrom the indicators in the tableau can be deduced. These groups are:

- Operative plans – Budgeting – operative measures
- Impacts from the environment – measures (e.g. market development, information about competitors)
- Strategy Implementation – aims, action plans and responsibilities – measures

According to Hoffmann 1999 the tableau is primarily used as a 'self assessment' for the management of a defined scope / field of responsibility. The presentation of the development of critical success factors should be used for forecasting rather than for evaluating the past performance of management. Generally the information is illustrated graphically in the tableau and is limited to a few important figures. Various authors cited in Hoffmann (1999, p. 46) argue that the selection procedure of the figures shown in the tableau is as least as important as the results and the information presented.

The absence of guidelines and recommendations for the presentation of a tableau also has negative aspects. The tableau can increase to a very complex and broad range sheet which results in high administration and actualization costs and non-transparency for useful interpretations. If used as a control instrument rather than a communication instrument it is possible that various information in the control reporting are kept secret. This disadvantages are typical for a decentralized performance management system which focus on non-financial figures (Hoffmann 1999, p. 48).

2.2.5.2 Scorecard approaches

According to Müller-Stewens and Lechner (2001, p. 526-531) there can be differentiated four types of scorecard approaches:

- The “trotter” of General Electrics
- The Balanced Scorecard
- The Scandia Navigator
- The EFQM-Model²⁸

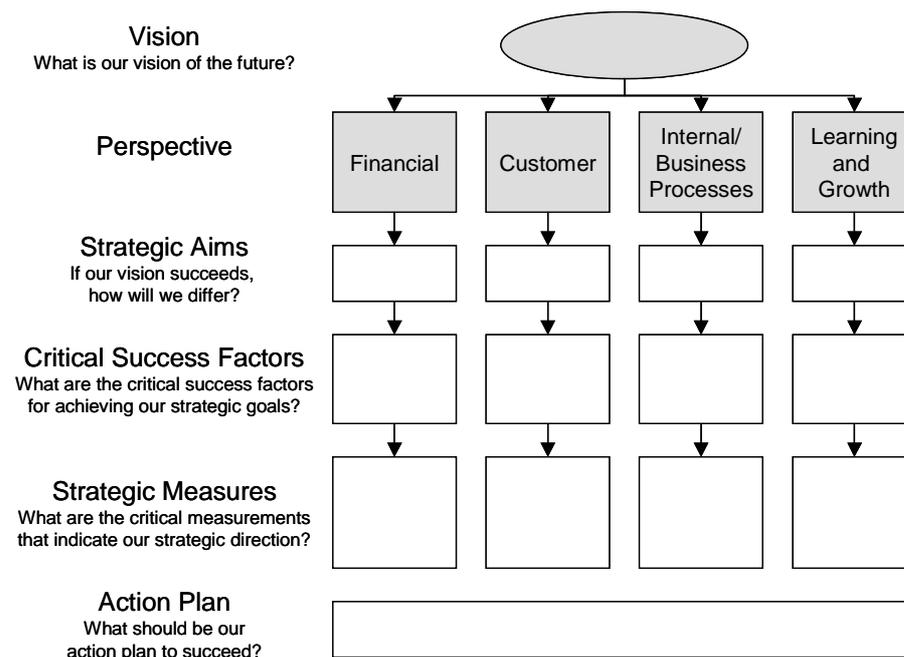
The central idea of all scorecard approaches is the evaluation of business activities based on a set of indicators integrating various perspectives. The most commonly known and most widespread approach utilized is the balanced scorecard.

The balanced scorecard was developed in the early 1990s by Norton and Kaplan based on a research project for performance measurement with a number of companies (Hoffmann 1999, p. 49). ‘Balanced’ is related to various aspects included in the approach. The approach is balanced in relation to short-term and long-term objectives, to internal and external orientation and in relation to outcome key data and output drivers (performance drivers). ‘Scorecard’ stands for the key figures (measures) within one figure sheet (Werner 2000, p. 455). Starting from an explicit vision and strategy of a company, objectives and measures are derived for the performance measurement (Müller-Stevens 1992, p. 527). The balanced scorecard combines four perspectives which are listed in the following questions (Kaplan and Norton 1997, p. 9; Olve, et al. 1997, p. 17):

- **Finance:** To succeed financially, how should we look to our shareholders?
- **Customers:** To succeed with our vision, how should we look to our customers?
- **Internal business process:** To satisfy our shareholders and customers, at what internal business processes must we excel?
- **Learning and growth:** To succeed with our vision, how shall we sustain our capacity to learn and to grow?

For each perspective strategic aims, measures, specific goals and action plans are formulated. The process of building a balanced scorecard is described by Kaplan and Norton (1997, p. 10). The process, described as a cycle, includes four steps: 1) clarifying and translation of the vision and strategy, 2) communication and linking, 3) planning and target setting, and 4) strategic feedback and learning. The follow-up results in learning lead to a re-examination of the vision. At every step, the scorecard serves as the means of communication (Olve, et al. 1997, p. 17). Bieker, et al. (2001) argue that the balanced scorecard works as a plan-, do-, check-, act-cycle. The development of a balanced scorecard includes the steps shown in Figure 20.

²⁸ European Foundation for Quality Management, see also chapter 2.1.3, p. 23.

Figure 20: Comprehensive view of the process to build a balanced scorecard

Source: Olve, et al. (1997, p. 42)

The vision is the company's desired future situation. Its purpose is to guide, control, and challenge an entire organization. The vision is decomposable in perspectives. The choice of perspective may differ from the commonly used perspectives shown in Figure 20. Certain companies added a separate perspective, called 'employee' or 'human perspective' (Olve, et al. 1997, p. 42). The strategic aims serve to guide the company in achieving the vision. The critical success factors describe factors that are most critical for the company's success. Furthermore measures and goals which have been developed to enable management to follow the company's systematic efforts are described. According to Kaplan and Norton every measure selected for a balanced scorecard should be an element in a chain of cause-and-effect relationship that communicates the meaning of the business unit's strategy to the organization. Measures describe either what is achieved (outcomes) or what affects outcomes (performance drivers). Bieker, et al. (2001, p. 29) defines the measure describing outcomes as the 'lagging indicator' and the performance driver as the 'leading indicator'. The choice of measures within the perspectives generally depend on the development stage of the company (Kaplan and Norton 1996, cited in Hoffmann 1999, p. 50). The action plan finally describes specific actions and steps which will be required in the future (Olve, et al. 1997, p. 42-43). The transformation of vision and strategies in measures and activities (Müller-Stewens and Lechner 2001, p. 528) illustrates the definition of causal relationships. These causalities are also described in Figure 17 (p. 33) in relation to the pre-control parameters. Horváth and Kaufmann (1998, p. 44) illustrate the link between the balanced scorecard and competitiveness. They argue that the balanced scorecard includes only factors which are crucial competitive drivers.

Hoffmann (1999, p. 60-63) evaluates the balanced scorecard as the following: It is an approach to combine internal and external, ex-post and ex-ante, and short- and long-term indicators. The utility of the balanced scorecard is its suitability as a communication instrument during implementation and deployment of corporate strategies. The fundamental negative aspect of the balanced scorecard is missing the integration of further stakeholder groups. The implementation procedure of a balanced scorecard can be difficult because it is defined by Kaplan and Norton as a top-down approach. This can be shown in practice in the field where scorecard projects are developed on the executive level but not transformed on to lower hierarchi-

cal levels. The main challenge on this hierarchy is the deduction of objectives, resources, responsibilities, and measures. Based on these difficulties, participation and involvement of employees which implement the scorecard is a key issue for a successful balanced scorecard (Hoffmann 1999, p. 63).

2.2.5.3 Intellectual Capital Approach

The Central idea of the intellectual capital approach is the explication of valuation of assets that are not listed in the balance-sheet, so called 'intangible assets'. Instruments have been developed to measure intangible assets. These instruments are based on a classification of various capitals. Based on this approach the market value of a company is composed of 'shareholder's equity' and 'intangible assets' or in other classification methods 'intellectual capital' (Hoffmann 1999, p. 67). Independent of the classification method the goal of the intellectual capital approach is to deliver additional measures which explain the market value.

This approach is mainly used for internal reporting and is not widely applied for external reporting. An exception is the Scandia Navigator (Hoffmann 1999, p. 71-74). The scandia navigator distinguishes six areas that are evaluated (financial focus, customer focus, human focus, process focus, renewable & development focus, and operative environment). On the time frame the navigator is divided in 'history', 'today', and 'tomorrow'. The financial focus represents the history of the company. The customer-, human-, and process-focus represents the present, and renewable and development focus and the operating environment stands for the future. The structure of the navigator is similar to the balanced scorecard (Hoffmann 1999, p. 71). This is the reason why other authors classify the scandia navigator as a scorecard approach (see Olve, et al. 1997, p. 26-32; Müller-Stewens and Lechner 2001, p. 530-531; and chapter 2.2.5.2).

The measures of intellectual capital approach are used as a base for planning and budgeting but also for calculation of additional incentive wages. However additional to the measurement of intellectual capital, its management is important. Hoffmann (1999, p. 75) illustrates the interaction between various capitals and defines the goal for the management of intellectual capital as: "to improve the company's value generating capabilities through identifying, capturing, leveraging and recycling intellectual capital". The focus on interactions between the capitals is the main difference between the intellectual capital approach (scandia navigator) and the scorecard approach (Hoffmann 1999, p. 77). Within these interactions the human factor "interpenetrates the others, serving as the active agent operation on all the others" (Edvinsson/Malone 1998, cited in Hoffmann 1999). The central role of the human factor is explained with the human being as the most important knowledge carrier of a company.

2.2.6 Conclusions about performance management

2.2.6.1 Comparing performance management approaches

Comparing the three approaches (tableau de board, balanced scorecard, and intellectual capital approach) Hoffmann (1999, p. 85) concludes the following: The tableau approach has individual possibilities for presentation, is strong in graphical presentation, includes corporate objectives with defined responsibilities and emphasizes on the decision-making process. The balanced scorecard approach has a limited number of measures, is linked with strategic aims and is top-down oriented in the implementation. The intellectual capital approach has its measures classified in dimensions, is based on stakeholder groups and focuses on the importance of employees in the performance management process.

2.2.6.2 Development of performance management and stakeholders requirements

Fopp and Rüttimann (1994) illustrate that the development of performance measurement and performance management comes along with the development of changing requirements and challenges for the management. The role of a company in the context of its stakeholders has basically changed. Traditional stakeholders for a company have been the owner, executive directors, and the investors. In the 20th century there was an increasing number of additional stakeholders with claims for securing the profitability in the long run, securing the existence of natural living space in the long run, and securing individual needs. The claims of these stakeholders resulted in increasing the responsibility of management. According to Fopp and Rüttimann (1994, p. 44-45) the stakeholders of the 21st century can be classified, as described above in stakeholders relating to profit, nature, and individual. The challenge for the managers is to define the position and requirements of the stakeholders in relation to their interests and to define a strategy concerning every group of these stakeholders. The management is forced continuously to look for new solutions to appropriately consider the stakeholders requirements.

2.2.6.3 Performance concept applied in the research

The question focus in the present study is on a single case study and the performance measurement is of a single farm, and a corporate performance concept will be applied to it. Restrictions and constraints are defined in the research question by ‘on the way towards sustainable management’²⁹. This can be understood as requirements for the management. It has to be concerned about sustainability issues even though they are not explicitly demanded by stakeholder groups.

2.3 Conclusions of sustainability and performance approaches

To summarize the theoretical and methodological background the following research question will be answered:

What is an adequate concept to evaluate the performance of a shrimp farm on the way towards sustainable management?

The research question asks for a focus on the firm-level which indicates that the focus will be on corporate sustainability and corporate performance. The conclusions are divided in two parts. In the first part the concept which is a combination of sustainability and performance aspects will be presented. The second part shows important aspects for the management in relation to monitoring.

2.3.1 Integration of sustainability in performance management

Based on the explications in chapter 2.1 and 2.2 can be shown overlapping trends in sustainability and performance management. The trend to a more-dimensional approach in the performance management and to a stakeholder based participative approach in the evaluation of sustainability requirements is an important parallel. Another parallel of performance and sustainability concepts is the application of minimum standards. In the performance management accounting measures are widely accepted as the minimum standards. In the formal analysis of sustainability safe minimum standards are defined to classify a development as either weakly

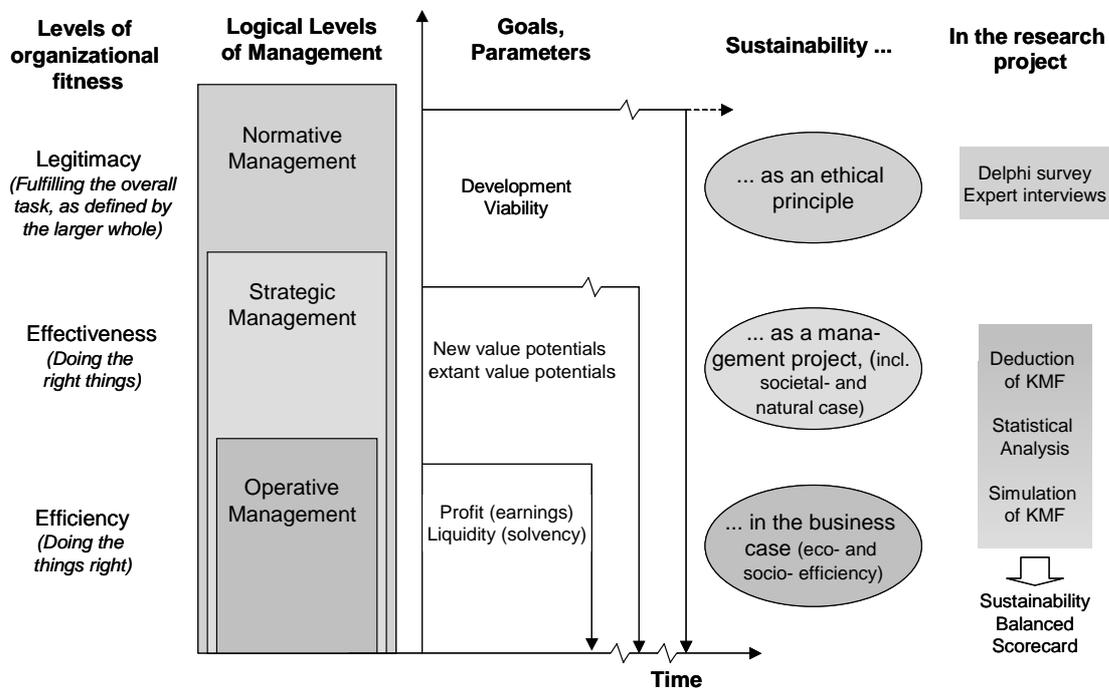
²⁹ ‘corporate sustainability performance of shrimp farming’ is used synonymous to ‘performance of shrimp farming on the way towards sustainable management’.

or strongly sustainable (see chapter 2.1.2.2, p. 19). The accounting measures are financial figures and the safe minimum standards are estimations or empirically determined levels of e.g. basic human needs.

An other point is the parallel of the terms used. According to the explications related to competitiveness (chapter 2.2.1, p. 31) and according to the corporate management shown in Figure 17 (p. 33) efficiency is also part of operational management, and effectiveness part of the strategic management. In the sustainability theories these two terms (efficiency and effectiveness) are important criteria of corporate sustainability (see Figure 14, p. 29). Effectiveness in the societal and natural case of Dyllick (2002) may be classified as strategic parameters. Dyllick, et al. (1997, p. 76) combines competitiveness and sustainability on a firm level by including ecological awareness in the strategic management, defining ecological competitiveness strategies. This kind of sustainability management and strategy is also explained by Schmid (1999). Dyllick and Hockerts (2002, p. 30) state the hypothesis that “a separation of the three areas makes sense at the operational level (i.e. keeping operative economic, environmental and social responsibilities distinct), while strategic decision will hardly be possible without simultaneously considering the three dimensions.” Improving efficiency is the main task of operational management. In relation to the business case of corporate sustainability improvement of eco-, and socio-efficiency are the main goals (Dyllick and Hockerts 2002). Schmidheiny is an advocate of efficiency strategies. Schmidheiny (1999, p. 145-146) demands for the definition of measurable goals for eco-efficiency. In this context he focuses on the shortage of natural resources and how companies are able to deal with this constraint.

The combination of sustainability aspects on different management levels are shown in Figure 21. The figure shows the underlying concept of the research project in question.

Figure 21: Levels of management and integration of sustainability concepts



Source: Adapted from Espejo, et al. 1996, p. 239

This concept will be filled with content and applied to the question focus in the following chapters. Normative management will be used as a participative approach such as a Delphi survey and expert interviews. Participative approaches are good instruments for controversial topics such as shrimp farming. The approach guarantees that cultural values and the stage of

development can be considered. The inclusion of stakeholders opinions helps to build the set of requirements for sustainable shrimp farming applied in the single case. The requirements will be outlined as a network through the method of qualitative system dynamics. Based on the network, Key Management Factors (KMF) will be defined on the strategic and the operational level. The KMF will be analyzed with statistical and simulation methods (explanative step, see Figure 5, p. 8). Additionally the performance of the financial figures will be measured with figures of the production process, resource demands and the socio-economic environment.

The connection of effectiveness and efficiency according to farm level is also stated in Shang and Tisdell (1997). The authors argue that the major decisions for sustainable aquaculture development on the farm level are: “what to produce and how to produce it” (Shang and Tisdell 1997, p. 132). What to produce is a decision of strategic management and how to produce it includes efficiency aspects of the operative management.

Based on the results and the concept recommendations for the management of a shrimp farm have to be deduced. The implementation step of this part will be explained in the following chapter.

2.3.2 Applicability for the management

Applied research in social science concludes the results in recommendations and action measures (see Figure 5, p. 8). To be able to control the implementation of new measures the management of a shrimp farm needs a reporting and monitoring system.

2.3.2.1 Performance and sustainability reporting

The evaluation of sustainability performance is generally related with reporting systems. On a global level the Dow-Jones Global Sustainability Index is a reporting system which has become popular in the last few years. Hauth and Raupach (2001) describe that sustainability reporting is part of strategic planning and of performance management. The authors state that based on the ‘Benchmark Survey of UNEP³⁰’ the worldwide tendency for sustainability reporting is obvious (Hauth and Raupach 2001, p. 28). Sustainability reporting asks for an internal and external ‘consciousness of responsibility’ including the improvement of a company in the three traditional sustainability dimensions (ecology, economy and social), and focus on the interactions between these dimensions. The increasing focus on interactions is also shown in the performance management, mainly in the approaches described in chapter 2.2.5. Additional to the evaluation and internal control, the reporting is important for the enterprises reputation. Gilbert (2001, p. 48) states that integrity and reputation are crucial factors for the competitiveness, because stakeholders do not only use economical factors to characterize and evaluate a company but more and more they evaluate whether the company is responsible according to its social and ethical task. This kind of management is called ‘value-oriented management’.

2.3.2.2 Sustainable Balanced Scorecard

For the implementation and the monitoring a balanced scorecard will be developed, including sustainable measures and requirements. Bieker, et al. (2001) developed concepts of a sustainability balanced scorecard for the business case. The balanced scorecard measurement allows a sustainability perspective to be included in addition to the traditional four perspectives of the scorecard. Bieker, et al. (2001, p. 30) concludes that the balanced scorecard has a good

³⁰ United Nations Environment Programme.

potential for an efficient transformation of sustainability issues in a company. Mainly the simultaneous consideration of financial and non-financial key figures and the possibility of a balanced scorecard for the deployment of strategic objectives into operative measures are important aspects for the implementation of sustainability issues. Bieker, et al. (2001) argue that the main challenge to implement strategic issues will be the strategic planning. The balanced scorecard supports strategic implementation, but if a management considers sustainability objectives unimportant, and does not include it in its strategy, the balanced scorecard or 'sustainability balanced scorecard' will change nothing (Bieker, et al. 2001, p. 30).

B PROBLEM STATEMENT

Valuation ultimately refers to the contribution of an item to meeting a specific goal.

Robert Costanza, Carl Folke

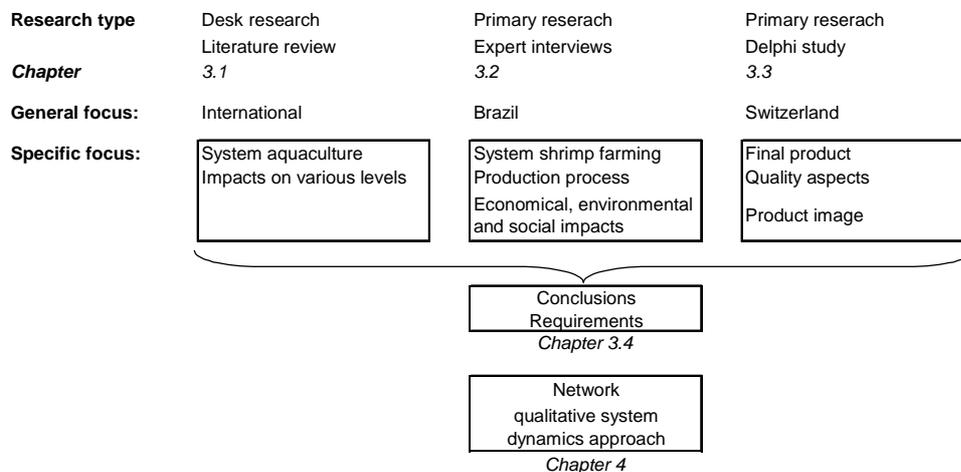
Compared to traditional agricultural activities shrimp farming is a new activity. The importance of shrimp as a traded good was illustrated in chapter 1. The majority of shrimp aquaculture occurs in tropical areas, often situated in developing countries (Thailand, China, and Ecuador) and the consumption is primarily by developed nations (United States, Europe, and Japan). Based on this connection - the international trade activities of this commodity good and the increasing awareness of the consumers and activist – results in requirements of various stakeholders and groups. The requirements may consider the final product, the circumstances of the production, and/or various factors along the process from production to consumption. The requirements can be summarized from literature and public discussions about shrimp farming and from primary research involving stakeholders with their claims against shrimp farming.

Research question:

What are the requirements for sustainable shrimp farming based on selected stakeholders' opinions?

This research question will be elaborated in part B. It is divided into two main chapters. Chapter 3 is the analysis of the impacts and the requirements of shrimp farming. This analysis is done by desk research (3.1) and primary research (3.2 and 3.3). The second chapter 4 focus on experts representing stakeholder groups in Brazil. An interactive process with experts results in a network according to the methodology of the qualitative system dynamics approach. Concluding the results of desk- and primary research a single set of requirements for a sustainable managed shrimp farm was developed. The definition of the requirements is essential for the strategic planning for a farm and its development to move forward.

Figure 22: Content of Part 0



3 Analysis of Impacts and Requirements

In the first part of chapter 3 the impacts and requirements described in the literature will be summarized. Chapters 3.2 and 3.3 are empirical analysis. The first part of this primary research includes expert interviews from the Brazilian shrimp farming system, each expert representing a Brazilian interest group. These experts defined main impacts and requirements. The second part (3.3) is based on experts from production to consumption whose opinions are pooled in a Delphi study. According to Lombriser and Abplanalp (1998, p. 124) the two chosen approaches (expert interviews and Delphi study) are instruments for an early detection in strategic planning.

Before starting with the description of the impacts and the requirements some general comments will be made. These comments consider general reflection of how requirements may emerge (affected groups) and how they may vary over time.

Affected groups

An aspect generally becomes relevant if there are affected groups who have claims and requirements. These groups can be directly affected (for instance employees, neighbors, customers) or indirectly affected (for instance pressure groups, people dealing with environmental and social development, authorities).

Problem identification depends on the knowledge and the experiences

If there is no experience about impacts of an activity, it will not be identified as problematic. This can be shown in an example: “When the industry was beginning 20-30 years ago, shrimp farmers were advised to build on former mangrove areas. Today, it is known that this should never happen. This is the worst possible place to build. Ponds built on former mangroves have shorter life expectancies.” (Clay 2001). This illustrates that recommendations may change over time, based on technological development, experiences, and also shift in opinions about which impacts are acceptable and which are not.

3.1 Desk research of impacts and requirements

Based on the rapid expansion of the shrimp industry and the collapse of production facilities in certain areas the discussion of the impacts became widespread in the literature. The discussion may take place on two levels. The first level considers the “source of impacts”, if it concerns the whole industry / sector or one single shrimp farm. The second level is the distinction between three different kinds of impacts such as economic, environmental³¹, and social impacts³². Based on the impacts requirements can be elaborated about how shrimp farming should work and what a single shrimp farm can contribute.

3.1.1 Impacts from the sector or from a single farm

The distinction of impacts either from a whole industry (sector level) or from a single farm is crucial. Referring to environmental impacts and the carrying capacity³³ of an ecosystem it can

³¹ Distinction of environmental and ecological impacts see Boyd 1999, p. 10-11.

³² Some of the described impacts are impacts of aquaculture in general, but can widely be adopted to shrimp farming. The impacts may refer to different production systems in different areas. A differentiation of farming systems will occur in 3.1.1.2.

³³ Carrying capacity is defined as “The maximum population of a given species that a particular habitat can support indefinitely” (Cattan, 1982, p. 272, quoted in Birkin 2001, p. 50) or as “the maximum size to which the biomass can grow” (Perman, et al. 1996).

be stated that in most cases one pond built almost anywhere could be sustainable. The problem is the cumulative effect of many ponds in the same ecosystem (Chamberlain and Rosenthal 1995, p. 23; Clay 2001). According to this statement sustainability of a firm is understood as a contribution of this firm to sustainability objectives of the society (see 2.1.3.1, p. 23). The World Bank report states the urgency associated with resource degradation in coastal areas and the significant levels of social conflict associated with shrimp aquaculture in some countries. Therefore the World Bank argues that neither of these issues can be addressed effectively through project-level – except in the case of large isolated developments (World Bank 1998, p. 63). World Bank further argues that social and environmental problems associated with shrimp culture are generally cumulative and incremental in nature, and therefore require a broader resource use planning approach.

Concerning economic decision making in sustainable aquacultural development Shang and Tisdell (1997, p. 132-140) distinguish between micro (farm) level and macro (societal) level. The authors illustrate that the major decisions on farm level are what to produce and how to produce it. Whereas at the societal/community level, the major decision making about sustainable aquacultural development involves the objectives of rational development, species for culture, culture systems and techniques, and environmental policy measures (Shang and Tisdell 1997, p. 135).

3.1.1.1 Sector level: Shrimp production industry

The activity of a shrimp industry stimulates local economies and generally provides import earnings for the producing nations (Boyd and Clay 1998, p. 48), but the distribution of the benefits is often considered to be uneven (Williams 1997, p. 15, Backhaus 1998, p. 281, Bailey 1988, p. 39). Shang and Tisdell (1997, p. 135-137) define the objectives of aquaculture development as to “maximize sustainable net social benefit”.

Relation between production and ecosystem

Kautsky, et al. (2000, p. 147) state that aquaculture is basically a natural ecological process that is underlying ecological principles. Most of the impacts facing the whole industry relate to the environment, as a consequence of the location (site evaluation) and the production system³⁴. Aquaculture relies heavily on environmental ‘goods’ (e.g. water, feed ingredients, seed, etc.) and ‘services’ (e.g. coastal ecosystems for pond water discharge), consequently aquaculture is highly sensitive to adverse environmental changes and interactions with non-aquaculturists that rely on similar ‘common’ resources (Phillips and Barg 1997, p. 47-48). The multi-user conflict is also discussed by Bailey 1988, where he states that “... a complex ecosystem supporting multiple uses by a variety of users is being transformed into a greatly simplified system that becomes the private property of an individual entrepreneur.” (Bailey 1988, p. 36). As aquaculture is strongly connected with its natural environment Phillips and Barg (1997, p. 48) argue: “It is in the long-term interest of aquaculturists to work towards protection and enhancement of environmental quality.”

Various authors describe the problem of abandoned shrimp farms. Kautsky, et al. (2000, p. 146) calls this phenomenon the ‘boom-and-bust’ pattern of the shrimp industry. Dierberg and Kiattisimkul (1996, p. 652), state abandoned shrimp farms are one of the major environmental impacts of shrimp aquaculture. Thereby emerges the issue of perpetuity of a sustainable production system (see A2.1.1.1, p. 15). In the context of shrimp farming this means that a aban-

³⁴ Typical production areas in the tropical coast lines are estuaries influenced by sea-, and freshwater.

done farm can never be considered as sustainable. This will be discussed further on in 3.1.3.1.

Relation between environmental and social aspects

Various authors discuss the relationship and the interaction between environmental and social impacts. World Bank (1998, p. 63) concludes that measures that “reduce environmental impacts and resource degradation, are likely to help reduce social impacts, as well”. Most of the arguments about the connection between environmental and social aspects focus either on direct competition, whereas the local community that depends upon natural resources for meeting basic survival needs may be displaced, or on indirect user-conflict of people which depend on the same ecosystem services that are utilized by shrimp aquaculture. (Lockwood 1997, p. 52; Clay 1997, p. 34; Backhaus 1998).

The creation of employment is a rather controversial issue. According to Bailey (1988, p. 38) shrimp aquaculture is capital rather than labor intensive, especially the big-scaled farms. Furthermore, he argues that it creates limited employment opportunities for coastal residents, which are hired as unskilled laborers and where the wage rates tend to be low. He concludes that shrimp aquaculture directly contributes to low wages by restricting access to local resources - thereby reducing local employment opportunities and increasing workers dependence on seasonal jobs which require few skills (Bailey 1988, p. 38). Other authors (Boyd and Clay 1998, p. 48; Williams 1997, p. 15; Shang and Tisdell 1997, p. 137) emphasize the positive impact due to the creation of direct and indirect employment opportunities in underdeveloped areas.

Shang and Tisdell (1997, p. 140) argue that the emphasis in environmental conservation depends on the economic development. “In many developing countries facing malnutrition and food insecurity, policy makers may feel that some deterioration in environmental quality is justifiable for economic development and that environmental conservation is a luxury practice they can ill afford” (Dixon et al., 1988 cited in Shang and Tisdell 1997, p. 140).

The impacts stated in this chapter declare the necessity of an Integrated Coastal Management (ICM), whereas planning and zoning of aquaculture activities takes place. This aspect will be illustrated further in chapter 3.1.3.1.

3.1.1.2 Single farm level

According to various authors the impacts take place on the farm level. Lockwood (1997, p. 53) states that the present problem “is not associated with aquaculture in general or shrimp aquaculture in particular, but is related to specific producers in certain countries who engage in intolerable abuses of the environment and subsistence-dependent people.” On the other hand, shrimp farms operated with good management and business practices can be profitable and benefit both the local economy and community (Boyd, et al. 2001, p. 303). In order to realize the impacts of a single farm, the farming practices / production system and the intensity of them have to be considered. Table 6 shows the classification of production systems according to Rosenberry (2001).

Table 6: Classification of farming practices

	Extensive	Semi-Intensive	Intensive	Super-Intensive
Location	Low-lying impoundments along bays and tidal rivers	1 – 2 m above high tide line	1 – 2 m above high tide line	6 m above high tide line
Pond size	20 – 200 ha	2 – 30 ha	0.1 – 1.5 ha	0.05 – 1.0 ha, or even raceways, tanks, covered or indoor
Construction	Artificial or natural embankment	Artificial embankment	Artificial embankment	Artificial embankment with plastic liners, drain in the middle of the pond
Initial stocking density	Less than 25,000 PL/ha, sometimes stocking through tide	100,000 – 300,000 PL/ha (wild or hatchery PL)	More than 300,000 PL/ha	More than 800,000 PL/ha
Water exchange	Through tide: 0 – 5% per day	Pumps: 0 – 25% per day	Can be more than 30% per day	0%
Aeration	no	Only in critical situations	5 – 20 hp/ha	> 25 hp/ha
Feeding and Fertilization	On naturally occurring organisms, may be encouraged with fertilizer	Fertilized to encourage a natural food chain, Supplementary feeding	Around-the-clock management heavy feeding	Five times per day, low protein feed, waste removal
Production, yield	50 – 500 kg/ha/year	500 – 5,000 kg/ha/year	5,000 – 20,000 kg/ha/year	25,000 – 100,000 kg/ha/year
Production Countries	Vietnam, Indonesia, Ecuador	Honduras, Mexico, Columbia, Ecuador, China, Brazil	Thailand, Indonesia, Taiwan	Belize Aquaculture Ltd.
General considerations	New construction in tidal areas is in many countries illegal, almost no new extensive shrimp farms	If there are too many semi-intensive shrimp farms concentrated in a small area, they can have a negative effect on the environment	Relatively easy to convert to other species, frequently cause environmental problems	Big challenge for management because of diseases, crop failures, water quality, finances and the environment ^{a)}

^{a)} Production levels above 10,000 kg/ha/year are considered as risky (Rosenberry 2001, p. 272)

Source: According to Rosenberry 2001, p. 270ff; and Boyd and Clay 2002

Other authors such as Dierberg and Kiattisimkul 1996 describe the farming practices based on the evolution in a typical production country such as Thailand. In addition to the practices shown in Table 6, Dierberg and Kiattisimkul (1996, p. 658) describe the tendency in Thailand of “semi-closed intensive farming”, “closed intensive farming” and “open semi-intensive with intact mangrove.”

The impacts of a single farm depend heavily on the farming practice. Phillips and Barg (1997, p. 49) illustrate that “in general, extensive shrimp culture systems with low stocking densities and little or no fertilization or supplementary feeding do not generate significant amounts of waste. Indeed, extensive systems may be net removers of nutrients and organic matter.” Also Shang and Tisdell (1997, p. 129-130) argue that extensive culture systems usually produce insignificant loading of nutrients or organic matter onto the ecosystem due to relatively low stocking densities, and little or no supplementary feeding or fertilizing requirement. Conversely, extensive systems require large areas (space) of land or water, potentially contributing to degradation of the habitat in some areas (Barg and Phillips 1997, p. 6). The authors also state the example of shrimp farming: “the highly publicized problems of wetland degradation are often associated with extensive systems. Intensive systems obviously may create pollution problems due to high inputs and high waste output, but this greatly depends on very site-specific characteristics, and, in particular, of the assimilative or environmental capacity of the recipient water body. In general, effectiveness of measures and efficiency in management at the production level may well be very important criteria for consideration when promoting sustainable development of aquaculture.” Farm size is also a characteristic effecting impact classification. Boyd and Clay (1998, p. 48) argue that “shrimp farming is an interesting ex-

ample of a situation in which a disproportionate amount of the environmental damage has resulted from smaller operators rather than from bigger ones". Nunes and Suresh (2001) also argue that pollution of ponds due to over-feeding takes place more often in small-sized operations. This connection is known in the microeconomics as the utilization of the scarce resource (in this case of land). Through producer associations and co-operatives the land utilization and the demand of resources can be organized.

The site selection is also a crucial factor in the decision of which intensity will be applied. Phillips and Barg (1997, p. 54) argue that "the opening up of ecologically sensitive areas for extensive monoculture farming seems hard to justify given the large areas required for profitable farming and the low economic returns per unit area". In relationship to the impacts Dierberg and Kiattisimkul (1996, p. 657) argue that „sustainability in any aquaculture industry depends on two major factors: site selection and pond management“. In the following two paragraphs the impacts of these two factors will be elaborated.

Impacts related to site selection

Site evaluation is a key issue to prevent environmental impacts (Boyd and Clay 1998, p. 43, Hargreaves 1997, p. 47; Phillips and Barg 1997, p. 48). The conversion of resources traditionally used by others - such as mangroves, agricultural land, salt flats, surface or subsurface water – is the most obvious environmental impact of shrimp aquaculture (Clay 1997, p. 35; McIntosh 1999, p. 46). Destruction of mangroves, wetlands and salinization of potential agricultural land are the most commonly known impacts related to constructing shrimp aquaculture facilities. Additional issues of siting that must be addressed are the design, water intake and discharges, buffers between ponds and between ponds and water sources, and the use of settlement ponds and/or filtration systems (Boyd 1999, p. 17; Clay 1997, p. 35; Gautier 2001, p. xiv). As illustrated above the number of already existing ponds in an area, the surrounding environment (see 3.1.1.1) and the kind of production system (see 3.1.1.2) are important factors for the site evaluation.

Impacts related to pond management

The main impacts related to the production and the pond management are an open connection to the natural environment and the use of inputs. According to critics, environmental impacts to the open connection are water pollution, detrimental effects of nutrient loading on adjacent estuarine and oceanic waters (McIntosh 1999, p. 46), excessive water exchange (Hargreaves 1997, p. 47), and salinization of freshwater changes in land use patterns, (Boyd 1999, p. 17). The origin of the post-larvae (PL), linked with the problem of bycatch of wild seed collection (Boyd and Clay 1998, p. 43; Rönnbäck 1999, p. 248; Phillips and Barg 1997, p. 50), the introduction of exotic species (Boyd 1999, p. 17), wasteful use of fish meal, and uncontrolled use of antibiotics, drugs, and other chemicals (Boyd 1999, p. 17, Hargreaves 1997, p. 47; McIntosh 1999, p. 46) are the main impacts concerning the inputs. Phillips and Barg (1997, p. 50) state that many factors leading to shrimp disease are also related to poor environmental performance. The authors conclude that this is "a potentially important 'win-win' situation" (Phillips and Barg 1997, p. 50). The incentive is for farmers to adopt improved environmental management practices to reduce shrimp disease problems.

3.1.2 *Thematically classified impacts*

The more widespread division of impacts is the classification concerning economical, environmental and social impacts. This classification is based on the concept of sustainability (see 2.1.1.2).

3.1.2.1 **Economical impacts**

Shrimp farms generate considerable economic returns and globally earn an estimated US\$ 6 billion annually at farm gate prices with the value increasing substantially as shrimp moves down the market chain to the consumer (Phillips and Barg 1997, p. 46). Shrimp farming is an economic activity where a significant part of the production is exported. According to Globefish (2001) shrimp exports reached, 1.4 million MT (US\$ 10.3 billion) in 1998 showing an 11% increase from 1997 and a 39% rise from 1990. The production of shrimp (capture and aquaculture) reached 3.8 million MT in 1998 and has increased steadily since 1990 (2.6 million MT). The economic significance through foreign exchange earning is described by various authors (Phillips and Barg 1997, p. 46; Bardach 1997, p. 8-9; Shang and Tisdell 1997, p. 136). Michielsens (2001, p. 18-19) illustrates that shrimp production values per ha are five to ten times higher than for agricultural food crops and three times higher than for other agricultural export crops.

Investment and economic output from shrimp generates considerable employment from input suppliers (e.g. hatchery operations, feed sales), producers (farmers and farm workers) and in post-harvest and processing and distribution, marketing and trade (Phillips and Barg 1997, p. 46). Some authors classify these impacts as socio-economic ones. According to Olsen and Coello (1995) cited in Phillips and Barg (1997, p. 47) employment on shrimp farms in Ecuador is estimated at 0.25 - 1 persons per ha. This is relatively low, perhaps due to the low intensity of farming systems in this country and/or the greater proportion of large farms. Including up and down the line well-run operations create one or two jobs for each hectare (Boyd and Clay 1998, p. 48). Michielsens (2001, p. 28) even states "it is estimated that indirect employment opportunities are about double those of direct employment". The creation of jobs has among other things contributed significantly to badly needed economic and social development in many parts of the world (Lockwood 1997, p. 52).

The aspect of human nutrition and food security is stated by various authors (Chamberlain and Rosenthal 1995, p. 22; Williams 1997, p. 27; Michielsens 2001, p. 16-19). In traditional fish- and seafood-eating societies aquaculture is an important contributor to provide a more available and affordable protein source. Whereas shrimp – compared to other aquaculture products – is a relatively expensive protein source. Even though aquaculture reduces the price of shrimp and brings them within the reach of a larger proportion of population. (Tacon, 1997 cited in Michielsens 2001, p. 17).

Williams (1997, p. 27-28) illustrates the problem of the inequality of the distribution of the benefits of aquaculture. He argues that policy interventions must contribute to equity mainly in the developing world. Concerning the distribution of the benefits Casavas (1994) cited in Williams (1997) illustrates a pair of contrasting objectives for national policy for aquaculture. Three of these pairs concerning economical impacts are:

- 'Highest volume of edible products' ⇔ 'Highest income for producers',
- 'Highest foreign exchange earnings' ⇔ 'Import substitution'
- 'Mobilization of private investments' ⇔ 'Assistance to small farmers'.

These contrasting objectives point out the trade-offs and the conflicts in defining sustainability strategies (see 2.1.1.2).

3.1.2.2 Social and socio-economic impacts

As is the case with the economic objectives the policy objectives concerning social impacts are also contrasting (Casavas 1994 cited in Williams 1997, p. 28) such as:

‘Highest absorption of labor’ ⇔ ‘Highest productivity of labor’ and
‘Development of vertical integration’ ⇔ ‘Community development’

The evaluation of these objectives takes place on a sectoral level. This is also required by the World Bank (1998, p. 63-64), therefore the authors argue that the evaluation of social impacts and of social sustainability strongly depends on the level of aggregation. Backhaus (1998, p. 274) argues that social elements in traditional communities are negatively affected by increasing trade activities. Traditionally, access to coastal resources in many countries has been open to all users. In such a situation, privately held shrimp farms are viewed as incompatible with traditional, open-access use of coastal resources (Boyd, et al. 2001, p. 307).

Lockwood (1997) focus on social consequences of shrimp farms by displacement of mangrove and as a consequence of coastal population, which depend upon these natural resources for meeting basic survival needs. Furthermore, he focuses on the positive social effects that are food production, increased employment, and social development in rural areas.

Michielsens (2001) creates six aspects to analyze socio-economic impacts of shrimp farming. She classifies some aspects under socio-economic that generally are considered as economic impacts. The first aspect considers the opportunities of shrimp production as part of all “food production”, where shrimp is considered the food production segment with the highest growth rate. The second impact is the “food security” where the author analyzes protein rates, yields, revenues, profits, etc. The third impact is the “rural employment” concerning productivity figures, comparison of wages in shrimp farming with other sectors, with a special focus on female laborers. The fourth impact are the “new sources of employment”. The fifth aspect analyzes the impact of “foreign exchange earning”, where she describes consumption trends. The last impact considers “interaction of shrimp farming with other coastal activities”. This impact describes the relationship between environmental and social impacts (see 3.1.1.1) where it is stated that “social conflicts are mainly related to water quality problems” (Michielsens 2001, p. 30).

3.1.2.3 Environmental impacts

As already stated in 3.1.1 the main concern about shrimp farming is the environmental impact. Muir (1996, p. 21) defines the problems (see Table 7) that are the main environmental issues associated with aquaculture. It gives an overview of the most common environmental impacts associated with shrimp farming. While most are negative impacts the decreased pressure on wild resources is considered to be a positive effect of shrimp farming (Boyd and Clay 1998, p. 43; Chamberlain and Rosenthal 1995, p. 21; Lockwood 1997).

Table 7: Environmental problems associated with aquaculture

Problem area	Nature of problem
Waste and nutrient loadings	Output of solids, N, P, vitamins, minerals, husbandry/disease chemicals, antibiotics; impacts of waste materials on the adjacent benthos and the water column; on species/community diversity, quality indices, stimulation of blooms.
Water exchange	In intensive land-based systems, or flushing through freshwater or marine cage or enclosures; quantities required, effects of abstraction, dilution with 'low grade' wastes, at concentrations sufficient to diminish measured quality, but too low for simple treatment.
Degradation of terrestrial environments	In coastal areas, caused by salinization of soils, affecting adjacent agricultural practices, coastal fringes; excessive clearance of mangroves and protective cover.
Escaped stocks	From damaged systems, or through flooding, damaged or ineffective discharge screens; risks of competition with/genetic contamination of local stocks, disease transmission, directly or indirectly reduced biodiversity.
Predation by conservation sensitive species	Causing damage, loss, stress-related disease to farmed stocks, requiring controls without compromising conservation interests.

Source: According to Muir (1996, p. 21)

3.1.3 Demands on shrimp farming

Based on the impacts described in 3.1.1 and 3.1.2 the requirements for shrimp farming to move towards sustainability are deduced. The requirements are thematically classified (3.1.3.2 until 3.1.3.4) and in 3.1.3.1 a sustainability definition concerning shrimp farming will be elaborated.

3.1.3.1 Sustainability definition for shrimp farming

Timeframe

Sustainability is often viewed as a process development over a long time, even over future generations. The evaluation of the shrimp activity can focus on such a timeframe, whereas the timeframe is usually not explicitly defined. Kautsky, et al. (2000, p. 146) state examples of shrimp farming systems that do not exceed 5-10 years. If the long-term existence of an industry or of a single farm is the basic criteria of sustainability these examples can never be considered as sustainable.

Based on the Brundtland definition

FAO 1997, cited in World Bank (1998, p. 14) defined sustainable development in relation to agriculture and fisheries in the following way: "Sustainable development is the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable."

Weak and strong sustainability

Analogous to Solow (see Table 3) whereas resources are managed to maintain production opportunities for the future, Thongrak, et al. (1996, p. 123) require, for shrimp farming to be sustainable, it must provide an adequate farm income, generate export earnings and protect the long-term productivity of natural resources and the environment."

The Mangrove Action Project 1999 defines sustainable shrimp production as that, which: 1) maintains the integrity of affected ecosystems, 2) is equitably balanced with the natural resources and resource-users of the affected coastal zone, 3) is structured so as to promote social and economic equity within and between nations, and 4) is economically viable. The first requirement of integrity of affected ecosystem can be considered as strong sustainability, which is based on a physical principle (Hediger 1999, p. 1123).

Berg, et al. (1996, p. 142) state: “If aquaculture development is to be ecologically sustainable, efforts must be directed towards methods that make use of the natural environment without severely or irreversibly degrading it.” According to the survey of concepts in Table 3, p. 18 this definition can be classified as “... satisfies minimum conditions of ecosystem stability and resilience through time”, which can be considered as an operational principle from the strong sustainability conception Hediger 1999, p. 1123).

Economical-, environmental-, and social sustainability

Shang and Tisdell (1997, p. 128) require that sustainable aquaculture is biotechnically feasible, environmentally sound, and socio-economically viable. According to the authors the biotechnical factors include the species selected (herbivores, omnivores, carnivores) and the culture system adopted (extensive, intensive; monoculture, polyculture). These biotechnical factors affect the environmental carrying capacity and socioeconomic viability. The environmental factors are divided by Shang and Tisdell (1997) and by Barg and Phillips (1997) in “Impact of aquaculture on environment” and “Impact of environment on aquaculture”, whereas the first named can be viewed from farm- and society level (Shang and Tisdell 1997, p. 130). The last requirement of “socio-economically viable” can be divided in “Social acceptability” and “Economic viability”. Even though the terms differ from the traditional three factors of sustainability the content covers the aspects of economical, environmental, and social sustainability.

Describing the management strategies for sustainable shrimp farming Phillips and Barg (1997, p. 50-51) divide the complex range of factors in the three common known categories.

Table 8: Three perspectives of management strategies for sustainable shrimp farming

	Emphasis on... / require ...
Economic sustainability	<ul style="list-style-type: none"> • Control of diseases (1) • Efficient use of inputs to ensure profitability (1) • Costs associated with environmental controls, monitoring (2) • Management strategies incorporated into farm planning (1)
Environmental sustainability	<ul style="list-style-type: none"> • Increased attention to efficiency in use of resources (2) • Including farming within assimilative capacity of ecosystems (2) • Advanced planning which allows for better predictions of impacts (1)
Social sustainability	<ul style="list-style-type: none"> • Greater awareness of social benefit and costs (1) • Attention to greater local participation and benefit sharing in shrimp farm projects (2)

(1): Farm level, farming activities

(2): Integration of shrimp farming in its context

Source: According to Phillips and Barg (1997, p. 50-51)

The issues listed in Table 8 reflect the different levels. One part – indicated with (1) – deals with farming activities (e.g. in terms of location, design, farming system and operational management) and the other part – indicated with (2) – concerns the integration of aquaculture into the development and environmental context characteristic of the specific coastal area in question. This second part is reflected in the following point.

A system perspective

FAO (1997) recognizes the opportunities of enhancing participation of aquaculturists and rural communities in the promotion of responsible aquaculture management practices. FAO states “Collaboration for sustainable aquaculture development will need to recognize the diversity of aquaculture practices as well as the diversity of the political, social, economic and environmental conditions in which they will be taking place.”

The evaluation of sustainability of shrimp farming does not depend exclusively on the farming activities. The Code of Conduct for Responsible Fisheries (FAO) identifies management strategies on three levels. 1) Technology and farming system, 2) Adoption of integrated coastal area management approaches, and 3) Policy support. According to Phillips and Barg (1997, p. 55) the integrated coastal management (ICM) is a participatory approach that involves aquaculture zoning, and assimilative capacity and modeling. The policy support includes aquaculture legislation, environmental impact assessment (EIA), environmental quality standards, specific introductions and movement of aquatic animals, drugs and chemical use, institutional capacity, and industry initiatives (Phillips and Barg 1997, p. 59).

The Mangrove Action Project 1999 requires that it has to be ensured that aquaculture is integrated in a compatible manner with the social, cultural, and economic interests of coastal communities; this includes the meaningful participation of local user groups in coastal management planning.

World Bank (1998, p. 63) defines two major components for making shrimp aquaculture more socially and economically desirable. The first considers the reduction of negative externalities of resource appropriation or degradation; and the second considers the increasing participation of the poor in shrimp farming activities, or a wider distribution the benefits.

Shang and Tisdell (1997, p. 128) summarize the following definitions and interpretations of sustainable aquaculture:

- Sustainable aquaculture is usually viewed as a farming system that is in harmony with other economic activities that use natural resources.
- It should produce a reasonable and relatively stable net income or benefit to both producers and society, compared with other economic alternatives, by using the same natural resources on a long-term basis without degrading the environment; therefore, the way natural resources are used in aquaculture should not leave future generations worse off than the current generation.
- Its development has to be balanced among production, marketing, and other supporting services (including legal measures) in order to be sustainable.

These definitions include a system perspective and focus on the development of the shrimp farming activity.

3.1.3.2 Economical requirements

Traditional economic analysis at the farm level can be used for sustainable aquaculture if they are refined and improved to take into account their applications to specific environments. (Shang and Tisdell 1997, p. 134). The economic viability as the central issue of economic requirements is defined on the farm level as ‘value creation over time’. Farm net income is a necessary part in the value creation. These factors depend on management strategies and the economic decision making on “how to combine inputs to produce a satisfactory if not optimal output mix” (Shang and Tisdell 1997, p. 133).

3.1.3.3 Environmental requirements

According to Boyd (1999, p. 17) the aquaculture industry should formulate an environmental agenda to identify major environmental impacts and to better define environmental management. The aquaculture industry should further initiate public relation programs, become active in the political arena, get involved with environmental management agencies in order to influence the nature of future regulations, and provide better environmental education.

Improvements in environmental management should involve better resource management, principally of non-renewable resources, the reduction of waste and nutrient loadings, the prevention of degradation of terrestrial environments, control of seeds and stocks, and management to avoid diseases, mainly stress-related disease. Mangrove Action Project 1999 presented in its list for sustainable aquaculture the following points concerning environment:

- Ensure the protection of mangrove forests, wetlands, and other ecologically sensitive areas.
- Discontinue the wholesale conversion of agricultural/cultivable land to aquaculture use.
- Stop the use of toxic pesticides and antibiotics, in addition to shrimp feeds consisting of fish that is or could be consumed by people.
- Stop the use of exotic/alien species and the use/development of genetically modified organisms.
- Stop the pollution of fresh water/ground water supplies necessary for drinking water or agriculture.
- Ensure that abandoned or degraded aquaculture sites are ecologically rehabilitated and that the companies or industry responsible bear the costs of rehabilitation.

3.1.3.4 Social requirements

Based on the “Codes of Practice for Responsible Shrimp Farming” the following points concerning community and employee relations are required (Boyd 1999, p. 11):

- Shrimp farms should employ local workers to the extent possible, provide good working conditions, and wages commensurate with local pay scales.
- Shrimp farms should abide by local laws and regulations regarding the rights of local people to use coastal resources.
- Shrimp farms should be supportive of local communities and engage in community activities.

3.1.3.5 Management requirements

Reviewing various Codes of Conduct Boyd, et al. (2001, p. 320) conclude that the program of the Global Aquaculture Alliance (GAA) based on the ‘Codes of Practice for Responsible Shrimp Farming’ may be the most promising. This code of practice includes management practices concerning mangroves, site evaluation, design and construction, feeds and feed use, shrimp health management, therapeutic agents and other chemicals, general pond operations, effluents and solid wastes, and community and employee relations (Boyd 1999). Further management requirements are discussed by Phillips and Barg (1997, p. 51 ff). These requirements are:

1. *Farm siting*: Mangroves are not suitable sites for shrimp farms, because of various risk factors (e.g. acidic soils, poor drainage, construction costs, etc.) Furthermore mangroves help to stabilize effluent canals and are an erosion control.

2. *Farm construction and design features*: Prevent salt water intrusion caused by seepage from ponds. Mangrove buffer zones provide protection from storms, maintain traditional fisheries and may even improve water quality (Phillips and Barg 1997, p. 52).
3. *Feeds, feed additives and fertilizers*: Feed Conversion Ratio (FCR) as a key number, possible reduction in the use of fish meal in diets for aquaculture species, redesign of systems to provide for recycling of excess nutrients and organic matter in effluent into secondary aquaculture products (e.g. fish, mollusk) or even agricultural crops. Generally these activities could help to increase the efficiency of resource use and make additional contribution to local food supplies.
4. *Shrimp health management*: Management practices to reduce stress, development of captive brood stock. Profitability achieved by integrating high health shrimp seed with disease control and appropriate farm management practices.
5. *Selection of suitable species and seed*: Trend towards use of hatchery reared shrimp provides a basis for reducing the reliance on wild stock.
6. *Water and sediment management*: Reduction of water use reduces the risk of introducing shrimp pathogens into the ponds, can dramatically reduce effluent loads while resulting in increased settlement of nutrient and organic matter in ponds. The reduction of nutrients or organic loads may occur through: a) removal of suspended soils and disposal of pond sludge using various techniques and b) bio treatment including artificial wetlands (mangrove wetlands), whereas roots are sediment sinks. Sediments also have potential as a useful fertilizer.
7. *Farming system development*: Generally it is not a question of the intensity of the management but more of the location and the quality of the management. An integrated system (reuse of effluents and pond water) of shrimp farming and other activities is a preferred system.
8. *Pond rehabilitation*: In tidal zones exist experiences with replanting of mangroves to reduce the problems of abandoned ponds.

3.1.4 Conclusions of desk research

The conclusions with respect to content will be stated in chapter 3.4. The conclusions stated in this chapter are general remarks of the desk research. Depending on the underlying concept and the perspective shrimp farming can be judged as sustainable or un-sustainable. The key issue is to properly identify and promote the system and management practices which are sustainable and promote these as a contribution to sustainable development for people and communities living in coastal areas (Phillips and Barg 1997, p. 45).

The requirements concerning sustainable aquaculture may not be easily classified into economical, environmental and social aspects. This depends on the relationship and connection between development of these three aspects, whereas changes in one aspect affect improvement in the other one. A typical example to illustrate this connection is the goal conflict concerning seed selection. Seed from hatcheries reduces the reliance on wild stock, but it may create the problem of livelihood of coastal inhabitants, when gaining income and employment through wild seed collection. Such goal conflicts illustrate that a sustainability concept can not be elaborated without seriously taking into account the local situation, tradition and existing technologies. Furthermore the decision of what is required and what should be implemented in sustainable shrimp farming is very subjective and depends on the values that are assigned to the impacts. The case of seed origin can be simplified and reduced to the question of environmental conservation versus improvement of socio-economic situation.

3.2 Primary research through expert interviews in Brazil

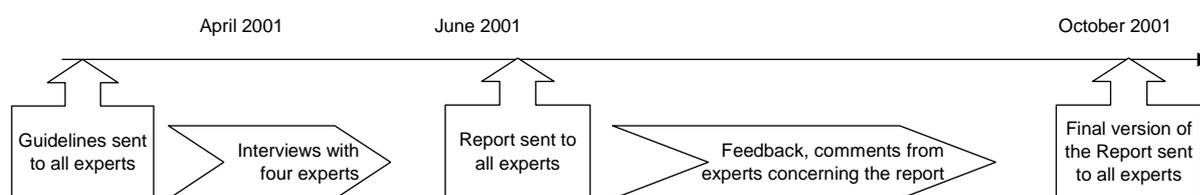
In addition to the results presented from the desk research the primary research shall give further information about the requirements to move towards a sustainable shrimp farm. Chapters 3.2 and 3.3 are empirical data collections based on the involvement of expert opinions for the project of a sustainable shrimp farm. Gregory and Wellman (2001, p. 38) illustrate the advantages of the involvement of stakeholder values, good science, and economic valuation into the design of a research program. The authors argue that “by the time a recommendation is advanced, there is a higher probability that it will meet with broad based approval and, in turn, succeed in achieving its stated goals.”

The purpose of the expert interviews in this chapter is the evaluation of expert opinions representing stakeholder groups in Brazil. The reference system for all of these experts is the Brazilian shrimp industry.

3.2.1 Method and procedure of expert interviews

The interviews occurred in a more-step procedure applying part of the methodology of a qualitative system dynamics approach. The important information for the definition of requirements resulted from the first step of the qualitative system dynamics approach. The procedure of this approach will be explained further on in chapter 4.1. In the more-step procedure the experts had the opportunity to write comments on the results. The timeframe of the procedure is shown in Figure 23.

Figure 23: Procedure of the interviews and its evaluation



Two weeks before the interview all experts received a guideline (workbook) about the content, procedure, and targets of the interview. The interviews with the four experts proceeded in the time from April 14 to April 25 2001. The results of the interviews have been presented in a written form to all experts (June 26 2001). Based on this report the experts were invited to give their remarks and suggestions. The final report – including some changes based on the remarks and suggestions was presented in the final report (October 1 2001).

For this interview an open guideline interview procedure was chosen, where the experts had to define in the first step their Know-how about shrimp farming, their experiences and their general attitude against shrimp farming. In a second step the experts had to define their requirements and necessities for a shrimp farm. This step was independent of sustainability targets, it was defined as creating their own “ideal shrimp farm”. The next question part was concerning sustainability issues and shrimp farming. The experts defined what they understand sustainable management to be and how they see the role of government, farmers, NGOs and others in the 1) creation, 2) implementation, and 3) control of sustainable shrimp farming. Based on these questions the general statement concerning shrimp farming from every single expert, a list of pro- and contra arguments related to shrimp farming, and a list of requirements was determined. Further questions of the interview have been used for network building and will be illustrated in chapter 4.

3.2.2 Experts for the interviews

An expert group was assembled with four experts representing different stakeholder interests for sustainable shrimp farming. Based on the question focus the consideration of financial, environmental, and social issues were taken into account by the group of experts. Boyd 1999, p. 10-12 defines the interest groups “Aquaculturists”, “Environmentalists”, “Government”, and “Consumers” that have an environmental philosophy of aquaculture.

The experts chosen for the interviews are shown in Table 9. The group includes important perspectives related to a shrimp farm. The experiences of all of them are based on Brazilian reality. This ensures that all experts are referring to the same circumstances, which is at the same time the system-frame for the thesis. This is important because the Brazilian shrimp industry is in many aspects different from shrimp industries in other countries (new industry, little tradition, high potential in land and water resource, inland based supply chain, limited pool of qualified labor and minimal knowledge about shrimp farming). The fast expansion rate of the Brazilian shrimp industry makes the sector very dynamic and fast changing.

Table 9: Experts, perspectives and special Know-how

Expert	Perspective	Know-how
Mr. Jaime Bunge	Economical, financial	Consultant and analyst for investment in organic projects, SP, Brazil
Mr. René Schärer	Social, Community, Human resource	Founding member of a native community based NGO (fishing community, CE, Brazil)
Mrs. Cristina Bonfiglioli	Environmental, consumers ^{a)}	Member of Greenpeace Brazil
Mr. Werner Jost	Practical, operational, with a long-time business experience	Owner and general manager of Shrimp Farm in RN, Brazil

^{a)} A explicitly consumer perspective is part of the Delphi study (chapter 3.3)

The four experts represent a selective choice of experiences and opinions about shrimp farming in Brazil. The three perspectives of economical/financial, environmental, and social issues are represented by the experts. The four experts represent the requirements shown in chapters 3.1.3.2 until 3.1.3.5. One of the stakeholder group, which is not represented in the expert group is the government. The government – responsible for the legislation and business environment – is not represented because the requirements shall focus explicitly on farm level, whereas legislation and general conditions mainly focus on a sectoral development. All four chosen experts are considered as important experts for farm level.

3.2.3 Results of the interviews

3.2.3.1 General statement and impacts of shrimp farming

Independent of each other all experts are convinced that shrimp farming in Brazil is an alternative to wild fishing and there exists a potential for this form of production. About the implementation and the actual situation of shrimp farming the experts have different opinions. Although all of them mentioned the risks and problems that can be caused / or are caused by shrimp farming.

The following points are the general opinion/statements concerning shrimp farming in Brazil of every single expert.

- Potentially a great opportunity for rural areas and for the development. Unfortunately it actually causes more negative than positive impacts because of irresponsible and anti-social managers and investors. Risk because of lack of control and regulation in the sector.

- In general great potential.
- A lot of social, cultural and ecological negative impacts are associated with shrimp farming. Idea to reduce the pressure of wild fisheries is positive; but in fact, in the practice, sustainable shrimp farming is very difficult to be implemented.
- Under condition that there is enough land for shrimp farming (areas that can not be used as agricultural land), shrimp farming is a great opportunity for development but there is a risk of uncontrolled development due to high pressure for greater profitability.

3.2.3.2 Pro- and contra arguments concerning shrimp farming

Table 10 shows the summary of the four opinions concerning shrimp farming. The pro- and the contra-arguments are listed below. The numbers in brackets reflects the number of experts whom shared the same argument.

Table 10: List of pros and cons concerning shrimp farming

Pros	Cons
<ul style="list-style-type: none"> • Increase of economical development in general, mainly in underdeveloped areas (3) • Creating working places (3) • Reduce the pressure on wild fisheries (ecologically and social) (3) • Export: foreign exchange (2) • Utilization of an otherwise deactivated, unfertile area (2) • Possibility for young people to stay in the rural area, generate an income, versus moving away (2) • Possibilities for community based projects (1) • Industrialization of a rural area – introduction of modern economy (1) • Increase also for the support- and supply-industries (1) • As a consumer: to have the possibility to consume shrimps (1) 	<ul style="list-style-type: none"> • Pressure on environment with discharged water and chemicals with possible neg. impacts on natural resources (4) • Danger of ecological disaster, natural and biological collapse (can be a result of pressure for higher profitability – inadequate management) (3) • Destruction of natural resource such as mangroves and agricultural land (3) • Dependency of poor people, problem of distribution of the profitability (2) • In the industry as a whole: No control, no restriction, uncontrolled rush (1) • Increasing valuation of land prices leads to an increased Gap between poor – rich (1) • Threat that local community can not have real participation (education) (1) • Threat of money laundering for rich investors (1) • To drive out the local community and their traditional lifestyle (1)

The general opinion about shrimp farming and the pros reflect the potential of this activity. All experts care about the negative impacts and the risks of the shrimp farming activity. The main challenge (or based on Figure 33, p. 85: the “Identification of a problem”) is to define the desired state of (more) sustainable shrimp farming and how this can be achieved.

3.2.3.3 Requirements for sustainable shrimp farming

Based on the general opinion and on the pros and cons about shrimp farming every expert defined the requirements for shrimp farming. These requirements are subjective and based on the experience of every single expert. The requirements listed in Table 11 have been elaborated during the interviews through the following questions:

- If you could define: what would you define as necessities/requirement for a shrimp farm?
- What do you think should be the responsibility mission of a shrimp farm?
- If you would create your own shrimp farm, what would you do first?
- Define the importance of the requirements you mentioned before.

The numbers in brackets show the amount of experts that used this requirement. In the second column, the author of this report defined the “level of action”, where this requirement can be situated and who/what institution, has the responsibility to introduce and implement the requirement.

Table 11: List of requirements for shrimp farming

General topic	Level of action ^{a)}
<p>Organizational, general requirements:</p> <ul style="list-style-type: none"> • Transparent internal and also external information policy – play an open game (3) • Definition of land use, integrated coastal management (ICM), agricultural land, situation of property rights, security of infrastructure etc. (2) • Legislation as minimum standards must be fulfilled, no illegal management (2) • Need of planning, strategic work of management (1) • Inclusion of environmental and social risks in the planning of a shrimp farming project (1) • Continuous technology improvement (1) • Active part of sector authorities (ABCC), define a “Business Plan of the whole sector, lobbying, monitoring and also controlling of the sectors activities (1) 	<p>CL/SL NL NL CL CL CL/SL SL</p>
<p>Ecological, environmental requirements:</p> <ul style="list-style-type: none"> • Definition of environmental regulations (no mangrove destruction, restriction in use of agricultural land, no interruption of water flow, etc.) (2) • Definition of maximal load of discharged water (N and P) (1) • Define limit of stocking density because of animal-stress and discharged water would be a prevention mainly by high concentrations of shrimp farms (1) • Regulation of use of antibiotics (1) • Monitoring of energy input (1) 	<p>NL SL/NL CL/SL SL/NL CL</p>
<p>Social, socio-economic requirements:</p> <ul style="list-style-type: none"> • Demonstrate responsibility and activities in the society and community (2) • Involve local community as labor and also as leadership in the company (1) • Create real possibilities/opportunities for your employees, long-term perspective, improve entrepreneurship, etc. (1) • Application of “Ethos-criteria”³⁵, socio-economical management (1) • Education of professional labor (1) 	<p>CL CL CL SL/CL SL/CL</p>

^{a)} The level of action can be divided in three levels: CL: company level (e.g. one single firm)
SL: sector level (e.g. a sector organization such as ABCC)
NL: national level (e.g. state or government)

The factors and requirements reflect the perspective of the four experts. They will be added to the requirements based on the desk research and summarized in chapter 3.4.

³⁵ Instituto ETHOS empresas responsabilidade social: is a Brazilian association of companies developing their activities in a socially responsible manner, in a permanent process of evaluation and improvement. Further information on <http://www.ethos.org.br/>.

3.3 Primary research through Delphi study

Characteristics of sustainable shrimp farming can be evaluated based on assessments from market actors. This evaluation may be an incentive for farmers to change their management. Management changes should not just be based on external factors (e.g. politic incentives). Changes in political systems are often much slower and in undemocratic areas often associated with corruption. Incentives that start with market forces are more efficient (Egger 2001). According to Lockwood (1997, p. 54) changes in aquaculture practices towards sustainability may be forced through consumers. He terms this as ‘the remaining remedy’. The group of consumers is a diverse group, generally with little knowledge about ecological aspects, environment and resource use (Boyd 1999, p. 10-12). Boyd argues further that consumers can easily be persuaded to follow the causes of environmentalists, however, in general, they are more concerned about the cost or quality of a product than about its environmental effects. It can be concluded, that the opinion of consumers and buyers of shrimps is important for the management of a shrimp farm.

Consumer and customer requirements were evaluated through a Delphi study. This study was part of the diploma thesis Lustenberger (2001a)³⁶. The aim of this study was to detect requirements for shrimp farming, deduce sustainability criteria for shrimp farming and estimate market share and willingness to pay for sustainably produced shrimp (Lustenberger 2001a, p. 33). Taking into account the research question, the evaluation of requirements and its validation as sustainability indicators were the main results of the Delphi study³⁷. These requirements will be processed and concluded in the requirement set (see 3.4, p. 80). The study took place on the Swiss market, which is a relatively small market for seafood products and shrimp. The total imports to Switzerland in 2000 have been 5.103 MT with a value of 92,5 million Swiss francs (Oberzolldirektion der schweizerischen Eidgenossenschaft various volumes). The reasons for choosing the Swiss market are shown in the Table below.

Table 12: Reasons for the choice of the Swiss market in the Delphi study

Increase of the demand	According to the Swiss Foreign Trade Statistics the imports increased from 1990 (2.992 MT) to 2000 (5.103 MT) around 70%.
Sensitization of Swiss customers	The Swiss market is world-leader in sales of organic products per capita (before Germany and Austria) (Richter, et al. 2002, p. 6). Based on sales the share of organic products is 2,1% in Switzerland with a strong increase of 20% from 1999 to 2000 (Richter, et al. 2002). According to Lustenberger (2001a, p. 80) ^{a)} almost 60 percent of interview partners / consumers pay attention to the origin of the product, and almost 40 percent pay attention to labels and certificated products. Swiss consumers let convenience and quality prevail over price (CBI, et al. 1998, p. 58).
Product preferences	According to CBI, et al. (1998, p. 57-60), compared with other European Countries, Switzerland imports fishery products with a very high value / quality.

^{a)} As an introduction into the topic (image of shrimp farming in consuming countries) Lustenberger 2001a started with an explorative survey. The interviews took place with 47 participators. It is not a representative survey and its results can not be used for statistical evaluation. It just gives some indications about possible sensitization points of (potential) consumers.

Further characteristic aspects of the Swiss market are:

- Limited tradition of preparing fish, most fish is consumed in restaurants (CBI, et al. 1998, p. 58).

³⁶ The quoted diploma thesis of Lustenberger was motivated and advised at the Department of Agricultural Economics under direction of the author.

³⁷ Possible requirements of Swiss experts have already been evaluated in the thesis of Züger 1998.

- Approximately 30 importers for shrimps on the Swiss market, whereas the biggest six suppliers (CR6) have a market share of 60% of the total imports (Lustenberger 2001a, p. 20).
- The retail distribution is dominated by two companies. Seventy five percent of fishery products are distributed through supermarkets. This percentage is one of the highest in western European countries (CBI, et al. 1998, p. 61).
- Swiss consumers care about quality, guarantees of hygiene and freshness, nutritional aspects and headlines about negative impacts of the production process (Lustenberger 2001a, p. 27 - 32).

3.3.1 Method and procedure of Delphi study

Historically the Delphi concept may be viewed as a spin-off of defense research in the early 1950s. The objective of the original study was to “obtain the most reliable consensus of opinion of a group of experts ... by a series of intensive questionnaires interspersed with controlled opinion feedback.” (Linstone and Turoff 1975, p. 10).

The Delphi study is a special form of expert interviews (Lombriser and Abplanalp 1998, p. 124). It is a useful method for proposal of possible solutions and for the evaluation of various solution versions. The Delphi study is a collective opinion building process, that occurs in an anonymous, standardized and multistage written questionnaire (Lombriser and Abplanalp 1998, p. 124-125). The communication process dealing with complex problems is a central aspect of the Delphi technique. “Delphi may be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem.” (Linstone and Turoff 1975, p. 3). It supports the creation of a “common language”.

The following characteristics describe the Delphi technique (According to Linstone and Turoff 1975, p. 5; Hess and Lehmann 1998, p. 9):

- Use of a questionnaire.
- The participants of the respondent group and their answers are anonymous.
- The monitor group evaluates the results and builds a statistical group answer.
- Based upon the results a new questionnaire is developed and will be sent to all participants of the respondent group.
- The respondent group has at least one opportunity to re-evaluate its original answers based upon examination of the group response.

As already illustrated at the beginning of chapter 3 the Delphi study can be considered as a forecasting procedure – so it is looking for trends about what is going on in ‘the heads’. Linstone and Turoff (1975, p. 4) specifies further reasons for the application of a Delphi technique, that is shown in the following list:

- The problem does not lend itself to precise analytical techniques but can benefit from subjective judgments on a collective basis.
- The individuals needed to contribute to the examination of a broad or complex problem have no history of adequate communication and may represent diverse backgrounds with respect to experience or expertise.
- More individuals are needed than can effectively interact in a face-to-face exchange, or time and cost make frequent group meetings infeasible.
- Disagreements among individuals are so severe or politically unpalatable that the

communication process must be refereed and/or anonymity assured.

- The heterogeneity of the participants must be preserved to assure validity of the results, i.e., avoidance of domination by quantity or by strength of personality.

The last point of domineering personality is also stated by Turoff (1975, p. 86) where he defines further reasons. His arguments are based on a rather psychological background that have motivated attempts to seek substitutes for the committee process.

- The unwillingness of individuals to take a position on an issue before all the facts are in or before it is known which way the majority is headed.
- The difficulty of public contradiction of individuals in higher positions.
- The unwillingness to abandon a position once it is publicly taken.
- The fear of bringing up an uncertain idea that might turn out to be idiotic and result in a loss of face.

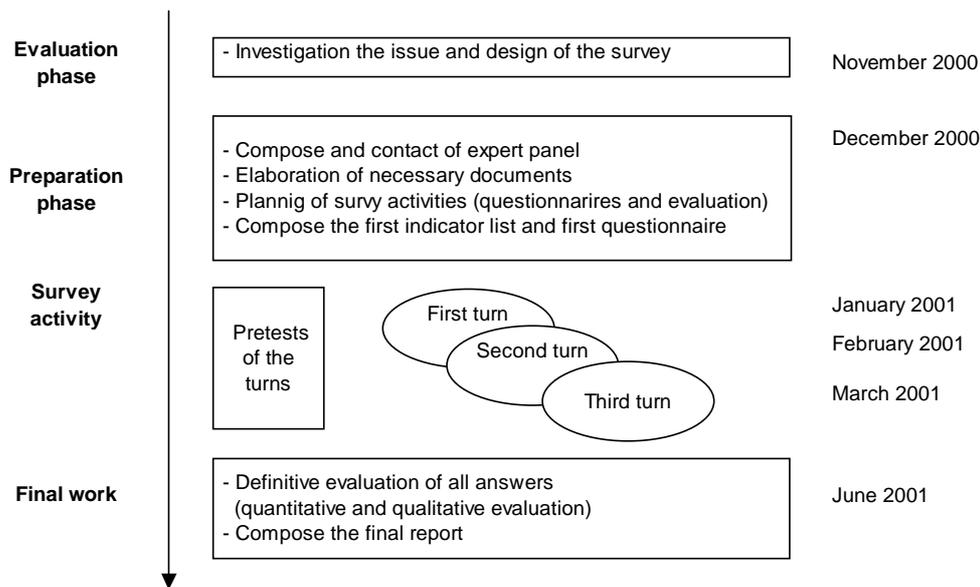
Based upon these points it can be deduced that a Delphi study deals with subjects and issues that are not value-free. The subjective opinion of experts and opposed views within an interdisciplinary group of experts can be combined in a Delphi study.

The problems involved in carrying out a Delphi study are stated by Linstone and Turoff 1975. The common reasons for the failure of Delphi are the imposing monitor view and preconceptions upon the respondent group and not allowing the contribution of other perspectives related to the problem. It also has to be considered that Delphi cannot be a surrogate for all other human communications in a given situation. Another problem are poor techniques of summarizing and presenting the group response and ensuring common interpretations of the evaluation scales utilized in the exercise. Further risks are ignoring and not exploring disagreements, and underestimating the demanding nature³⁸ of a Delphi and the fact that respondents should be recognized as consultants (Linstone and Turoff 1975, p. 6).

The survey is structured in rounds of questionnaires, answers of the respondent group, evaluation through the monitor group, re-evaluation of answers through the respondent group and further questionnaires. The number of rounds depends on the goal and the complexity of the issue.

The Delphi study was carried out in four phases, these phases and the timeframes are illustrated in Figure 24. The procedure ran from November 2000 until June 2001.

³⁸ In the Delphi study are made high demands on the participants (complexity of the topic and time-costing).

Figure 24: Procedure of the Delphi study

Source: According to Hess and Lehmann 1998, p. 19

3.3.2 Experts in the Delphi study

According to Lombriser and Abplanalp (1998, p. 124) an expert group should ideally include internal and external experts and should also be made up of interdisciplinary experts. Creating panels is usually the first task and one of the most important steps. Scheele (1975, p. 68) distinguishes three kinds of panelists that may be part of a panel for creating a successful mix. The three categories are: stakeholders (those who are or will be directly affected), experts (those who have an applicable speciality or relevant experience), and facilitators (those who have skills in clarifying, organizing, synthesizing, stimulation, etc.). According to Scheele (1975) the proportion of a panel from each category should be tailored for each application. According to Hess and Lehmann (1998, p. 14) it is promising to start with a small group of potential panelists and to evaluate further panelists together with them.

In the case of the present Delphi study it was important to have experts from the production process downstream to consumption. Another condition was the opinion of external experts that are not involved directly in the flow of goods. The experts have been chosen through these two criteria. Initially 30 experts agreed to become part of the panel of the Delphi survey. From the 30 questionnaires that have been posted to the panel in the first round the rate of return was 23 questionnaires (77%)³⁹.

Table 13 shows the list of the participants of the survey, the sectors, organizations, and their names. The classification of the panel in group A to C is chosen according to the market structure. Group A is considered as part of the producer market, whereas group B is part of the consumer market. Group C is considered as outside of the trade chain.

³⁹ For additional information see Lustenberger 2001a.

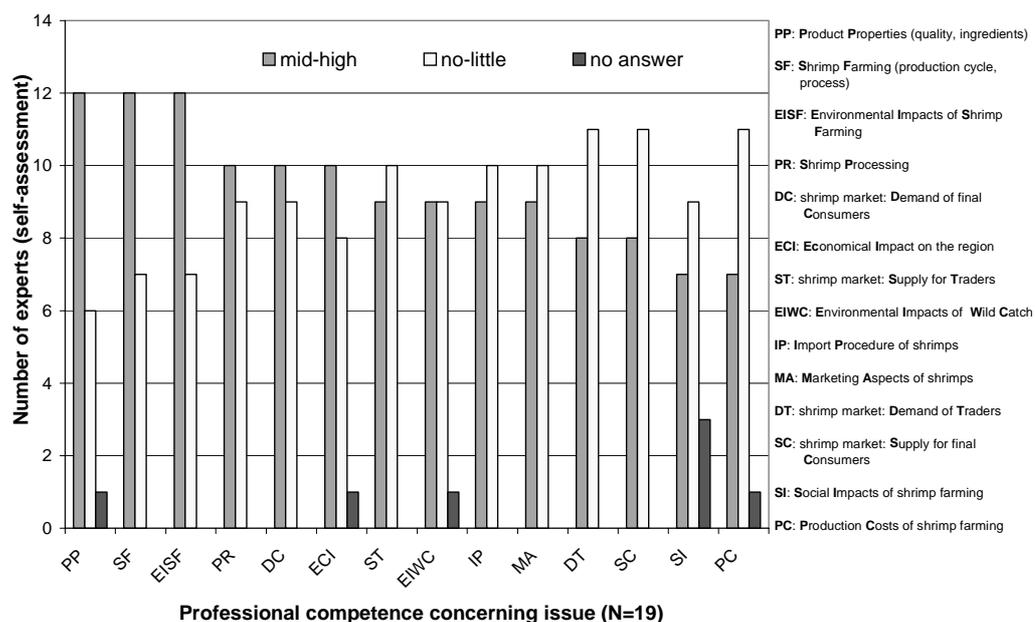
Table 13: Experts participating in the Delphi study

	Sector	Organization	Name of Expert	participating in rounds
Group A	Producer	Camanor, Shrimp farm, Brazil	Werner Jost	1+2+3
		Sibner Hegner Import	Alfred Blattmann	1+2+3
	Importer and Trader	Bianchi AG	Rudolf Bachmann	1+2+3
		Frionor AG	Remo Glaus	1+2+3
Group B	Retailer	Migros	Erwin Freitag	1+2+3
		Coop	Stephan Lustig	1+2+3
		Globus	Hansrudolf Obrecht	1+2+3
	Gastronomy	SV-Service	Victor Zemp	1+2+3
		Futurelog (Mövenpick company)	Markus Bader	1+2+3
		Nordsee GmbH & Co. Germany	Michael Bannick	1
		Candrian Seafood AG, Franchise of Nordsee	Karl Dübendorfer	1
	Consumer	Foundation for consumer protection	Eric Send	1+2+3
Consumer		Franz Geiser	1	
Group C	Media	NZZ, Bangkok-Office (field correspondent)	Urs Morf	1+2
		Handelszeitung	Michael Zollinger	1
	NGO's	Greenpeace Schweiz	Andreas Schneider	1+2+3
		Max Havelaar	Heini Conrad	1+2+3
		WWF / Scomber consultancy	Kees Lankester	1+2
	Science and others	Geographical Institute, University of Zurich	Norman Backhaus	1+2+3
		Swiss Federal Institute of Technology Zurich, food technology	Leo Meile	1+2+3
		Federal office for Veterinary	Thomas Jemmi	1+2+3
		Alltech inc (feed manufacturer for aquaculture)	Peter Spring	1+2+3
		Natuland (for organic certification)	Stephan Bergleiter	1+2

Source: According to Lustenberger 2001b

The control of the quality of the expert panel was done in the first round based on a self-assessment of the experts. The self-assessment is shown for the 19 experts that continued in the second round (see Figure 25). For a better overview two categories of professional competence have been added in “no or little”, and “mid or high” professional competence concerning one criteria.

Figure 25: Self-assessment of the experts



Source: Adapted from Lustenberger 2001a

According to the self-assessment the knowledge about product properties, grow-out process on a shrimp farm, and environmental impacts of aquaculture is relatively high. Less knowledge in the group exists related to production costs, social impacts, supply side of final consumer, and demand side of trader.

3.3.3 Results of the Delphi study

3.3.3.1 First round

Content and objectives

The questionnaire of the first round contains three parts. The first part includes the self-assessment about professional competence of the experts. The second part deals with comments on statements about shrimp production from aquaculture. The third part are open questions concerning trends and effects of shrimp farming (see Lustenberger 2001a, p. 85-94).

The objectives of the first round have been 1) to evaluate the professional competence, and to determine the state of knowledge, 2) to record the general attitude of the experts towards shrimp farming, and 3) to elaborate criteria of what should be considered regarding shrimp farming activities.

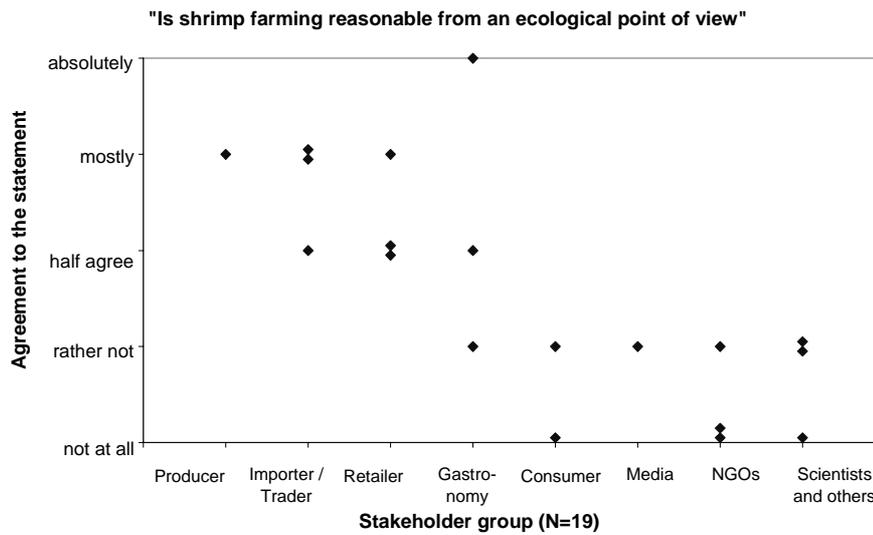
Results

The results have been presented to the panelists in the second round of the Delphi study for a re-evaluation of their answers. The results are based either on all 23 answers of the first round - if their answers were not used for further questions - or on the 19 experts that continued in the second round (see Table 13).

Based on the professional competence concerning environmental impacts of aquaculture (shown as one criterion in Figure 25) the consistence in the expert opinions was tested. As an example the experts had to evaluate the statement whether shrimp farming is reasonable from an ecological point of view. The experts had to value their agreement with this statement. The relation is shown in the Appendix, Figure 92. It can be shown that professional competence of the experts was not correlated with their agreement to a correspondent statement. A similar pattern was shown regarding the professional competence about social impacts and the agreement to the statement whether shrimp farming is reasonable from a social point of view.

Further, the agreement is classified by stakeholders which is shown in Figure 26. The opinion of the three stakeholders from the group 'gastronomy' vary from 'rather not' to 'absolutely', whereas the other stakeholder groups are relatively consistent in their opinions. It can be concluded, that for the evaluation of a statement the interests of the experts are more important than their professional competence. It has to be pointed out that this conclusion is based on this expert panel, and on their self-assessment. Furthermore it has to be stressed that the number of experts is different in every group.

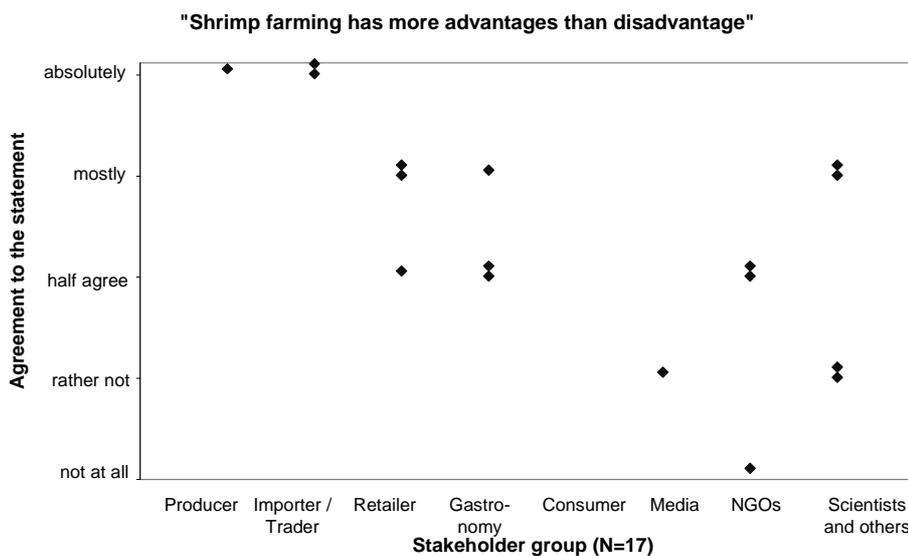
Figure 26: Statement by stakeholder group concerning ecological reasonability



Source: Adapted from Lustenberger 2001a

There is a clear tendency along the trade chain from producer to consumers. In all questions about the reasonability of shrimp farming (whether shrimp farming is reasonable from an ecological, social, and economical point of view) the producer’s agreement to the statement is higher than that of the consumer (Lustenberger 2001a, p. 41-42). The agreement with the statement of the stakeholder groups ‘Consumer’, ‘NGO’ and ‘Scientists and others’ are similar. The differences concerning the reasonability between the stakeholder groups indicate generally different attitudes and may be a potential conflict in the discussion about sustainable shrimp farming. Even though shrimp farming may not be reasonable from a specific point of view it is important to focus on opportunities and possible ways to make shrimp farming more sustainable. In the same part of general statements the experts had to comment on the statement whether shrimp farming has more advantages than disadvantages. The agreement to this statements is shown in Figure 27.

Figure 27: Statement by stakeholder group concerning advantages and disadvantages



Source: Adapted from Lustenberger 2001a

The experts also had to comment on the statement whether shrimp farming should be abolished. This question has been asked as a control question to the question illustrated in Figure 27. It could be shown that the comments concerning abolishment correspond with the comments to the question of advantages and disadvantages (see Appendix, Figure 93). This is an indicator of good data quality of the respondent group.

The elaboration of possible criteria took place through open questions. The objective of these open questions is to elaborate new aspects of possible criteria and requirements, and to focus on a specific issue (Theler 2001, p. 115). The questions have been structured to determine requirements concerning site evaluation, environment, social equity, financial aspects of a shrimp farm, larvae production, health and animal management, feed management, use of chemicals, water management, and processing and distribution activities⁴⁰. The classification in these types of requirements is based on the consideration of up- and downstream activities of shrimp farming (from larvae production to processing) and on the special focus of sustainability (economical, environmental, and social issues).

The criteria and requirements defined by the panelists are structured into five groups. The groups correspond to important aspects which are illustrated in the desk research (see 3.1.1.2 and 3.1.2). The groups are: Site evaluation, production process (grow out), environmental issues, social equity, economical issues and processing. Further information and the detailed criteria and requirements are shown in Lustenberger (2001a, p. 99-111).

According to the objectives of the first round following points can be concluded:

- ⇒ According to the self-assessment and to the experience and activities of the panelists the necessary knowledge in the expert group is available.
- ⇒ The general attitudes of the experts against shrimp farming are contrasting. The opinions vary mainly between different interest groups (represented in stakeholder groups).
- ⇒ The criteria / requirements of the experts correspond in many cases of what the literature states.
- ⇒ The criteria describes different types of requirements. Some of the criteria are closed criteria, which can be fulfilled or not, other criteria need a limit or an additional specification (e.g. it can be prohibited that shrimp farms are built on former mangrove areas. On the other hand the question of adequate wages need a specific definition of what is meant by 'adequate').

3.3.3.2 Second round

Content and objectives

The questionnaire of the second round contains two parts. The first part is a summary of the results of the first round and the second part includes the validation of the criteria and requirements defined in the first round (see Lustenberger 2001a, p. 96-112).

The objectives of the second round have been 1) validation of the results of the first round 2) estimation of the importance of the requirements defined 3) variation between the different opinions concerning the importance and 4) definition of requirements for a possible label for sustainable shrimp farming.

⁴⁰ Questions are shown in Lustenberger 2001a, p. 43-44 and p. 90-93.

Results

Most of the experts agreed to the comments on the statements of the first round. Aspects that were focused on were the variation of the interests within and between the stakeholder groups. One aspect is the heterogeneous formation of group C (NGOs, Media, Scientists and others) and the fact that the members of this group do not depend directly on the shrimp business. It also has to be noted that the groups are relatively small (one to five members per group).

The evaluation of the criteria that resulted from the first round included the following four tasks: 1) Evaluation of criteria according to its importance 2) Reasons for the rating (why is it important or why not?) 3) Explanation and definition of the terms (how can the criteria be specified?) and 4) Define measurable indicators. In this last point the panelists defined limits for a possible implementation of the requirements. For instance, regarding the question of mangroves the experts have been asked about the percentage of ecological important area that has to be sustained. Additionally they have been asked what they think about the criterion of no net loss of ecological important areas.

The evaluation of the importance has been conducted through valuation with points. 100 points indicates an estimation of 'very important' and zero points 'absolutely unimportant'. The results of this evaluation concerning environmental aspects is shown in Figure 28. Eleven criteria concerning the environment have been classified. The given possibility for 'no answer', resulted in varying number of answers (N=12 thru N=16). The average of the experts results per group were calculated (A, B, and C) as well as the average of all panelists (see lines in Figure 28). The variation coefficient was also calculated, which depicts a measure for the variation of the answers. It is a convenient measure for not negative figures and is used to compare different variations (Fahrmeir, et al. 2001, p. 71). The variation coefficient is also used to compare the variation of several samples with different mean values (Köhler, et al. 1996, p. 38). The coefficient is calculated as shown in Equation 4.

Equation 4: Variation coefficient

$$v = \frac{\sigma}{\bar{x}}; \bar{x} > 0$$

Source: Fahrmeir, et al. 2001, p. 71

whereas:

$$\sigma \quad \text{standard deviation} \quad \sigma = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2} \quad (\text{Fahrmeir, et al. 2001, p. 68})$$

n number of results

\bar{x} mean value

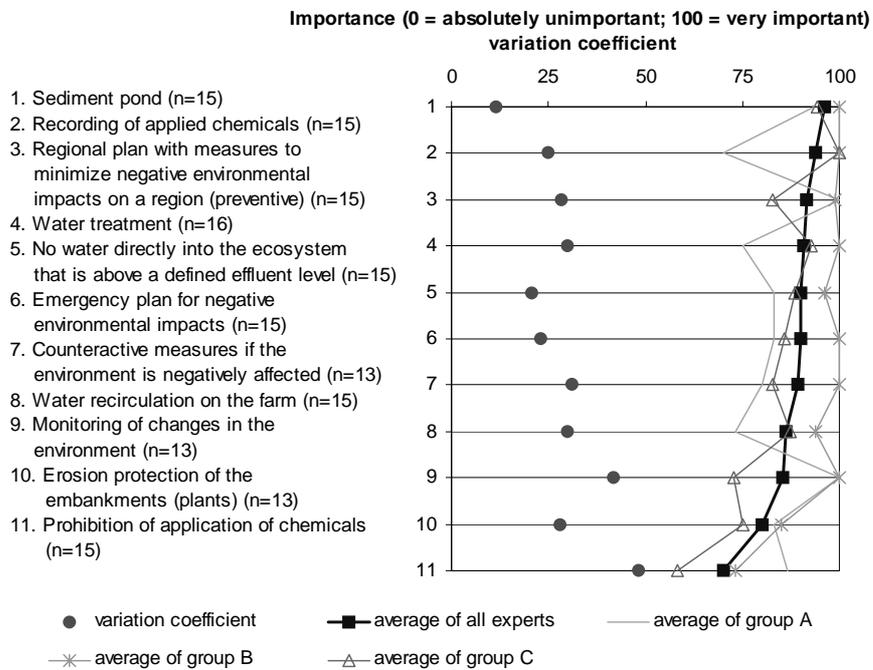
The variation coefficient v is calculated within all the answers of the experts and multiplied by 100. A low variation coefficient is equivalent to a consistent opinion on one criterion. Variation coefficients which are higher than 40 reflect a high variation (Lustenberger 2001a, p. 48).

Environmental aspects

With an average of N=14,6 answers to these criteria, 77% of the panelists classified the criteria concerning the environmental aspects. It can be shown in Figure 28 that group B (retailer, gastronomy and consumers) considers the environmental criteria as more important than group A (producer, importer). Group C (Media, NGO, scientists and others) is generally intermediate to the other two groups. The most important two criteria are the sediment pond and the recording of applied chemicals. The panelists agreed to the necessity of a sediment pond

with a variation coefficient of 12. A relatively high agreement can be seen concerning criterion 5 (water into the ecosystem) and 6 (emergency plan). The lowest agreement was concerning criterion 11 (prohibition of application of chemicals). This criterion is also considered as less important relative to the other criteria of the same group.

Figure 28: Importance of criteria concerning environmental criteria



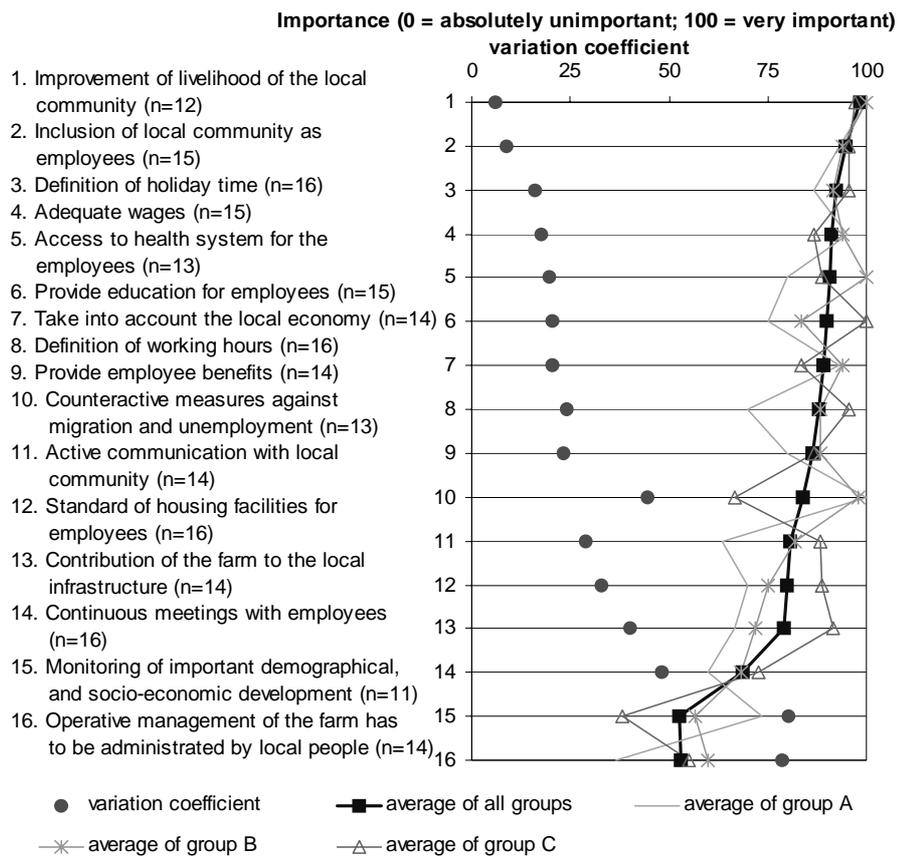
Source: Adapted from Lustenberger 2001a

Social aspects

The rating for the 16 social criteria was done in the same way as the environmental criteria (shown in Figure 28). This rating is shown in Figure 29. In the average 75% of the panelists classified this set of criteria.

The first 9 criteria (with more than 85 points) may be considered to be very important for the experts. As important criteria with a high consistency are criterion 1 (improvement of livelihood of the local community), and 2 (inclusion of local community as employees). Criterion 16 (operative management by local people), and 15 (monitoring of important demographical socio-economic development) reflect lower consistency. The variation coefficient of these two criteria amounts to 79 respectively 81. Generally it can be stated that those criteria which are evaluated as important criteria show a high consistency. And criteria that are considered as less important, show a higher variation in the experts view. It may be concluded that it is worthwhile to focus on a few criteria that are considered as important and where experts are consistent in their evaluation, whereas other criteria contain conflict according to different evaluation.

Figure 29: Importance of criteria concerning social criteria



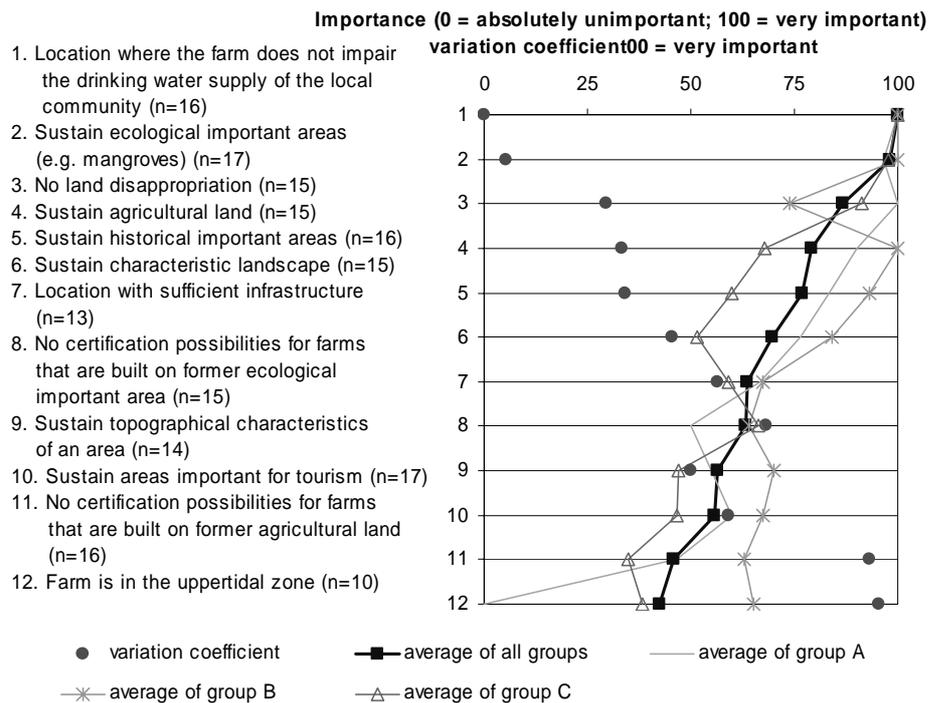
Source: Adapted from Lustenberger 2001a

In the group of economical criteria two criteria have been classified. Criterion 1 considers the financial compensation for the compliance of the requirements and the second criterion is the share of the profit earnings with the local community. All other economical and financial important criteria are considered as basic business requirements and are not evaluated in this Delphi study especially focusing on sustainability requirements. The first criterion of the financial remuneration was considered as more important than criterion 2 (profit earning for local community). The second criterion also had a higher variation coefficient (67%) that indicates a low consistency of the experts opinion. Both criteria are evaluated as less important by group A than by all other groups.

Site evaluation aspects

The experts classified 12 criteria concerning site evaluation (both concerning new location and existing locations). The classification is shown in Figure 30.

Figure 30: Importance of criteria concerning site evaluation



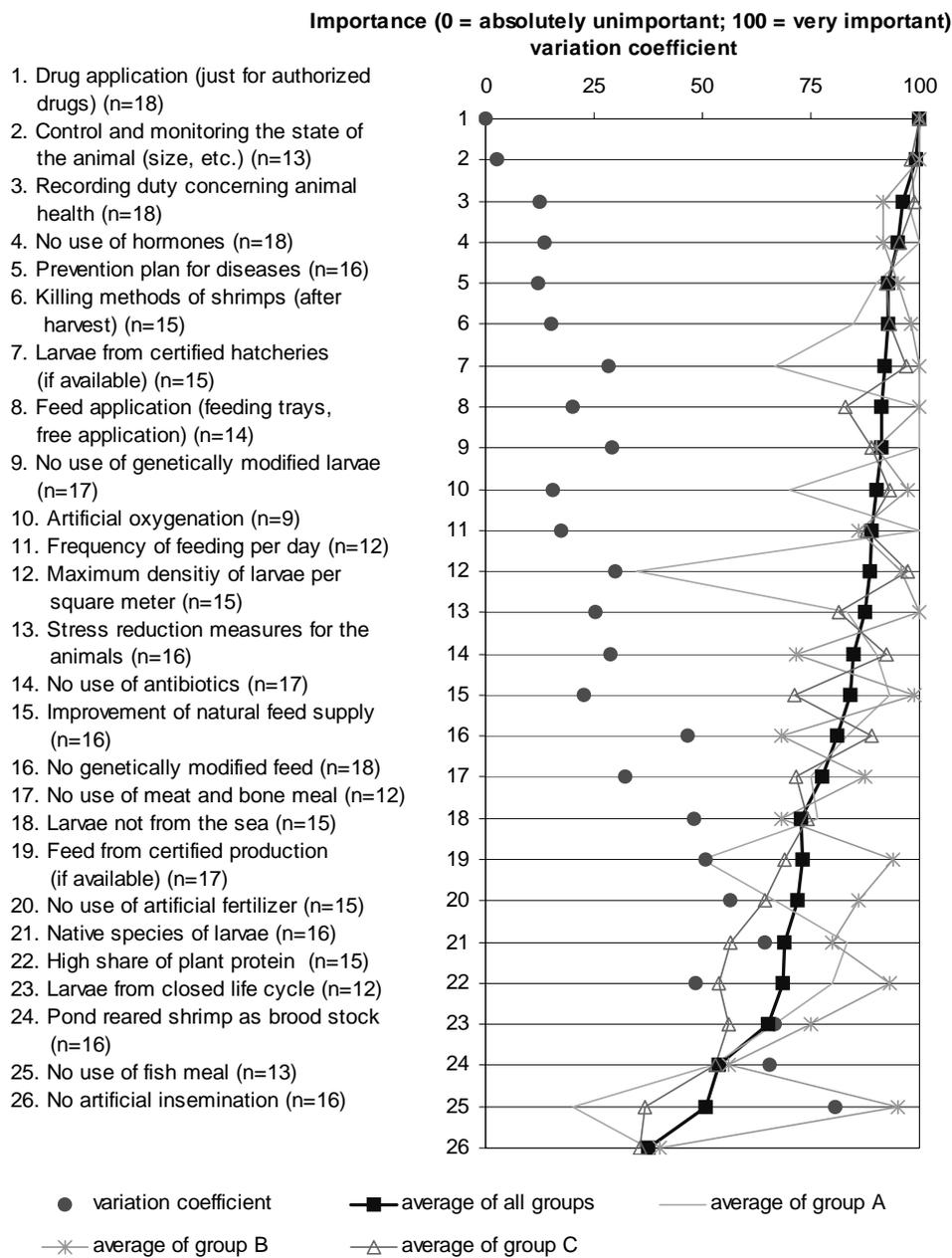
Source: Adapted from Lustenberger 2001a

Not to impair drinking water supply of local community is considered by all experts as a very important criterion and the experts are absolutely consistent relating to this point. Also criterion 2 (sustain ecological important areas) is considered as very important and shows a low variation coefficient. There was almost no consistency in the two less important criteria (farm in the upper tidal zone and no certification possibilities for farms that are built on former agricultural land). One reason for the inconsistency concerning these two criteria may be the fact that these requirements depend on the area and on the kind of production system applied (see Table 6, p. 51). The tendency recorded in Figure 29 is even more pronounced in Figure 30 where the high consistency is in criteria considered as important and the less consistency in criteria as considered less important.

Grow-out aspects

The experts classified 26 criteria regarding production process. The criteria covered input characteristics, such as origin of PL and feed content, general production management, such as use of aerators, and harvesting methods. The classification of these criteria is shown in Figure 31. The most important criterion, with a very low variation coefficients, are criteria 1 (application of authorized drugs) and 2 (control and monitoring the state of the animal). The requirement of traceability is included in various criteria (e.g. 2, 3, and 7). Preventive measures are also included in several criteria (e.g. 5, and 13). The least important criterion of this group with the lowest consistency in the view of the experts (variation coefficient 103) is the requirement of no artificial insemination.

Figure 31: Importance of criteria concerning production of shrimps (grow out)

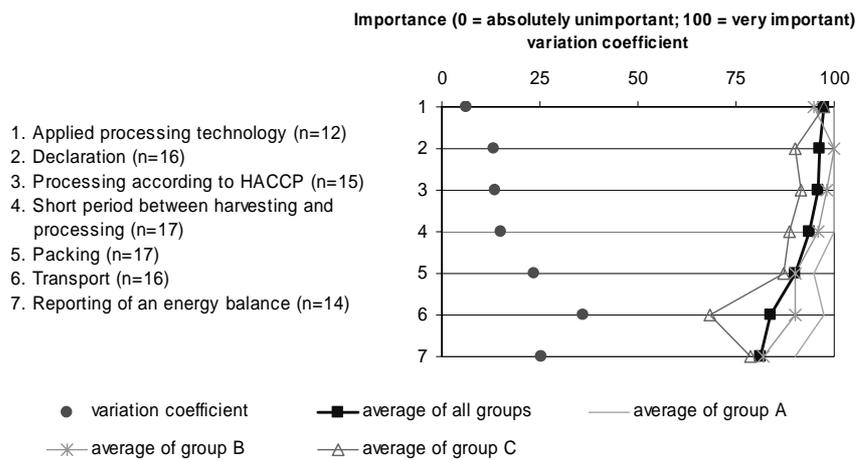


Source: Adapted from Lustenberger 2001a

Some of the criteria depend strongly on the production system (see Table 6, p. 51) and the variation in the expert opinion can be explained due to different knowledge about farming systems (e.g. frequency of feeding depends strongly on the intensity of the production system). Criterion 14 (no use of antibiotics), might be evaluated differently after the headlines related to antibiotics in shrimp (January 2002).

Processing aspects

In the last group the experts had to classify criteria concerning processing of shrimps. The question of processing technology applied and the declaration are the most important criteria. Whereas reporting of an energy balance and transport are classified as less important by the experts.

Figure 32: Important criteria concerning processing of shrimps

Source: Adapted from Lustenberger 2001a

Comparing the six groups of criteria (environmental aspects, social issues, economical issues, site evaluation, production process, and processing) differences between the groups can be recognized. For instance the criteria set on processing is generally considered as more important by group A (with an average of 98) than by group C (average of 86). A similar result can be shown concerning site evaluation criteria. On the other hand the social aspects are considered as more important by group C (with an average of 93) than by group A (average of 82).

There have been additional comments relating to the second round of the Delphi study. While some of the criteria have been too technical and too detailed for some experts it was too superficial for other experts. This rating depends on the professional competence and the experience of every single expert.

According to the objectives of the second round the following points can be concluded:

- ⇒ The panelists added four criteria to the initial list of 74 criteria. It can be concluded that the proposed criteria covered the most important requirements.
- ⇒ The main part of the criteria have been evaluated as important or very important. Only a few criteria in each group were considered as rather unimportant⁴¹.
- ⇒ The definition of the label could be elaborated with the additional comments of the experts concerning the criteria. It is a big challenge to describe the requirements as clear as possible.

3.3.3.3 Third round

Content and objectives

The questionnaire of the third round contains two parts. The first part includes the ranking of the criteria within their groups. The main idea of ranking the aspects was to constrain the experts responses. The panelists had to prioritize the criteria and assess them with points. The second part includes an estimation of the willingness to pay and an estimation of its market potential based on a defined label from the second round. In the context of the elaboration of requirements (see 3.4) the results of the estimation of willingness to pay are not relevant. For further information about this topic see Lustenberger (2001a).

⁴¹ It has to be mentioned that with this classification the experts did not have to make a ranking of the criteria. One could classify all criteria as very important without assign priorities.

In this context the objectives of the third round have been 1) the ranking of the aspects and criteria as a validation and continuation of the results from the second round and 2) comments on the label defined as a result of the second round.

Results

As shown in Table 13, p. 68 three of the 19 panelists did not participate in the third round (because of missing time or missing experience). The rate of return was therefore 84 percent. Group C decreased from nine to six members. According to the results from the second round the sustainability criteria were classified in five groups. The five groups included: environmental-, social-, economical-, production process-, and site evaluation criteria. To determine, which of these groups has to be considered in a possible label for sustainable shrimp farming the groups have to be prioritized.

The group of environmental criteria has been classified by all expert groups (A, B, and C) as the most important group. Site evaluation was considered as the least important group of criteria by expert groups A and B⁴². Group C considered the economic criteria as the least important group of criteria for the definition of a label (see Appendix, Table 49).

The results of round 2 have been presented to the panelists and they had to prioritize the criteria within a criteria group (e.g. the experts had to distribute 100 points to the 12 criteria of the site evaluation). This prioritization in round three was on one hand a validation from the classification of the second round, and on the other hand – as it is typical for a Delphi study – a process of opinion formation. The answers of the experts can either be independent of what was presented to them as a result of the second round or can be a consequence of the classification presented. For instance if an expert did not agree with the classification of the importance of one criterion he might intend to change this result by surpassing weighting of another criterion (“strategic answering”). Weighting was done in different ways according to the experts. Some of the experts distributed the points to few criteria, whereas others distributed the points to all criteria. In the following section the main differences to the results from the second round will be discussed. The classification is based on the ranking of the criteria. The first column (importance in round 2) corresponds with the numeration of the criteria resulted from the second round.

Environmental criteria

Table 14: Ranking of environmental criteria round two and three

Ranking round 2		Ranking round 3
5	Water effluents above critical level not directly into the ecosystem	1
3	Regional plan with preventive environmental measures	2
7	Counteractive measures against environmental degradation	3
2	Recording of chemical application	4
4	Water treatment	5
6	Emergency plan	6
11	No chemicals	7
8	Water re-circulation (closed system)	8
1	Sediment pond, settlement	9
9	Recording of environmental changes	10
10	Erosion protection	11

The first three criteria of the third round became more important relative to the second round. Criterion 5 (avoiding water effluents above a critical level to flow back directly into the ecosystem) became the most important criterion. On the other hand the requirement of a sediment pond became less important in the third round relative to the second one. It has to be stated that some of the criteria encompass various aspects. For instance to build a closed water system (criterion 8) with re-circulation needs to have a sediment pond (criterion 1).

⁴² This is surprising, because the main environmental impacts are caused through a wrong site evaluation.

This means that some of the criteria could be summarized in one single requirement.

Social criteria

Table 15: Ranking of social criteria round two and three

Ranking round 2		Ranking round 3
2	Involvement of local employees	1
6	Education	2
4	Adequate wages	3
5	Access to health facilities	4
1	Improvement of livelihood of local community	5
12	Housing facilities of employees	6
9	Social benefits for employees	7
13	Improvement of infrastructure	8
8	Definition of working hours	9
7	Consideration of local economy	10
11	Active communication with community	11
14	Continuous meetings with employees	12
10	Counteractive measures against migration and unemployment	13
3	Definition of vacation time	14
16	Local people in operative management	15
15	Recording of demographical changes	16

The first four criteria ranked in round three became more important relative to the ranking of the second round. On the other hand the criteria 1 (improvement of livelihood) and 2 (definition of vacation time) became less important relative to the second round.

The first seven criteria of ranking round 3 include measures to improve the situation for the employees of the shrimp farm.

Site evaluation criteria

According to the site evaluation criteria there is almost no difference in the ranking from round two to the ranking from round three (see Appendix, Table 50). ‘Not affecting drinking water’, ‘Sustain ecological important areas’, ‘No disappropriation’ and ‘Sustain agricultural important areas’ remain as the four most important criteria also in the third round.

Production process criteria

Table 16: Ranking of production criteria round two and three

Ranking round 2		Ranking round 3
1	Just authorized drugs, medicals	1
4	No hormones	2
14	No antibiotics	3
3	Recording of animal health	4
15	Improvement of natural feed	5
12	Definition of max. density	6
9	No GMO post-larvae	7
2	Control and monitoring of animal state	8
17	No meat and bone meal	9
23	PL from closed cycle	10
22	High share of plant protein	11
13	Stress reduction measures	12
16	No GMO feed	13
6	Killing method	14
11	Feeding frequency	15
5	Disease prevention plan	16
7	PL certification	17

Compared to the second round the criteria 14 (No antibiotics), 15 (Improvement of natural feed), 12 (Density), 17 (No meat and bone meal), 22 (High share of plant protein), and 23 (PL from closed cycle) became more important in the third round. Criteria 8 (Feed distribution), 10 (No artificial oxygenation), 7 (PL certification), 5 (Disease prevention plan), 11 (Feeding frequency), and 6 (Killing method) became less important.

18	PL not from the sea	18
19	Organic feed	19
21	Native species	20
20	No artificial fertilizer	21
24	Brood stock not from the sea	22
25	No fish meal	23
10	No artificial oxygenation	24
8	Feed distribution	25
26	No artificial insemination	26

Based on the weighting of the criteria in the third round the variation coefficient (%) has been calculated. The graphical illustration of these results is shown in the Appendix (Figure 94 to Figure 97). The variation coefficient is generally higher in the third round than in the second round. There is also no notable tendency that the variation coefficient is lower for criteria classified more important, such as it was recorded in the second round.

According to the objectives of the third round the following points can be concluded:

- ⇒ Environmental criteria are considered as the most important group of criteria for a possible definition of a label.
- ⇒ Site evaluation are considered as the least important criteria even though these criteria help to avoid many negative environmental impacts (see 3.1.1.2).
- ⇒ Concerning the production aspects central criteria include feed management (antibiotics, hormones, natural feed) and health management, such as record keeping and stress reducing measures.
- ⇒ The most important social criteria include improvements for the employees and their situation.
- ⇒ Based on the changes in the ranking of the criteria it can be concluded that the issue of sustainable shrimp farming is a controversial one. What is considered as important for shrimp farming is in the process of opinion formation.

3.4 Conclusions of desk- and primary research

Chapter 3 focuses on the impacts and requirements for sustainable shrimp farming. To summarize, the analysis was based on the following research question:

What are the requirements for sustainable shrimp farming based on selected stakeholders' opinions?

Before answering the research questions an overview will be given of the most important impacts stated in the primary- and desk research. As illustrated in Table 17 impacts may have positive and negative aspects, according to their occurrence and to the environment affected.

Table 17: Impacts and their positive and negative aspects

Impact	Positive aspect	Negative aspect
Nutrient loadings in the discharged water	<ul style="list-style-type: none"> • Increased primary production through fertilization in the surrounding environment • Higher yields of local fishery 	<ul style="list-style-type: none"> • Risk for Eutrophication of the environment • Pollution of surrounding water system
Change land use	<ul style="list-style-type: none"> • Formerly unproductive land (e.g. abandoned salt mines) become productive again • Food production 	<ul style="list-style-type: none"> • Risk of destruction of ecologically important areas (mangroves, wetlands, etc.) • Risk of salinization of former agricultural land and of water (drinking water)
Installation of a new shrimp farm in a local community	<ul style="list-style-type: none"> • Creating jobs, job opportunities for local labor force • Security of income, multiplication effect • Farm demand for goods and services 	<ul style="list-style-type: none"> • Competition for resource use, e.g. access to mangrove areas

A main challenge is to strengthen the positive aspects and to try to avoid or minimize the negative ones.

The desk and primary research has shown that the requirements can be classified into requirements concerning economical, environmental and social sustainability. The responsibility to implement measures depends on the kind of measure. Lockwood (1997, p. 54) points out some causes (including failures of local and global government) for the actual concerns about shrimp farming. He also states that the international public sector has the prime responsibility for creating the framework for sustainable global commerce. Nevertheless the necessity of action by responsible shrimp farmers exists. The requirements can be grouped by the type of requirements (vertical axis) and by the level of action (who is responsible for the action). Muir (1996, p. 33) illustrates relevant factors related to aquaculture and water resources. He grouped the relevant factors on one hand into physiochemical, bio-ecological, socio-economic and production and on the other hand on scale levels geo, macro, median, small, micro, and nano.

The requirements evaluated through the desk- and primary research are shown in Table 18. The level of action is divided in three groups: national level, sectoral level, and farm level. The requirements are divided in economical and financial requirements, environmental and social requirements.

Table 18: Requirements and level of action - tasks

		Level of action		
		Government / National (NL)	Sector/professional organization (SL)	Producer / Farmer (CL)
Requirements concerning...	Economical, Management	<ul style="list-style-type: none"> • Planning and zoning (integrated coastal management) • Provide good infrastructure 	<ul style="list-style-type: none"> • Transparent information policy 	<ul style="list-style-type: none"> • Profit to guarantee the viability of the company • Cost control • Efficient use of inputs • Control of diseases • Management strategies incorporated into farm planning • Implement value focus to avoid short-term profit thinking • Farm contributes to the national income (currency, taxes) • Implementation of standardized processes, dominate of production vs. random production results
	Environmental	<ul style="list-style-type: none"> • Planning and zoning (ICM: integrated coastal management): build a framework for the site evaluation • Prevention of ecologically sensitive areas – no locations where could be affected drinking water • Environmental impact assessment (EIA) • Legislation concerning licenses, control of animal movement, drugs and chemical use • Regulation of use of chemicals, antibiotics, etc. • Inspection of farms concerning legal aspects (authorization) 	<ul style="list-style-type: none"> • Contribute to studies to test effect of chemical application (identify major environmental impacts, and define better environmental management) • Ideas for environmental activities, additional to the legislation, e.g. mangrove reforestation of a specific area (preventive environmental measures) • Planning and monitoring of development of different production systems (intensive – extensive) 	<ul style="list-style-type: none"> • Efficient use of resources, especially natural resources • Control of chemical use (no hormones, no antibiotics) • Advanced planning for better predictions • Reduction of negative externalities • Reduction of waste and nutrient loadings • Control of effluents (sediment pond) • Reduction of stress factors for the animal (disease prevention) • Recording of all applications and of animal state • Improvement of natural feed supply
	Social	<ul style="list-style-type: none"> • Contribute to equity (rules for minimum wages, working conditions) • Provide better infrastructure (e.g. general education, health facilities) • Regulating property rights 	<ul style="list-style-type: none"> • Provide technical education specific to the needs (courses, meetings, etc.) • Communication with local, regional, and national governments 	<ul style="list-style-type: none"> • Create job opportunities • Employ local workers, involve in management • Education possibilities for the employees • Adequate wages • Attention to more local participation • Livelihood improvements
	Others		<ul style="list-style-type: none"> • Promotion, Monitoring and Communication of labels, codes of conduct, etc. 	

The requirements can be translated in a set of indicators that are measurable and also controllable. The indicators can provide assistance in decision-making at various levels (see Table 18). It is necessary to define requirements and indicators for a possible label in a way that the label is generally valid and understandable so that it can be easily communicated. This helps to create and relate a certain image to a label and its attributes. A very important point is that the label focus on specific crucial points to address the central issues of either evident connections of actions and negative impacts or of central requirements of the interest groups.

Based on the analysis in the chapters 3.1 until 3.3, and the overview in Table 18 defines a framework for a possible label for sustainable shrimp farming. The requirement for this label is illustrated in Table 19.

Table 19: Framework for a possible label

<p><i>Site evaluation</i></p> <p>Land disappropriation is prohibited. There is no net loss of mangroves and wet lands accepted. The water supply of the local community must not be affected by the shrimp farm.</p> <p><i>Input</i></p> <p>If available, post larvae has to be bought from hatcheries. As many inputs as available, especially feed and PL should be acquired from certified (label certification) companies.</p> <p><i>Feeding management</i></p> <p>Meat and bone meal, hormones and antibiotics are prohibited, also no genetically modified larvae nor feed may be applied. If antibiotics have to be applied, the treated shrimp can not be sold as certified shrimp.</p> <p><i>Water management</i></p> <p>The shrimp farm has a water treatment facility and possibility for water re-circulation. There should be no direct water exchange with the ecosystem (sedimentation pond).</p> <p><i>Control and monitoring</i></p> <p>Relevant changes in the environment and of chemical and medical applications have to be recorded. The chemicals and medicals applied have to be listed and defined by an independent control group. The relevant animal changes and the health management have to be recorded. With the monitoring and records the traceability of the product should be guaranteed.</p> <p><i>Employees and community aspects</i></p> <p>All wages are adequate to regional wages, whereas the minimal wage has to be above the minimum wage defined by legislation. The farm has to provide all employees benefits and education for the employees. The local economy (if available) should be considered as an up- and downstream industry. The contact and the communication with the local communities and local authorities has to be part of the management duties. The enterprise has to implement/support a health and educational program for the employees and their families.</p> <p><i>Administration of the label</i></p> <p>The labelling organization has to be kept updated in time of drugs application not allowed for label products. The criteria will be controlled by an independent, professional, international board of control. The inspectors of this board are entitled to unannounced inspections and compose an annual statement of accounts.</p>

Requirements for a first certification are based on criteria which can be judged as achieved or not. For instance whether the farm has water re-circulation or not, or whether it has an educational and health program. For the re-certification in the following years the audit of the certifier should focus on improvements attained. It has to be pointed out that there are relatively few ‘experts’ in the field of sustainable shrimp farming. This is mainly due to highly specialized knowledge required, country specific cultural diversity, and few experiences of the relatively new industry.

4 Requirements outlined in a network for a shrimp farm

In this chapter the requirements of chapter 3 will be integrated by the method of the qualitative system dynamics approach into a network for a shrimp farm. The chapter is divided into three parts, the methods and procedures, the results, and the conclusions utilizing the qualitative system dynamics approach. The objective of this chapter is to identify Key Management Factors (KMF)⁴³ for sustainable shrimp farming.

Research Question:

What Key Management Factors for sustainable shrimp farming can be deduced from the requirements and theoretical cognitions?

Based on the question focus and on the research question it is evident that the sustainability indicators (including economical, ecological and social perspective) can not be evaluated and measured in an isolated way⁴⁴. The network building is done by a qualitative system dynamics approach⁴⁵. The network elucidates the interactions between the different indicators. The network and furthermore the portfolio (see 4.2.4) are used as a 'framework'. The KMF will be identified based on this framework and analyzed in part C (called 'spots'). Gomez and Probst (1997, p. 83) illustrate the functionality of the network and the spots. The authors distinguish between networked thinking, analytic, and synthetic thinking. Relative to the research question the identification of the KMF is done through networked thinking and the analysis of the KMF in part C, is analytical thinking. For instance 'Feeding management' may be defined as a KMF in the whole network. Feeding management includes variables such as feeding time, frequency of feeding, feed components, feed conversion ratio, feeding price, etc. Furthermore, the analysis of feeding management in part C includes, feed conversion ratio divided into productivity, and duration of the production cycle. This kind of analysis delivers numerical results about interactions within the KMF 'Feeding management'.

4.1 Method and procedure

4.1.1 Qualitative system dynamics approach

The method used in the network building process is shown in Gomez and Probst (1997) and is based on the theory of Ulrich 'Integral Management approach' and 'Network Thinking' with its application in the ecological context by Vester. It is a general method of system description and analysis which is based on a system theory approach (Vennix 1996, p. 110)⁴⁶. The network is a system thinking approach which is derived from an approach called qualitative system dynamics (see for example Senge 1996, Flood 1999, Vennix 1996). The network is a result of an interactive process with key persons dealing with an issue in focus. Qualitative system dynamics refers to the stages of problem identification and conceptualization. Quantita-

⁴³ The term has been explained in chapter 1, it involves 'important abilities and necessities for a management to guide a company'.

⁴⁴ "The system is more than the sum of its parts" Weberão 2002.

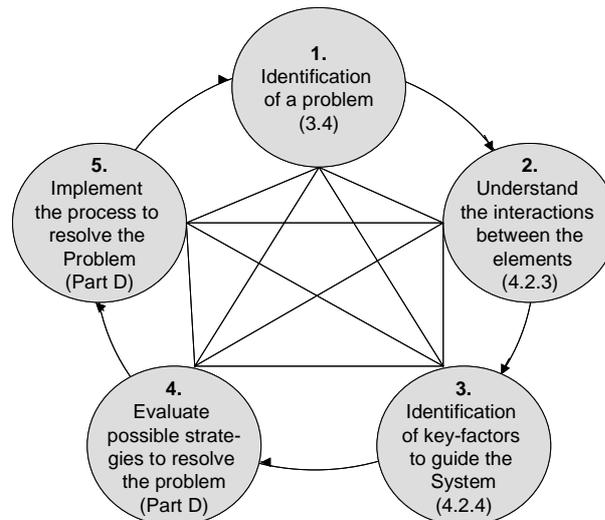
⁴⁵ According to Forrester, cited in Vennix (1996, p. 44) system dynamics is a theory of the structure and behavior of complex systems.

⁴⁶ Vennix (1996, p. 107) says that this is "primarily a diagnostic and impact assessment method: finding out what the problem is, what structural causes are responsible for it, and which policies prove robust to tackle the problem."

tive system dynamics involves building a model and using it as a simulation tool (Vennix 1996, p. 108).

Figure 33 illustrates the general method of the integral system approach used for complex problem-solving. Based on the research question the first three steps out of five will be discussed in this chapter, while step four and five are included in part D⁴⁷. The first three steps are the identification of the problem (see chapter 3.4), the definition of the interactions between the elements (see chapter 0) and the identification of KMF (see chapter 4.2.4). The strategies and implementation are part of further steps in the research project (Part D). An important point of the network is the ‘process-focus’. The process is iterative and includes five main steps (shown in Figure 33).

Figure 33: Problem-solving steps based on the method of integral system approach



Source: Based on Gomez and Probst 1997, p. 27

The system approach has many advantages. It helps to understand the relationship between structure and dynamics in a system. This knowledge and understanding might change perceptions of the system. The system approach initiates the creation of a shared social reality and language for mutual understanding, and foster consensus and commitment with the decision. (Vennix 1996, p. 109).

According to Gomez and Probst (1987, p. 7ff) the network building process helps to avoid faults dealing with complex situations. The authors argue that misleading assumptions are often the reason for failed problem solutions. These misleading assumptions are listed below:

- Problems are objective, they just have to be clearly formulated.
- Every problem is a direct consequence of one single reason.
- To understand a situation it is enough to take a picture of the actual situation.
- A forecast of behavior can be made based on good and enough information.
- All problem situations can be dominated with enough input (expenses).
- An “active” person can implement every problem solution in the praxis.
- With the implementation of a solution the problem doesn’t exist any more.

⁴⁷ According to the explication in the guidelines/workbook for the interviews Schwab (2001).

The main problem of these assumptions is that they disregard the human factor in social systems, acting based on subjective perception, neglect dynamic and environmental changes over time.

4.1.2 Relevance of the method used in this context

An advantage of the system dynamics approach is the creation of a common understanding. This is essential for a controversial issue like shrimp farming, and this approach provides a framework for the research to find a solution and to define a more sustainable system for shrimp farming.

The system dynamics approach has been used in various research projects. Most of the projects describe aquaculture as part of its natural environment focusing on ecological interactions. Folke and Kautsky (1992) depict aquaculture as an economic sub-system of the overall ecosystem. Troell, et al. (1999) built a simple conceptual model with the main purpose to view aquaculture from an ecological perspective focusing mainly on resource input and waste management. A broader system approach was utilized by Twilley, et al. (1998). The authors demonstrated with the strategic simulation model the important consideration of ecological constraints in determining economic and management decisions. The necessity to evaluate sustainability including the farm and its context was shown by all of the interactions described in 3.1.1 and 3.1.2 and is also based on the sustainability theory. In relation to sustainable forms of aquaculture Muir (1996, p. 23) states that the definition of such sustainable forms “cannot be done by considering the aquaculture sector and its activities in isolation; rather it is important to attempt to understand activities and processes within a wider system context, where aquaculture may occupy at most only a partial role in locational demands, resource use and socio-economic significance.” The author argues that a single aquaculture operation is part of a complex system involving other activities, resource users, producers, consumers, etc. Against this background Muir (1996) describes the aims and advantages of a system perspective as shown in Table 20.

Table 20: Aims and advantages of a systems perspective

Aims, features	Issues/potential benefits
Definition and comprehension	Description of system and sub-system structure helps to provide understanding of frameworks of context, cause and effect, implications of change at the system or sub-system level, effects of management or intervention.
Elements and interrelationships	Description and characterization of intra-system elements and their interrelationships provides the basis from which system behavior can be understood, hence effects on other systems.
Functions and controls	These determine the characteristics of inter-relationships, their significance, their potential for management, response to external perturbation, stability, etc.
Implications and impacts	These are usually defined in the context of an internal (sub-) system or an external system, and provide the means to specify quantify, the potential outcome of system change.
Context and explanation	A more detailed description of a system, including its internal elements, provides more explanatory power, and/or allows hypotheses to be tested.
Prioritization and choice	An understanding of the complete systems context, from the social/ethical to the molecular, allows areas of choice to be identified and their implications to be understood through the system chain.

Source: Muir (1996, p. 39)

Also other authors describe the necessity of a system approach for the design (modeling and evaluating) sustainability on the farm level (Kautsky, et al. 2000, p. 151; Kropff, et al. 2001; and Leung and El-Gayar 1997, p. 168).

4.1.3 Procedure to build a system dynamics approach

The model building of system dynamics was done by interviews with experts representing stakeholder groups. The procedure of the interviews and the group of experts are listed in chapters 3.2.1 and 3.2.2. Table 21 summarizes again the specific know-how of the experts and the stakeholder group which they represented.

Table 21: Experts of the interview

Perspective, Representatives of Stakeholder group	Know-how
Economical, financial	Consultant and analyst for investment in organic projects, SP, Brazil
Social, Community, Human resource	Founding member of a native community based NGO (fishing community, CE, Brazil)
Environmental, consumers ^{a)}	Member of Greenpeace Brazil
Practical, operational, with a longtime business experience	Owner and general manager of Shrimp Farm in RN, Brazil

^{a)} An explicitly consumer perspective is part of the Delphi study (chapter 3.3)

As shown above the steps included identification of the problem, description of the interactions between the elements and identification of key-factors. The first step is described in chapter 3.2, where the experts have been asked to define their perspectives, statements, and a list of pros and cons regarding shrimp farming.

Understanding interactions between the elements

After the discussion about the impacts and requirements the idea of the network (qualitative system dynamics approach) was explained and how to build a network was also illustrated. The main message was that the important elements of a shrimp farm are not always in a linear connection but much more linked up in a complex system. Afterwards the experts were asked to define their priorities based on the question of what factors they would primarily focus on when constructing and implementing a shrimp farming operation. In the discussion with the experts these named factors were correlated. The results of all of these factors and interactions, in addition to the results of the desk research (see chapter 3.1) and the Delphi study (see chapter 3.3) have been summarized into a draft of a network. This network was sent to the experts illustrated in the report (Schwab Züger 2001b) and the experts were asked to give their feedback on the results.

Identification of key-factors to guide the system

The factors named by the experts have been added to the factors based on the results from chapters 3.1 and 3.3. All factors have been listed in a matrix and the experts were asked to give value to the interactions between the factors (see Schwab 2001). Based on these numbers, the influence matrix a Portfolio was built as shown in Figure 34.

Figure 34: Position of elements depending on their force to influence

How is it to influence	<i>easy</i>	<i>PASSIVE</i> <i>Indicator</i>	<i>CRITICAL</i> <i>caution: chain reaction</i>
	<i>hard</i>	<i>INERT</i> <i>unimportant</i>	<i>ACTIVE</i> <i>Guiding element</i>
		<i>low</i>	<i>high</i>

Exertion of influence

Source: Gomez and Probst 1997, p. 88

These results were sent again to the experts to get their feedback. The report was reviewed and revised based on the comments and sent again to the experts. The communication process with the experts took place with each expert separately⁴⁸. Most of the discussion issues had to be raised by the moderator during the interviews.

4.2 Results of the qualitative system dynamics approach

The results are divided in four parts. The first part summarizes the results from chapter 3.2.3. The second part shows the important factors that have been defined by the experts. The third part illustrates the network, and the fourth part focus on the interactions and the characteristics of the factors. The list of the deduced KMF are presented in chapter 4.3.

4.2.1 Problem identification

The problem identification was shown in chapter 3.2.3. It can be summarized that shrimp farming is a high potential economic activity. But there must be defined requirements and considerations which have to be taken into account when initiating and operating a shrimp farm. Furthermore, the desired state of a sustainable shrimp farm and how this can be implemented has to be defined. In this context it was identified that the central problem is lack of knowledge and experience about shrimp farming, and as a consequence no clear definition of requirements for sustainable shrimp farming.

4.2.2 Important factors

A number of important factors resulted from the impacts and requirements have been stated by the experts. The list is shown in Table 22. The factors are used in the network (0) and in the influence matrix (4.2.4) and will be explained in these chapters.

Table 22: Important factors for the network

- | | |
|--|--|
| <ol style="list-style-type: none"> 1. Quantity of production 2. Production costs (total costs) 3. Profit 4. Selling price 5. Quality of product 6. Customer benefit 7. Investment | <ol style="list-style-type: none"> 19. Contact with society, community 20. Local labor 21. Information policy of the company 22. Planning of company strategies 23. Dependency of employer - employees 24. Political involvement 25. Illiteracy, poverty of community |
|--|--|

⁴⁸ It was not possible to bring all experts together for a common workshop.

- | | |
|---------------------------------------|--|
| 8. Competition | 26. Corruption |
| 9. Economical situation | 27. Image, social acceptance |
| 10. Satisfaction of business partners | 28. Infrastructure |
| 11. Policy regulation | 29. Natural potential of the environment |
| 12. Innovations | 30. Resource demand |
| 13. Salary policy, incentives | 31. Negative ecological impacts |
| 14. Motivated labor | 32. Positive ecological impacts |
| 15. Qualified labor | 33. Conflict because of multi-users |
| 16. Job market, alternatives | 34. Efficiency |
| 17. Attractiveness of workplace | 35. Working atmosphere |
| 18. Labor training | 36. Number of neighbor farms |

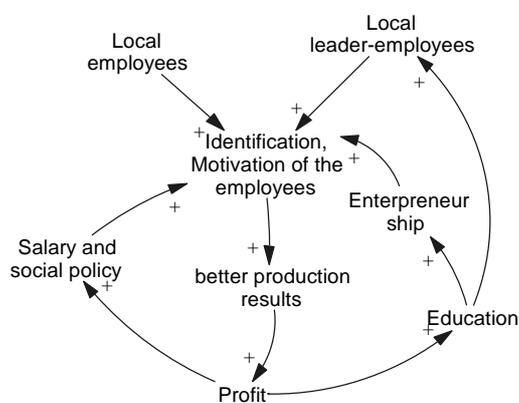
4.2.3 Network

4.2.3.1 Central cycle

To initiate the process for network building a central cycle was built by every expert. This cycle represents the perspective of the experts. It is also called ‘main engine’ and includes reinforcing connections between important factors. As all of the experts have a different vision of shrimp farming and how it works or should work, four different central cycles were developed. The cycles reflect what the experts defined as requirements for a shrimp farm. Figure 35 shows one central cycle as an example of the four different central cycles defined by the experts.

The arrows show the connection between the elements. The ‘+’ means a positive connection between the elements: ‘More of ..., leads to more of ...’, but also ‘less of ..., leads to less of ...’. The ‘-’ means ‘less of ..., leads to more of ...’ and the other way round.

Figure 35: Central cycle – human resource perspective



The central element in this cycle is the ‘Identification and Motivation of the employees’. Meaning that the main concern of management has to focus on this central cycle by trying to increase the identification and motivation of the employees. Due to better motivation and identification the success of the company will increase and will also reinforce the motivation of the workforce. This central cycle reflects the importance of the human resource policy of the company.

Source: Schwab Züger 2001b, p. 6

The three other cycles have their main focus on ‘Efficiency’, ‘Productivity’, and ‘Marketing’ (see Appendix, Figure 98 to Figure 100).

In the Efficiency-cycle the efficiency can be increased by motivated and qualified labor and has its influence on costs, profit, incentives and working atmosphere. This cycle focuses strongly on the production process. Based on the conclusions in chapter 2.3.1, p. 43 ‘efficiency’ is a KMF on the operative management level. According to Dyllick (2002), and Schmidheiny (1999) efficiency includes the issue of resource demand and eco-efficiency.

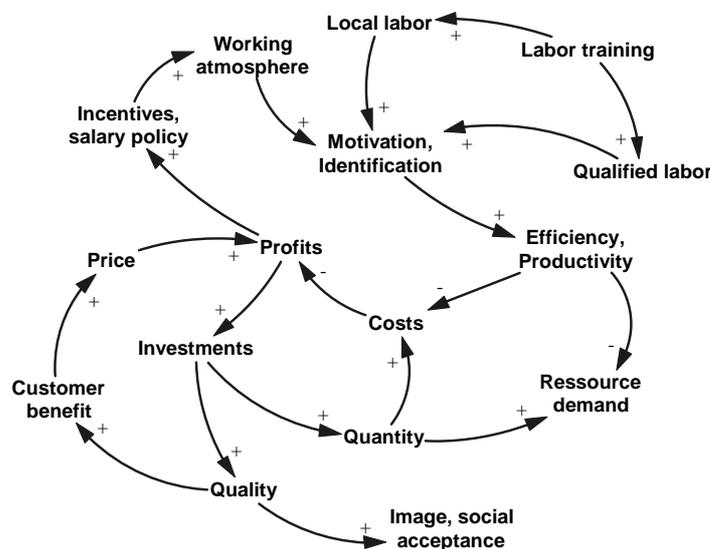
The factor ‘productivity’ is the main factor in the third cycle. The underlying ideas of this cycle are the marketing- and process point of view, by increasing quality and customer satisfaction and influencing the production process due to knowledge. This cycle also

faction and influencing the production process due to knowledge. This cycle also involves the human resource policy.

The fourth cycle reflects a marketing point of view. In contrast to the previous cycle, it focuses on external elements of the company instead of internal ones. It is on a different level of action. General awareness and the kind of consumers are important elements of the central cycle.

Few central elements are used in more than one cycle. When connecting the four central cycles it is conspicuous that the main elements (with a high number of connections) are: 'Profit', 'Motivation and Identification of the employees', and 'Efficiency and Productivity'. It is also noticeable that these three elements reflect the three perspectives of sustainability. Profit represents economical sustainability. Identification and motivation of employees stands for human resource policy of the company and in this context for a social responsibility. Productivity and Efficiency⁴⁹ as a number of input per output, includes the ecological and environmental perspective on the farm-level. Figure 36 shows the summarized network of the four cycles defined by the experts.

Figure 36: Combination of central cycles



Source: According to Schwab Züger 2001b, p. 8

4.2.3.2 Entire network

In addition to the network shown in Figure 36 the factors listed in Table 22 are connected. In the first step external factors such as general economical situation, exchange rate, political regulation and so on have been added. Additionally socio-economical and environmental factors are also included. These factors are added to the network shown in Figure 36 (bold arrows) and result in the whole network shown in Figure 37.

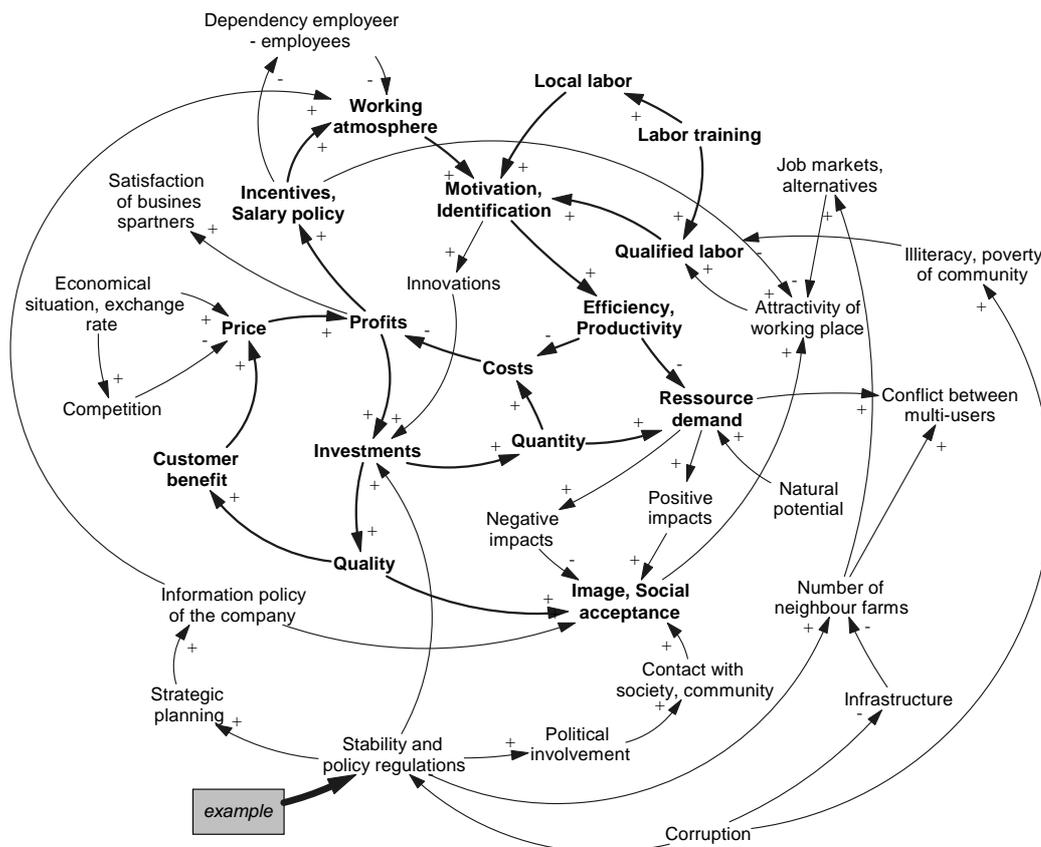
The following description should give an example of how to read and interpret the network (see Figure 37 'example'). For instance a good and transparent policy regulation (defined fiscal policy, defined land use, etc.) makes it easier for companies to plan and define their strategies. This can lead to a better information policy (internal and external) for the companies.

⁴⁹ Efficiency is a condition of the economy, more generally and productivity is one possible measurement for efficiency.

This information policy leads to a better working atmosphere (internal) and to a better image and social acceptance (external). Due to increased attractiveness of the work place and higher motivation and identification of the employees, the efficiency in the production process can be increased, and so on.

It is important to mention that the illustration of this network is based on the question focus and the research question. In many cases interactions between elements are reinforcing or stabilizing loops. Depending on the point of view of a shrimp operation, other elements are important to make the operation run (central cycles). The bold illustrated factors and interactions represent the combination of central cycles shown in Figure 36.

Figure 37: Entire network



Source: According to Schwab Züger 2001b, p. 10

4.2.4 Influence matrix and portfolio analysis

Factors listed in Table 22 and outlined in Figure 37 have been classified in the influence matrix. In the matrix the intensity of the relationship between all the factors was quantified. The intensity could be classified in either weak (1), middle (2) or strong (3) interaction between the elements. The sum for each factor concerning the direction and exertion of its influence was calculated. The factors have been categorized in a portfolio according to their classification. For each expert a different portfolio representing their opinion was developed⁵⁰. For instance in the portfolio of the expert representing the human resource perspective, the factors 'working atmosphere' and 'local labor' have been classified as active measures. It was not

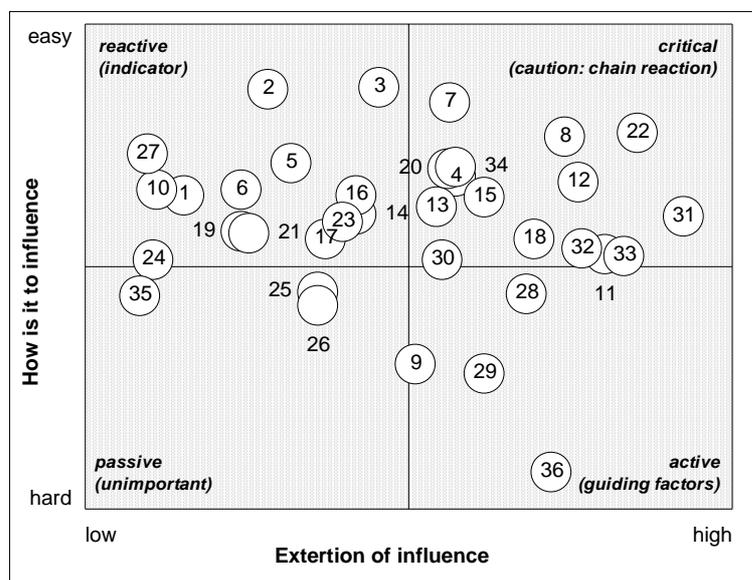
⁵⁰ For detailed information see Schwab Züger, B. (2001b)

possible to summarize the four different portfolios by simple addition, because not all factors were classified by every expert. Some factors were classified by at least three of the experts in the same position, and these factors are:

- Passive, Indicator elements: 27. Image and social acceptance, 3. Profit
- Inert, unimportant elements: 26. Corruption, 24. Political involvement
- Active, guiding elements: 36. Number of neighbor farms
- Critical elements: 22. Planning of company strategies, 31. Negative ecological impacts, 8. Competition

By indexing these factors (the opinion of all experts are equally weight) Figure 38 was developed. It demonstrates that most of factors are in the same position as they were in the individual portfolios.

Figure 38: Portfolio summarized



- 1. Quantity of production
- 2. Production costs
- 3. Profit
- 4. Price
- 5. Quality of product
- 6. Customer benefit
- 7. Investment
- 8. Competition
- 9. Economical situation
- 10. Satisfaction of businesspartners
- 11. Policy regulation
- 12. Innovations
- 13. Salary policy, incentives
- 14. Motivated labor
- 15. Qualified labor
- 16. Job market, alternatives
- 17. Attractivity of workplace
- 18. Labor training
- 19. Contact with society, community
- 20. Local labor
- 21. Information policy of the company
- 22. Planning of company strategies
- 23. Dependency of employer - employees
- 24. Political involvement
- 25. Illiteracy, poverty of community
- 26. Corruption
- 27. Image, social acceptance
- 28. Infrastructure
- 29. Natural potential
- 30. Ressource demand
- 31. Negative ecological impacts
- 32. Positive ecological impacts
- 33. Conflict because of multi-users
- 34. Efficiency
- 35. Working atmosphere
- 36. Number of neighbour farms

The elements in the upper left corner (easy to influence and low exertion of influence) are reactive elements. They can be used as indicators of a system. Based on the Portfolio shown in Figure 38 this means that for example factor 27 (Image and social acceptance) can be used as an indicator for a sustainable shrimp operation. As a consequence measurable facts that give an idea of social acceptance and image have to be defined. A measurable fact could be the number and context (positive or negative) of articles in local newspapers or even on the

radio stations (excluding commercials) and the reaction of reader’s letters. Another indicator of Figure 38 is profit (factor 3), which is a easier factor to measure. The factor profit is almost always a critical factor (easy to influence and high exertion of influence) this means that the profit is an economical result of the activities of a company and at the same time it is a reason for internal reaction and changes such as more investment, more innovations, possibility for expansion, etc.

Factors in the lower right corner are considered as active, guiding elements. They have a high exertion of influence and they are hard to influence. These factors are crucial for the company, because they are most effective if a company wants to initiate a change or reform. But some factors cannot be steered by one single company. Portfolio factor 36 for example, (number of neighbor farms) is an active element which is strongly connected with other elements and its exertion of influence is high. The number of neighbor farms however, is not a guiding factor for a single farmer. The single farmer has to be aware of the number of neighbor farms and needs to know that his farm might be affected directly by activities of other farms connected with the same ecosystem. Based on this context the “site evaluation” is an important guiding factor for a shrimp farmer. In part C it will be analyzed what is the influence of this factor based on the data record of the case study.

It has to be stated that the classification of the factor as active, reactive, critical, and passive depends on the development phase of the company. For example the number of neighbor farms is an active guiding element in the first phase of the development of a farm. This aspect has not been considered in the portfolio. Based on the classification of the factors, indicators and a monitoring system or a strategy can be elaborated.

4.3 Conclusions of system dynamics approach

The investigations of this chapter were based on the research question shown below:

What Key Management Factors for sustainable shrimp farming can be deduced from the requirements and theoretical cognitions?

The qualitative system dynamics approach is a useful method to illustrate factors within a system and to describe interactions between the factors. The network and the portfolio are important parts of this approach. Even though the position of every factor in the portfolio is subjective - depending on the value the experts estimate for each factor - the portfolio supplies additional information about the factors. Important sets of factors which result from the analysis give indications for the management where it has to focus. Based on this recognition, active elements may be evaluated. At the same time, it has to be determined if active elements are also guiding elements for the management. Factors which were judged as important can be used by the management as an indicator for the focus and efforts to be taken.

Table 23 summarizes important factors which are guiding factors for management. The factors are divided into factors on strategic and operative levels (analog to Figure 21, p. 44).

Table 23: Key Management Factors on strategic and operative levels

Strategic management level	Operative management level
<ul style="list-style-type: none"> • Efficient resource management • General production management • Reduction of negative impacts • Human resource management 	<ul style="list-style-type: none"> • Productivity of production process • Guarantee financial situation (long-term viability) • Production costs • Net yield

Even though there was not the possibility to discuss the results directly in the expert-round, the process to elaborate the portfolio provided valuable results. The different perspectives of how shrimp farming is seen by different representatives resulted in different central cycles. And this fact initiated a communication process about values and different perspectives, which may be the first step for the creation of a 'common language' about what sustainable shrimp farming is.

An important result of the qualitative system dynamics approach is the discussion of interactions between factors. This discussion helps to raise the awareness for shrimp farming management to the consequences of decisions and modifications. These interactions are also helpful for the interpretation of the results (analysis in part C).

C CASE STUDY AND DATA ANALYSIS

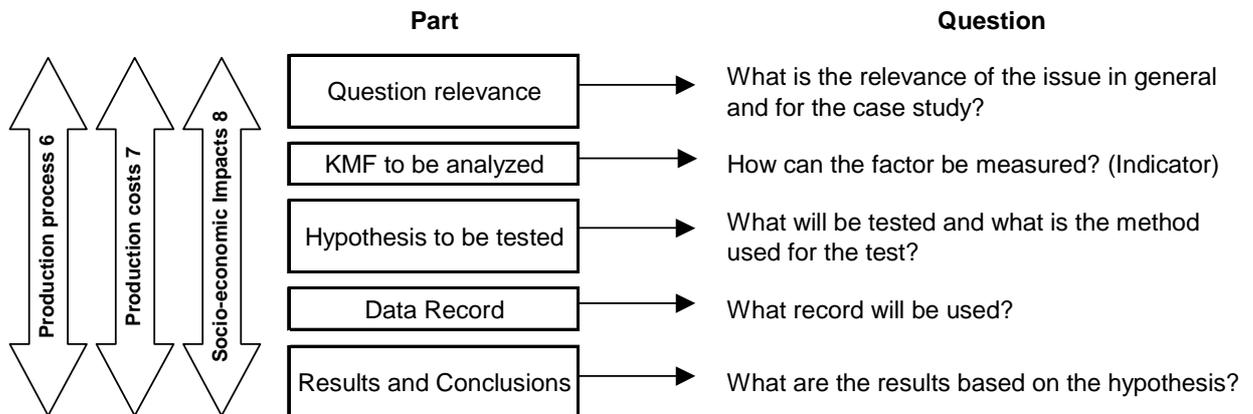
The identification of the requirements and the KMF will be applied and analyzed on data and experiences from the case study. The main focus of part C is the following research question:

How can the Key Management Factors be measured? What conclusions can be drawn from these analysis?

Part C is structured in four chapters. Chapter 5 includes general considerations about the case study as a research method, a short description of the Brazilian shrimp industry, and the development of this case study. It shows the important steps in the development of the company and the actual situation. The second chapter includes spot and detailed analysis of key factors for the production process. The third chapter (7) focuses on cost control of production correlations. In the last chapter some areas of socio-economical impact of shrimp farming will be analyzed.

All chapters (6 - 8) are structured the same way as shown in Figure 39. The question and relevance of the issue is a summary of the requirements defined in the chapters above.

Figure 39: Content of Part C Data Analysis



As shrimp farming is still a new industry the main management focus is concentrated on the production process. As a result the production process deserves primary focus due to its close relationship to the environment and negative impacts result from failures in the production process (see 3.1.1, p. 48).

5 Case study method and Background of Data Analysis

Chapter 5 is divided in three parts. The first part focuses on the method of a single case study. The second part describes the Brazilian Shrimp Industry in the context of this case study. The last part (5.3) gives an overview of the actual situation and the developmental steps of the company that is the subject of the case study.

5.1 Case study as a research method

According to Yin (1994, p. 1) case study is a form of research for social science. It is a “preferred strategy when ‘how’ or ‘why’ questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context.” Case studies have an important place in evaluation research. The most important application is to explain the causal links in real-life interventions. A second application is to describe an intervention and the real-life context in which it occurred and third, case studies can illustrate topics within an evolution, again in a descriptive mode⁵¹ (Yin 1994, p. 15).

5.1.1 Case study design

To design a case study some crucial points which are listed as following have to be defined (Yin 1994, p. 52-53)

- Defining the boundaries of a case study
- Defining the unit of analysis for a case study
- Defining a case study research design
- Establishing the rationale for single- and multiple-case studies
- Defining the criteria for judging the quality of research design (validity and reliability)

The issue of single- and multiple-case and the issue of units of analysis will be explained. Yin (1994) distinguishes between single- versus multiple-case designs, and holistic versus embedded case studies. The presented research is a single-case study, using an embedded (multiple units of analysis) case study design. Yin (1994, p. 38-52) illustrates reasons for the choice of a corresponding design. The reasons will be discussed in relation to the presented case study.

5.1.1.1 Single case study

Single case-studies are used where the case represents a critical test of existing theory, where the case is a rare or unique event, or where the case serves for revelatory purpose (Yin 1994, p. 44). Additionally to these three reasons single case studies may be conducted as a prelude to further studies. For the analyzed shrimp farm the second and third reason (rare or unique event, and revelatory purpose) justifying the decision for the single case. The shrimp farm ‘Camanor Produtos Marinhos Ltda.’⁵² (Camanor) is one of the oldest shrimp companies in Northeast Brazil. It has a unique record of production data, production results and experiences. As the research was partly integrated in the daily business and management of the shrimp farm it has also a revelatory purpose, where the investigator had an opportunity to observe and analyze a phenomenon previously inaccessible to scientific investigation (Yin 1994, p. 40).

⁵¹ Schramm 1971, cited in Yin (1994, p. 12) states that case study tries to illuminate a decision or set of decisions: why they were taken, how they were taken.

⁵² For detailed information about the company see 5.3.

5.1.1.2 Embedded case study

If a case study involves more than one unit of analysis it is also called embedded case study (Yin 1994, p. 41). In a single case study this is achieved through analyzing subunits. Subunits can often add significant opportunities for extensive analysis, enhancing the insights into the single case. The whole shrimp farm as a company was chosen as a case study. To analyze its management and the corporate sustainability performance of the farm it is necessary to define subunits. The subunits allow analysis with more details - for instance - the relevant production factors or the socio-economical impact of the company. The integration of these recognitions in the holistic case is important for general recommendations for the management.

5.1.2 Conducting case studies

Relative to other research methods like experiments or surveys, the skills required for data collection in a case study are much more demanding (Yin 1994, p. 55). This is because the collection procedures are not routinized and because of the continuous interaction between theoretical issues being studied and the data being collected. Yin (1994, p. 56-59) defines required skills for assessing case studies, such as the ability to ask good questions, to be a good “listener”, adaptability and flexibility to new situations, to have a firm grasp of the issues being studied, and to be unbiased by preconceived notions.

Evidence for case studies may come from different sources. Yin (1994) describes six different sources, such as: documents, archival records, interviews, direct observation, participant-observation, and physical artifacts. Considering the data collection Yin states three main principles. The first principle is to use multiple sources of evidence. Any finding and conclusions based on the use of multiple sources is much more convincing. The second principle is related to creating a case study data base. This aids in the organization and documentation of the collected data. The last principle of data collection is to maintain a chain of evidence to increase the reliability of the information in the case study. The chain of evidence allows an external observer to follow the evidence from initial research questions to ultimate conclusions.

By conducting the case study at Camanor the investigator became part of the case. There was a continuous interaction between the theoretical issues and the data being collected. Another important issue conducting the case study was the participant-observation process. As the investigator was part of the management for almost three years the participation increased over this time.

5.2 Brazilian shrimp industry

The content of this chapter relates to the report of Schwab, et al. (2002), Bunge (2000) and an article of Nunes and Suresh (2001). It is divided in four parts. The first part gives an overview of the development of the Brazilian shrimp farming industry. The second part focuses on culture methods. The third part includes the supply of main resources for shrimp farming such as post-larvae (PL) and feed, and the final part illustrates some issues of the industry association for Brazilian shrimp farmers and some legislative aspects.

5.2.1 Development of the Brazilian shrimp industry

Shrimp farming in Brazil is relatively new, mostly situated in the northeastern part of Brazil. In the 1970s the first attempts towards the experimental culture of penaeid shrimp were made with the indigenous shrimp *Penaeus brasiliensis* and the exotic species *Penaeus japonicus*. In the early 1980s federal government agencies began encouraging shrimp farming by providing

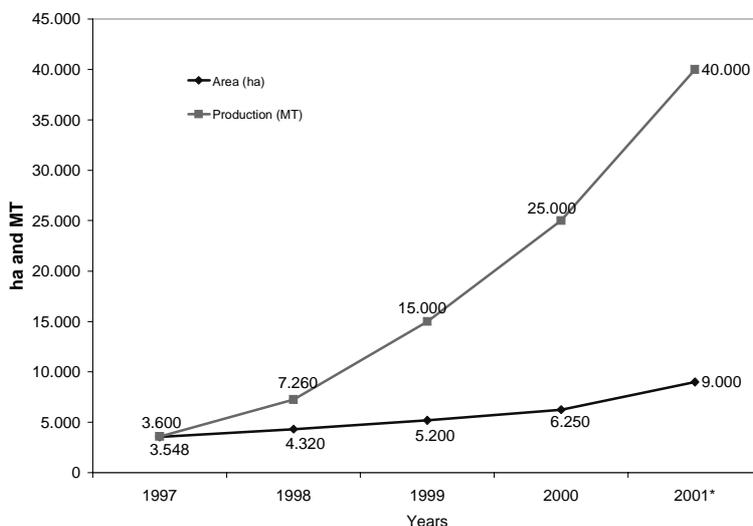
special financial incentives (Bunge 2000, p. 6). At that time large coastal areas used for traditional salt production became available.

According to Nunes and Suresh (2001) the first phase of shrimp farming development in Brazil was characterized by trial and error. Much of the government funding was not invested appropriately and by the middle of the 1980s most of the projects had closed down. Lack of technical expertise, poor production methods, limited tolerance of *Penaeus japonicus* to salinity, high inflation rates, lack of reliable sources of post-larvae (PL), and poor farm design and site selection were the main reasons for the farm failures (Schwab, et al. 2002, p. 2).

In the second phase, only farmers committed to shrimp farming remained in business (Nunes and Suresh 2001). The cultivation of locally available native shrimp (*P. subtilis* and *P. schmitti*) was dominant during this phase. Productivity of these systems was low due to lack of specific formulated diets and adequate management strategies. In the late 1980s the Pacific white shrimp (*Litopenaeus vannamei*) was introduced, together with the support of foreign technical expertise in Bahia State. Hatchery and grow-out technology for the cultivation of this species remained in isolation of one single large operation until 1993 (Nunes and Suresh 2001). As soon as *L. vannamei* became available for farmers through new private commercial hatcheries the culture of native shrimp was rapidly replaced by semi-intensive culture of white shrimp. Parallel to a stabilized Brazilian economy further incentives to new investments in the shrimp sector took place (Nunes and Suresh 2001). The economic environment and primarily the constant availability of improved inputs of PL and feed were the main reasons for the transformation of Brazilian shrimp farming to a highly attractive economic opportunity by the middle of the 1990s.

The enthusiasm and rapid expansion of the Brazilian shrimp industry occurred primarily after 1997. In addition to production improvements and increasing professionalism, growth has been stimulated by re-opened export possibilities as a result of currency devaluation. On a parallel basis, shrimp prices rose substantially in the international market, due to disease problems in Latin American countries (mainly Ecuador) on the Pacific coast (Bunge 2000). In 1997, Brazil's annual shrimp aquaculture production was 3,600 MT, in 1998 7,260 MT, in 1999 15,000 MT and in 2000 25,000 MT (Rocha 2000). The production increase occurs through internal (increase of stocking densities) and external (expansion of new land) growth. 97 percent of the Brazilian production comes from the northeastern states.

Figure 40: Brazilian's farmed shrimp production



Source: ABCC, cited in Bunge 2000, p. 9; * ABCC projections

5.2.2 Culture methods and production systems

While the wild-caught shrimp industry exists mainly in the south of Brazil, aquaculture is located primarily in the northern states. Currently Rio Grande do Norte (RN) is the largest shrimp aquaculture producer, with more than 30 percent of the national production. High temperatures all year long, flat terrain, availability of old salt mines, the presence of commercial hatcheries and some bigger farms that developed technologies are the main reasons for the expansion of shrimp farming in RN (Schwab, et al. 2002, p. 2).

Differences in shrimp farming techniques among Brazilian states are primarily explained by history and tradition. Most of the small producers in RN were fishermen who already had a basic infrastructure for salt ponds. Traditionally no large shrimp farms existed in this state. The local availability of PL allowed farms to increase their operations. As a result, their development was more independent than that of small farms in other states such as Bahia or Ceará, where big farms had already invested in infrastructure for processing plants, hatcheries, and so on. The large farms in these states promoted the development of small farms that produced under contract for them (Schwab, et al. 2002, p. 5).

In the early 1980s pioneers of shrimp farming in Brazil operated mainly on former salt mines with large ponds (over 15 ha in area), low stocking densities (1 to 3 shrimp/m²), using little or no external food supply (Nunes and Parsons 1998). In the mid 1990s due to constant supply of PL and feed, productivity doubled from 0,3 MT/ha/crop to more than 0,6 MT/ha/crop (Nunes and Suresh 2001). In the late 1990's the broad introduction of *L. vannamei* and the adoption of new management practices increased yields to over 2 MT/ha/crop.

Over 60 percent of all shrimp reared in Brazil are produced by large operations (101 to 600 ha in area), followed by small (1 to 30 ha in area; 27%) and medium ones (31 to 100 ha; 12%) (Nunes and Suresh 2001). The variation of the pond size depends on the intensity of the production system (see also Table 6, p. 51).

Nunes and Suresh (2001) summarized production variables of 20 marine shrimp farms surveyed in January 2000 in the northeast of Brazil. The results are presented in Table 24. Farmers obtain between 2.5 and 3.5 harvests/year. Grow-out period lasts on an average of 104 days. Shrimp may attain a final body weight of 11.5 g with survival ranging from 55% to 70%. As intensification increases, productivity increases from 550 to 2,200 kg/ha/crop and water exchange rate from less than 1% to 15% of total pond water volume/day.

Table 24: Production variables of 20 marine shrimp farms in NE Brazil

Production variable	Mean	Range
Feed Conversion Ratio	1.25	1.00 - 1.60
Survival in Intensive Nursery Tanks (%)	75	60 - 90
Survival in Grow-out Ponds (%)	55	55 - 70
Shrimp Final Body Weight (g)	11.5	10.0 - 14.0
Harvests (number/year)	2.9	2.5 - 3.5
Grow-out Period (days)	104	80 - 130
Water Exchange Rate (%/day)	6	< 1 - 15
Yield (kg of shrimp/ha/cycle)	1,267	550 - 2,200

Source: Nunes and Suresh 2001

Contrary to other shrimp production countries the Brazilian shrimp industry was never hit by a disastrous crisis, in particular severe diseases. In 1994 Brazil was struck with Taura-syndrom and also NHP (Necrotizing Hepatopancreatitis) became visible. The Brazilian

shrimp farmers learned how to manage these diseases and implemented stress reducing measures in pond management. After hitting Asian countries the WSSV (White Spot Syndrome Virus) caused disastrous mortalities and losses to the shrimp industry in other countries like Ecuador, Panama, and Honduras. Brazil has not yet been hit by the disease (Bunge 2000, p. 14-15). When the outbreak of WSSV was reported in the main production centers of the Pacific, Brazil had already closed its production cycle and was no longer dependent on imports of PL or brood stock from outside (see following chapter). The government implemented a strong policy of protection against contamination due to restrictions on the importation of shrimp (live or dead) or feed from affected countries.

5.2.3 Supplies

5.2.3.1 Brood stock and post-larvae

The complete closing of the life cycle of non native species *L. vannamei* in Brazil, by in-house reproduction, offers several advantages to the shrimp farming industry. There is the possibility of periodic renewal of brood stock and lower risks of disease transfers for example (Nunes and Suresh 2001). However in relation to brood stock, the disease contamination (due to exposure to other cultured animals and lack of disease monitoring), and the loss of original genetic characteristics are issues affecting the Brazilian shrimp maturation (Nunes and Suresh 2001). Brood stock facilities are implementing biosecurity strategies and at least one maturation facility in the country is working with a program for genetic improvement.

As stated in chapter 5.2.1 the constant availability of high-quality PL was one of the most important factors in the development of the Brazilian shrimp industry. The production of approximately 5 billion PL was guaranteed by twelve hatcheries (Guerrelhas 2000, p. 42).

The growth of the shrimp farms itself is likely to contribute to a shortage of PL. If demand increases, however, there will be market incentives to increase the production of PL – but there is a lag between higher demand and supply. A national PL shortfall will directly affect the shrimp farms because of the moratorium for imports of life crustaceans into Brazil (Schwab, et al. 2002, p. 3).

5.2.3.2 Feed

As illustrated in chapter 5.2.1 the missing supply of quality feed initially forced producers to extensive production methods. In the mid 1990s feed mills using Taiwanese and American technical experience started to produce quality-pelletized food for semi-intensive culture of *L. vannamei* (Nunes and Suresh 2001). Stated in Schwab, et al. (2002, p. 3) four shrimp feed producers supply the Brazilian market at the moment. Purina Agribands, still dominant, has approximately 80 percent of market share in Brazil. Socil, Sibra, and Burris Mills also sell shrimp feed. With the exception of U.S.-based Burris Mills, the other companies produce their product in Brazil (as of 2000).

5.2.3.3 Processing and marketing

According to Schwab, et al. (2002) all shrimp production was sold as a fresh product on the national market. Modern processing technology has not been an important factor in the past. Such processing became important however, in the late 1990s with the possibility of exportation. Abandoned processing plants were reactivated. Several processors have invested in plants and freezing equipment to enter the export market for frozen shrimp. Existing operations have increased their capacity for processing while others have built processing capacity from scratch to add value to their on-farm production. In 2000 the process-capacity in Brazil

was about 24,000 MT of shrimp from aquaculture. About 50 percent of the countries production is exported⁵³.

On the Brazilian wholesale market, almost all shrimp are sold head-on. In the export market the head-on shrimp are sold mainly to the European market where prices and profits are generally higher. Head-less shrimp are sold mainly to the US (as of June 2000).

5.2.3.4 Land tenure and land prices

Potential sites for new shrimp farms are still widely available in the northeastern Brazilian coastline. The Brazilian Ministry of Agriculture estimates an area of 300,000 ha for potential shrimp farming areas (Ministério da Agricultura e do Abastecimento 1999). In its program the ministry promotes the development of 30,000 ha of shrimp farms until 2004. Based on the fast rate of growth, land values have increased from US\$ 100/ha to more than US\$ 800/ha in the past few years (Nunes and Suresh 2001).

However, some implications may take place due to property rights. Brazil does not recognize any claims over the domain of marine lands (including a military delimiting area of 33 m from the sea margin). Private acquisition of coastal and mangroves lands is provided by law but there are some implications (Bunge 2000, p. 18-19). It is established in this law that “the legal regime upon which such areas are to be conceded to individuals or corporate entities is the one of lease, so to say the interested party will be able to be granted the domain for the purposes of utilization of a certain area” (Bunge 2000, p. 19). But there does not exist the legal possibility to acquire proprietary rights over the land.

5.2.4 Shrimp farmers association

The formation of the Brazilian Shrimp Farmers Association (ABCC – Associação Brasileira de Criadores de Camarões) in 1984 was a response to the crisis facing the industry. ABCC began fighting for political, financial, and technological support for the industry (Wainberg and Camara 1998). The role of ABCC is to bring together the interests of companies and organizations represented in the association. It initiates scientific programs to obtain more knowledge about shrimp production in Brazil, financed from a ‘feed fund’⁵⁴.

The legal aspects of shrimp farming activities are summarized in Bunge (2000). The aspects are divided in fiscal aspects, federal regulation on registry, environmental aspects and land tenure.

5.3 Information about the case study company

As outlined in chapter 5.2, the Brazilian shrimp industry has passed through different phases of development. These developmental phases are also observable in the shrimp farm chosen for the single case study. The figures of this chapter are based on the explications in the report ‘Key Management Challenges for the Development and Growth of a Shrimp Farm in North-east Brazil: A Case Study of Camanor Produtos Marinhos Ltda.’ (Schwab, et al. 2002).

⁵³ Personal communication Arimar F., June 2000, owner and general manager of the states biggest processing plant.

⁵⁴ See further explications in Schwab, et al. (2002, p. 5) and ABCC (2000).

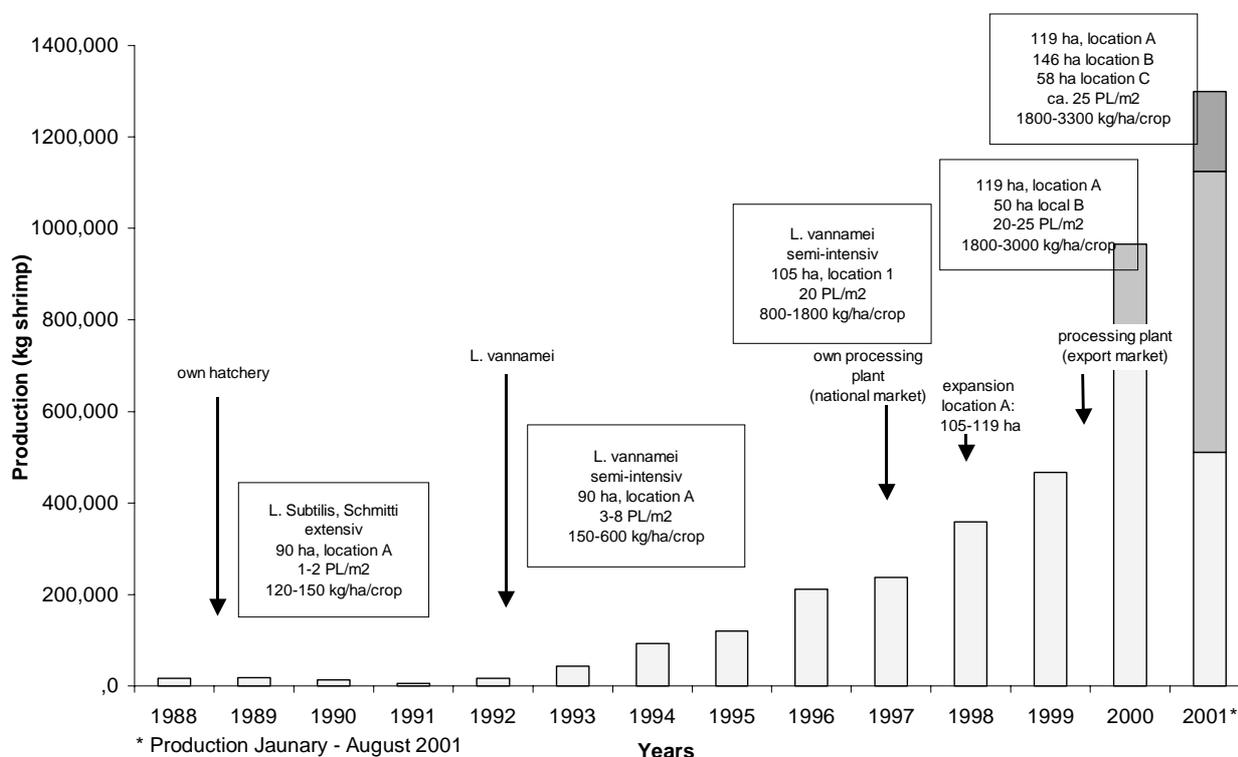
5.3.1 Situation of Camanor (August 2001)

This chapter gives an overview of the actual situation of the company Camanor Produtos Marinhos Ltda.⁵⁵ (as of August 2001). All statements made are based on assumptions valid for Camanor only and related to the situation of this company (case study).

Production system	Semi-intensive
Species	<i>Litopenaeus vannamei</i> (Pacific white shrimp)
Density	20-25 post larvae (PL) per m ²
Water exchange rate	average 5% per day, no aeration
Production cycles	90 days, 2.8 cycles/year, 2,000 kg/ha/cycle
Areas	119 ha in production at site of parent company, location A 146 ha at second location B 58 ha at third location C (Joint venture) Areas under construction (at location C: 350 ha, at further location: 700 ha)
Process and distribution	Mainly frozen shrimp for export market (Europe and USA), before 2000 fresh shrimp on domestic market.

Figure 41 shows the production increase as well as the production technologies used on the farm. Important development changes have included the introduction of the exotic species *L. vannamei*, the hatchery and the processing plant. The three different patterns of the columns show the production quantity at three different locations. Location C started to produce the first shrimp in 2001 and is still under construction. Information concerning the situation of Camanor as an employer will be given in chapter 8 (p. 148).

Figure 41: Development of Camanor



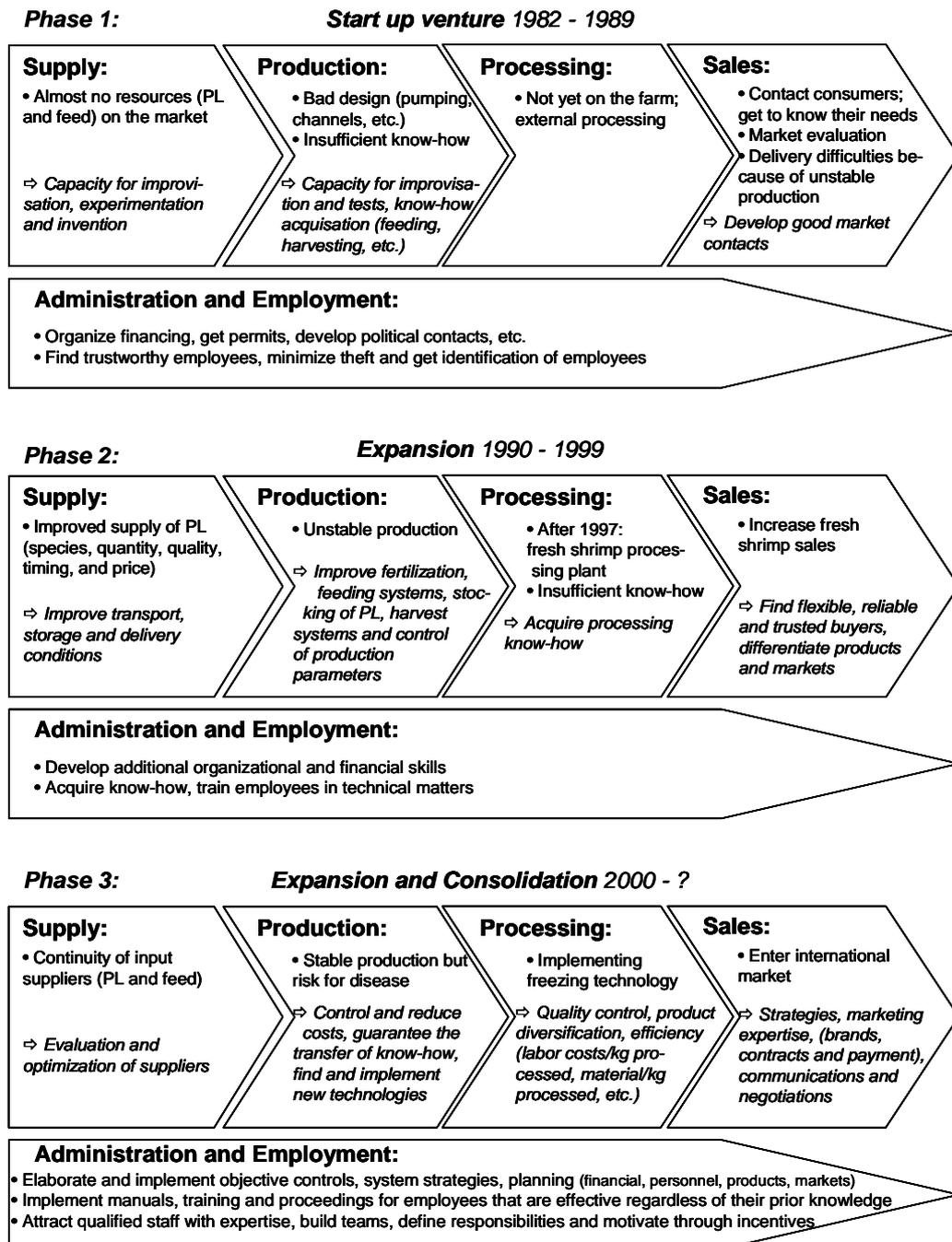
Source: Own calculation, Camanor data base, 1988-2001

⁵⁵ As following Camanor Produtos Marinhos Ltda. will be called 'Camanor'.

5.3.2 Phases in the development of Camanor

Figure 42 identifies the key factors in the first 18 years of Camanor's existence. The columns specify the main elements that are required for the operation to work. Administration and employment matters are management factors that influence the whole operation. The figure also shows the importance of different skills over the years and indicates clearly how some factors became more important over time and others less important. Figure 42 shows internal factors at Camanor, so it does not portray the external circumstances, including other producers, increasing supply, and increasing processing capacity in the sector.

Figure 42: Development and management tasks of Camanor in its first 18 years



Source: Schwab, et al. 2002, p. 23

5.3.2.1 Understanding production management and technology

During the first few years of shrimp production, the key factors for the management were to understand production and to set up systems to monitor the impact and effectiveness of the production systems being used. As shrimp farming was a new technology and a new industry in Brazil, there was very little information available for producers. One of the problems in the early years was the lack of sufficient track records to base all decisions on data rather than on instinct.

5.3.2.2 Managing financial resources

Another critical issue during the initial years of operation was the management of financial resources. Since the economy was very unstable (e.g., artificially high official exchange rates, inflation, financing for fixed or working capital loans was difficult to obtain), many important production changes and adaptations could not be undertaken. For example, in 1989, necessary adaptations of shrimp pond design, inlet canal and others could not be undertaken, due to the lack of financial resources. During the first phase of the company's development, reducing overall risk at Camanor was linked to keeping debts as low as possible. By increasing the number of customers, the risk of insolvent buyers was reduced. Strict cash management was also very important.

At this time, planning and managing financial resources are the main challenges for management to allow the expansion of the farm. In order to prevent financial-dependency problems, Camanor management intends to finance at least 70 percent of the ongoing investment out of the company's cash-flow⁵⁶. This strategy has been adopted primarily because of high interest rates. Because of the actual rapid expansion, managing liquidity of the operation became a key issue for management (as of 2000).

5.3.2.3 Input supplies and viability

PL and feed are the two most critical production factors. Around 40 percent of the working capital of a shrimp farm in Brazil are PL and feed. In addition, the quality of these factors have a direct impact on production. The quality of PL affects directly the survival rate, FCR, and as a consequence growth rate, and ultimately productivity of a production cycle. In 1990 there was no reliable, high-quality shrimp feed supply on the national market, and there was a shortage of PL. As a consequence, the management of Camanor was driven by these external factors. The construction of its own hatchery was very important for the viability of the farming operation. This vertical integration of a key input allowed Camanor to reduce the risk of unstable supply and was an important factor in controlling the costs of production.

5.3.2.4 Getting more from the product through value added processing

By starting up their own processing plant, the company benefited in two ways. It gave the company more freedom and flexibility from other processing plants and it gave the company the opportunity of adding value to its product. This forward integration allowed the company to diversify risk and generate better financial returns through processing. However, there are also risks involved by owning and running a processing plant. The main risks are maintaining costs and quality so that product is not rejected by buyers.

⁵⁶ Oral information Werner Jost, owner and general manager of Camanor.

5.3.2.5 From apprenticeship to professionalism

Developing a business in a poor, underdeveloped local community is a big challenge. Continuous contact and communication with the community is very important. This helps the company develop reliable supplies of labor as well as gaining acceptance of the company by local residents over time.

The first challenge was to find reliable, confident employees. The fact that the owner was not Brazilian and had limited experience with the Brazilian reality undoubtedly complicated this situation. After hiring people, the next challenge was to train them and to develop teamwork. Basic education was also an important challenge. Once the size of the operation was determined, management responsibilities were defined and assigned so that the company could be managed with a specific set of objectives. Strategic planning, good communication, effective implementation and strict systems of management control become more important. The development of professionalism is often linked with the organizational development within an enterprise. The functionality of a company not only depends on one single key person but on a group of motivated and skilled labor.

5.3.2.6 Good siting and construction of production facilities is invaluable

After its experiences with setting up the first production facility, Camanor has taken a different route during the second phase of expanding the operation. Now the company knows that good site evaluation and planning of the design and construction of the operation are very important for the ultimate viability of the enterprise. Camanor's experience shows that it is worthwhile to invest more time and money before construction and initial operations rather than try to fix things later. Once the plans were completed for the expansion of the operation, then the strategy was for a fast and economical construction. By pursuing this strategy, management believes that Camanor can take advantage of the good market situation in Brazil both for production and export. Furthermore, it is possible to address tight liquidity with this strategy.

6 Production process

6.1 Relevance of the production process

The production process determines inputs to be used and the management of resources for the production. As shrimp farming is a relatively new activity (see 0, p. 47) the technology and the knowledge about the production process are still on a basic level. Improvements in the production process may lead to a decrease of negative impacts mainly on the environment. For instance improvements in the feeding management may result in lower feed conversion ratio (FCR)⁵⁷. As a consequence of a better FCR, pond effluents contain less nitrogen and phosphorus, which cause less eutrophication of natural waters (Boyd 1999, p. 12). Additionally a lower FCR causes less feeding costs per kilogram shrimp harvested.

Compared to mature industries, improvement of the production process in new industries are quite obvious and relatively easy to work out. This fact is also stated in Bardach (1997, p. x) where the author makes a comparison between aquaculture and avian and mammalian animal husbandry. According to Clay (1997, p. 34) the increase of efficiency and productivity of existing ponds is one possible business opportunity for sustainable aquaculture. The author argues that most environmental problems are caused by poor management practices where producers do not have the resources to invest in improved production methods.

The production process within the network built for sustainable shrimp farming is determined as shown in Figure 43. The upper part of the figure shows the network from chapter 4.2.3.2 (Figure 37). The lower part reflects some connections within the production process. Productivity is determined as output per input. It is an important result of the production process and influences strongly the resource demand (inputs). The aim of the future investigation is to find out, what parameters influence productivity. As is common in shrimp farming, the output is 'kg of harvested shrimp', whereas the input (needed area) is determined by 'pond area in ha'. However, productivity of a shrimp farm is usually defined as harvested shrimp in kg/ha/cycle (Rosenberry 2000), or in kg/ha/year (Michielsens 2001).

⁵⁷ FCR is measured as kg feed per kg harvested shrimp.

Figure 44: Structure of analyzed spots in Chapter 6

KMF			Sub-chapter	Hypothesis	Data Record	Results & Conclusions
Efficiency		6.2	Productivity	6.2.1	6.2.2	6.2.3
	Animal health	6.3	Survival rate	6.3.1	6.3.2	6.3.3
Feeding management		6.4	Medical Feed	6.4.1	6.4.2	6.4.3
		6.5	Feed- and waste management	6.5.1 FCR and waste management 6.5.2 Animal protein and soy		

6.2 Productivity

Productivity is a measure for efficiency. According to Shang and Tisdell (1997, p. 133) farm productivity depends mainly on two set factors:

1. Stocking rate, survival rate, and growth rate, which are in turn affected by technical factors such as rate of feeding and fertilization, whether the culture is mono- or polyculture, stocking and harvesting strategies, and so on.
2. Environmental factors such as water quality (water temperature, dissolved oxygen, pH levels, etc.), chemical inputs to treat diseases and predators, and so on.

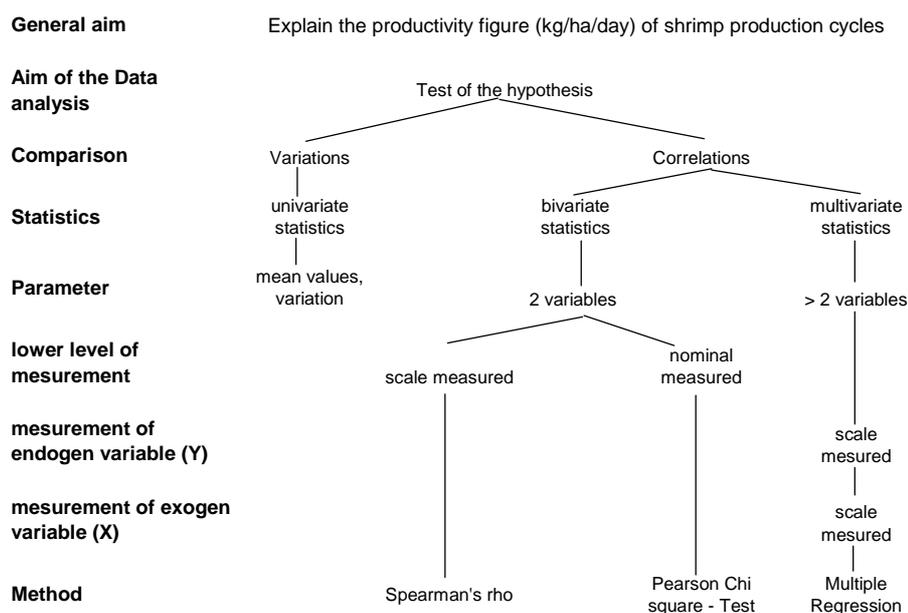
Vale (2000) confirms in his studies that the stocking density has a direct influence on the growth rate of the shrimp and as a consequence on the productivity of a production cycle.

6.2.1 Hypothesis and method of productivity data analysis

Based on practical experiences, presumptions and theoretically known correlations the following hypothesis will be tested:

Productivity (kg/ha/day)⁵⁸ is influenced by survival rate, average weight, stocking density, average temperature during the production cycle, duration of the production cycle, and farm location.

Figure 45: Statistical procedure to test the productivity hypothesis



⁵⁸ The reason for the definition of productivity as kg/ha/day will be outlined in 6.2.3.1.

Figure 45 shows the statistical procedure used to test the hypothesis. The more-step statistical analysis includes in its first step the validation of the data record (univariate statistics). The second part (bivariate statistics) includes a correlation analysis. This analysis determines connections between variables. The production data (productivity, survival rate, stocking density, average weight, and days of the production) are a scale measured. Average temperature of the production cycle is an ordinal measured and the variable ‘farm location’ is a nominal measured. According to Köhler, et al. (1996, p. 47-58) the following measures to determine correlation between variables are used :

- Spearman’s rho: correlation between scale measured data:
- Pearson correlation (Chi squared test): correlation between scale-, ordinal- and nominal measured data

Based on the correlation analysis, focus is on variables with significant coefficient of correlation. According to Wagner 1998 cited in Theler, et al. (2000) there exist various reasons for correlation between two variables:

- The independent variable is the direct cause for the dependent variable
- The dependent variable changes the independent variable
- The independent variable causes a variation of the dependent variable, but it is not the only reason
- Disruptive variables are existing
- Both variables have the same cause
- Both variables change over time
- The correlation is coincidental

The third step includes a regression analysis which is a method to detect and to explain correlation between variables. It also helps to estimate and forecast values of the dependent⁵⁹ variables (Backhaus, et al. 2000, p. 2). The model will be determined according to the experiences of the production process. Afterwards, the regression equation will be estimated and finally the equation will be tested.

The component not explained by the regression equation is called residues (variance of the linear regression line). The aim of the regression model is to determine a linear equation with minimal residues (Backhaus, et al. 2000, p. 13). According to Backhaus, et al. (2000, p. 17) the multiple regression model has the following determination:

Equation 5: Form of multiple regression model

$$\hat{Y} = b_0 + b_1X_1 + b_2X_2 + \dots + b_jX_j + \dots + b_JX_J$$

Source: Backhaus, et al. (2000, p. 17)

whereas:

\hat{Y}	Estimation of the endogen variable through the regression model
b_0	constant part
b_j	Regression coefficient (j = 1, 2, ... , J)
X_j	Exogenous variable (j = 1, 2, ... , J)

⁵⁹ ‘Dependent’ is synonymous for ‘endogen’ and ‘independent’ is a synonymous for ‘exogenous’.

The parameters b_0 , b_1 , ... have to be determined under the objective function of minimized sum of squares (least squares method). According to Backhaus, et al. (2000, p. 19-44) the test of the regression model includes the steps shown in Table 25.

Table 25: Test of the regression model

General test of the model		Test of Parameters	
What will be tested	Statistical test-number	What will be tested	Statistical test-number
“Goodness of fit” of the regression equation to the empirical data	Coefficient of Determination R^2 Adjusted R^2 (adjusted for degrees of freedom - df)	Significance of coefficients, to detect if the variable has a significant influence	t-test
F-Statistics, to find out if the model is valid beyond the empirical data	F-test	Values of the coefficients, (reliability of the regression model according to one parameter)	Confidence intervals of the regression coefficients
Average error of the regression equation to estimate the dependent variables	Standard Error of the Estimation	Test model premises: 1. Linearity 2. Completeness of the model 3. Homoscedasticity 4. No autocorrelation 5. No multicollinearity 6. Normal distribution of residues	2. expected value of the residues = 0 3. visual inspection of residues, Goldfeld/Quant test 4. Durbin-Watson statistic 5. Tolerance value of the correlations among the independent variables

Source: According to Backhaus, et al. 2000

6.2.2 Empirical data record for productivity

The data used for the analysis are regular production data from the farm. There have been no specific circumstances, trials or experiments during that time. On one hand this allows conclusions closer to the ‘reality’, but on the other hand a higher danger of potential errors during data collection. The record was kept on an Access data base and statistically analyzed with the software SPSS. The record relates to the period of 17.03.1999 until 05.05.2001 (date of PL stocking). During this period 222 ponds on three different locations have been stocked. 219 production cycles have been classified as valid and used for the statistical procedure of the productivity. Table 26 shows a description of the record. Farm location B and C are new locations where the production was initiated during the period of observation.

Table 26: Record for productivity analysis

Farm location	A	B	C	Whole farm
Number of production cycles	168	41	10	219
Start of first production cycle	17.03.99	06.01.00	19.11.00	
Data of last fishing	22.08.01	16.08.01	11.08.01	
Number of ponds analyzed	29	18	8	
Average size of ponds (ha)	4.31	7.85	7.20	5.10
Average preparation time (days)	22.6	14.9	11.0	20.7
Average days of production	101.5	124.7	100.7	105.8
Average stocking density (animals/m ²)	26.45	25.25	23.94	26.11
Average productivity (kg/ha/cycle)	2,178	2,556	2,082	2,244
Average productivity (kg/ha/days)*	21.64	21.04	20.60	21.5

Farm location	A	B	C	Whole farm
Average survival rate (%)	75.1	79.9	72.4	75.9
Average weight per shrimp (g)	10.9	12.6	12.4	11.3
Total production over sampling period (MT)	1,566.61	804.36	147.86	2,518.83

* days of production, without days of preparation

Compared to the average figures of shrimp farms in Northeast Brazil (see Table 24, p. 99) the case study farm shows above-average results for its production. Productivity and survival rate are in the high upper range of the state's average. Comparing productivity figures, it can be stated that based on the productivity per cycle, location B shows approximately 20 percent higher productivity than location A. Comparing the productivity per day, it can be observed that productivities are similar between farms. For this reason productivity per day seems to be a better indicator to compare production results.

The temperature data which will be used in the analysis is based on meteorological data obtained from the government (INMET 2001)⁶⁰. It is a daily average air temperature recorded in the capital, 80 km north of production location A. The temperature data is used to estimate the average temperature during the production cycles. For this purpose all daily average air temperatures during a production cycle were added up and divided by days of production.

6.2.3 Results and conclusions of productivity analysis

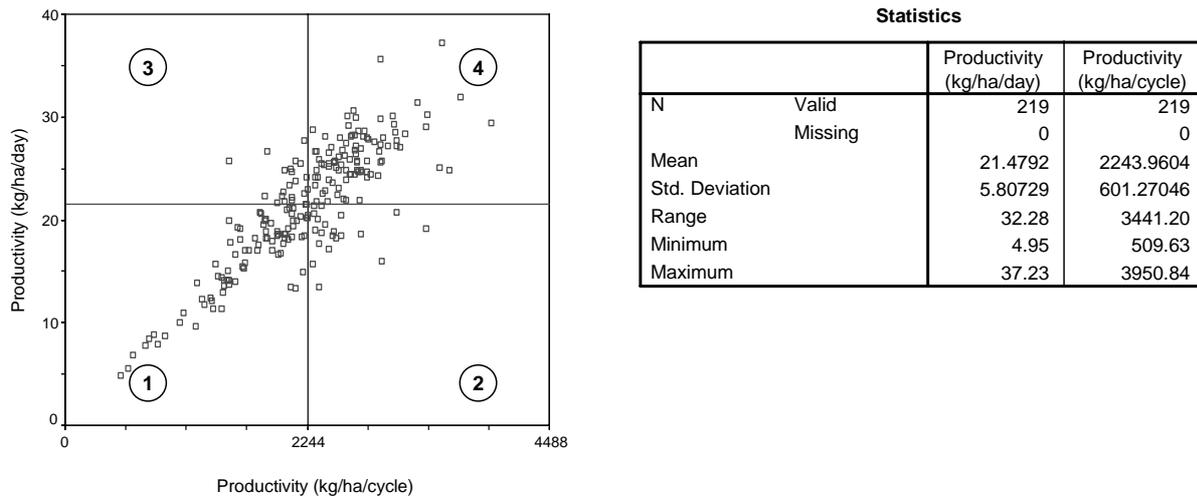
6.2.3.1 Analysis of original data (productivity)

Productivity of a production cycle

Productivity on the farm level is generally calculated as kg/ha/cycle. As long as all production cycles are of the same duration, it is an adequate way to compare production cycles within the same farm or between farms. As the farm productivity depends also on the number of cycles, and as a consequence the time a cycle occupied an area, the indicator kg/ha/day should be used for any analysis of productivity. This would avoid misleading evaluations of production cycles as shown in Figure 46. The figure shows on the X-Axis the productivity measured in kg/ha/cycle and on the Y-Axis the productivity measured in kg/ha/day. The graph is divided in four squares defined by mean values.

⁶⁰ INMET is the national meteorological institute.

Figure 46: Productivity in kg/ha/cycle and in kg/ha/day (N=219)



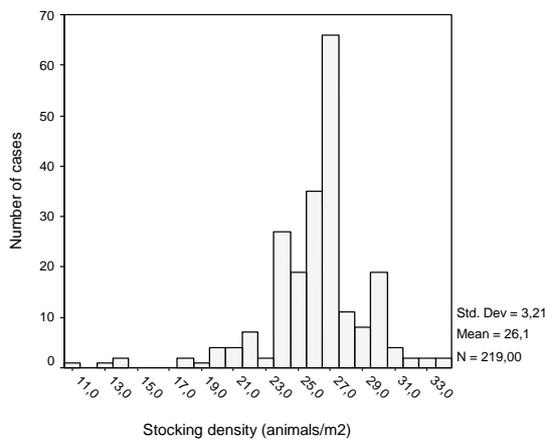
Cases in squares 1 and 2 are below the mean of 21.47 kg/ha/day, while cycles with a high productivity (above the mean) are shown in square 3 and 4⁶¹. Square 2 includes cycles which are considered as good cycles using the traditional indicator kg/ha/cycle, while they have to be considered as poor ones using the adequate indicator (kg/ha/day). The contrary happens with the cycles in square 3. With the commonly used indicator they are considered as poor cycles, while they showed good productivity using kg/ha/day. The evaluation of productivity results is crucial for the learning process and analyzing parameters of outstanding results. For further investigation, the productivity measurement in kg/ha/day is proposed. The distribution of the original data in a histogram is shown in the Appendix (Figure 101).

Stocking density

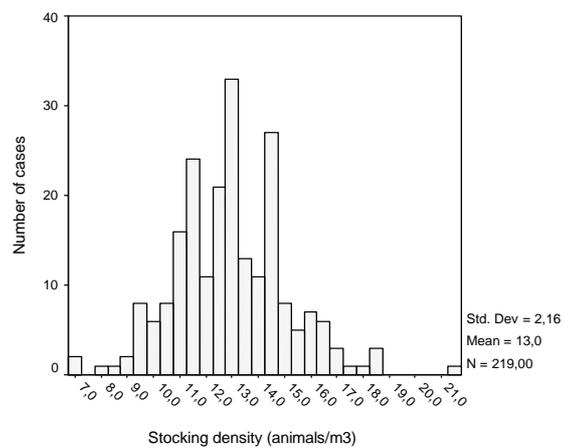
Stocking density is commonly measured in animals/m². Due to different water levels in shrimp ponds different densities per m³ are resulting⁶². Because of this fact the density is calculated in animals/m³.

Figure 47: Stocking density

a) in animals/m²



b) in animals/m³

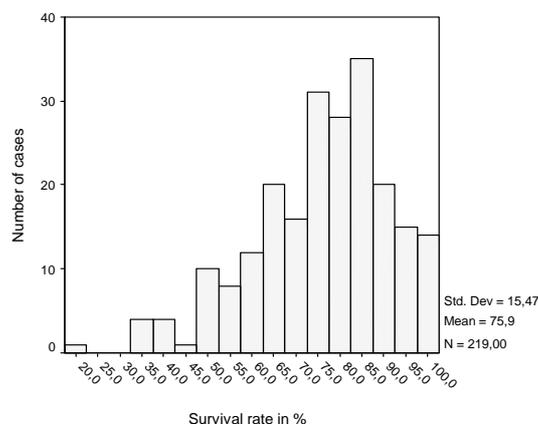


⁶¹ To simplify cycles above the mean value are considered as ‘good’ cycles, while cycles below the mean are considered as ‘poor’.

⁶² The volume is calculated based on an estimated average water column.

Survival rate

Figure 48: Survival rate (%)



Survival rate is calculated as a percentage of harvested and stocked animals. Both numbers (number of PL stocked and number of animals harvested) are estimated numbers, based on volume sampling (PL) respectively weight sampling (harvested animals). The average survival rate of the record is shown in Figure 48. The production cycles that resulted in a survival rate >100% (due to counting failures) are considered as survival rate of 100 percent.

Average weight

The average weight is calculated at the end of the harvest, by the kg of shrimps processed per grade divided by the average weight per grade.

The record of the average weight shows a normal curve of distribution with a mean value of 11.3 g/animal and a standard deviation (Std. Dev.) of 1.57. The minimum value of all production cycles (cases) is an average weight of 6.4 g/animal and the maximum weight is 16.1 g/animal.

Duration of the production cycle

The duration of the production cycle includes the day of stocking thru the last fishing of the pond. Not included is the preparation of the pond (tilling, etc.) and the preparation of the water before stocking PL.

The average duration of the production cycles are 106 days. As the farm does not have nursery ponds it includes the whole grow-out phase from PL10/PL12 until the final animal weight in the pond. In practice the duration of the production cycle can vary due to different growth rates, planning of harvesting and market demand.

An analysis of the duration of the production cycle in relation to the average temperature is shown in Figure 49.

Average temperature during the production cycle

The production cycles are divided in four periods. The periods are classified according to the temperature. The variation is small between each group of temperature (group 1 to 4). Table 27 shows the temperature group and the number of cycles analyzed per farm and per year. The classification of the production cycles in group 1 to 4 is used further in the statistic analysis, where temperature is ordinal scaled.

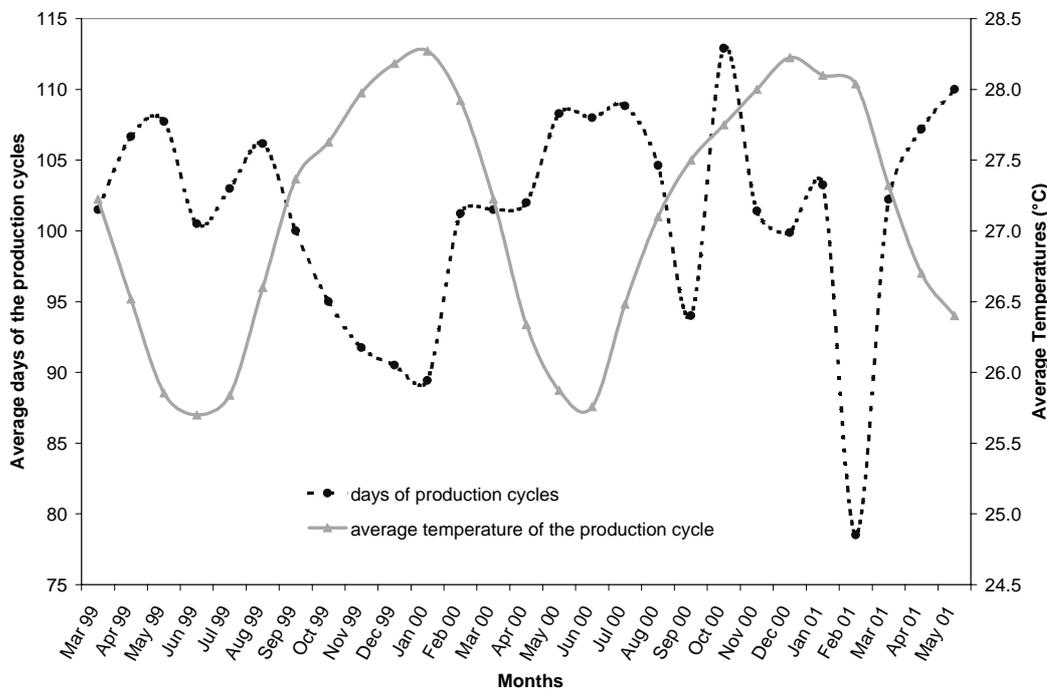
Table 27: Classification of production cycles in four periods

Group	Av. air Temp. (°C)	Number of cycles per farm				Number of cycles per year			
		A	B	C	Total	1999	2000	2001	Total
1	25,7 – 26,4	47	10	0	57	23	30	4	57
2	26,5 – 27,3	40	6	3	49	13	18	18	49
3	27,4 – 27,9	36	13	2	51	12	30	9	51
4	28,0 – 28,4	45	12	5	62	9	32	21	62
	Total	168	41	10	219	57	110	52	219

Figure 49 refers to the duration of the production cycles of location A (N = 168). It shows the duration (dark dotted line) over the observed period (March 1999 thru May 2001). The drawn clear line shows the average temperature of the production cycles that have been stocked in the corresponding month.

It can be seen in Figure 49 that the production cycles are negatively correlated with the temperature. Based on technical knowledge of the production process this correlation is logical. Higher temperature results in higher growth rates and as a consequence in shorter production cycles to get to the final weight of the animal. The increasing variation of the duration of the production cycles after August 2000, and the longer cycles even during high temperature periods may be due to various reasons. Possible explanations are problems in the growth rate, problems during harvesting, or shorter cycles due to solvency problems of the company.

Figure 49: Duration of production cycles and average temperatures (N=168)



Source: Own illustration, data Camanor and INMET 2001

Farm: Location of production (dummy variable)

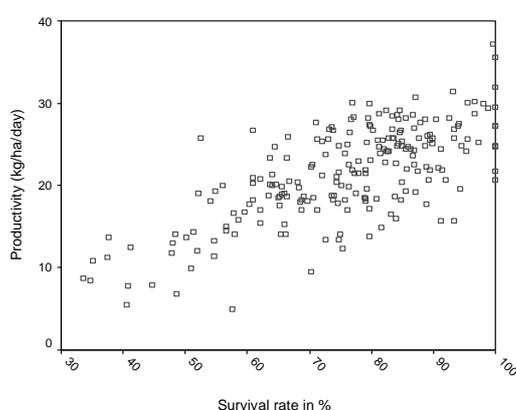
The three locations of the farm are a nominal measured and considered as dummy variables. A dummy variable is a numerical variable used in regression analysis to represent subgroups of the sample in the study. In the research design, a dummy variable is often used to distin-

guish different treatment groups⁶³. As shown in Table 26 the farms are located on three different places. 76.7% of the cases are production cycles of location A, 18.7% of location B, and 4.6% of location C. The total production in MT in this period on the three locations was 2.519 MT. On location A 1.567 MT (62% of the total production), on location B 804 MT (32%) and on location C 148 MT (6%) were produced.

6.2.3.2 Correlations between the variables (productivity)

From a technical point of view, it can be assumed that a correlation exist between productivity and survival rate. Such correlations are analyzed through bivariate statistics. Correlations between two variables can be determined, but it gives no information about the causality of the correlation.

Figure 50: Correlation between productivity and survival rate (N=219)



Based on technical understanding a high correlation between 'Survival rate' and 'Productivity' can be expected. This correlation can be verified by the record in Figure 50.

As shown in Table 26 the average productivity of the three farm locations do not vary strongly. The average productivity (measured in kg/ha/day) on location A was 21.64, on location B 21.04 and on location C 20.60. As the number of cases on these three locations is uneven no correlation between 'Farm location' and 'Productivity' can be stated.

Due to the geographical distance between the three different farm locations, the explanation of the average temperature refers only to location A (N=168). The variable 'Productivity' is categorized in three groups, each group consisting of one third of all of the production cycles.

⁶³ See Cornell (2002).

Figure 51: Productivity and average temperature (N=168)

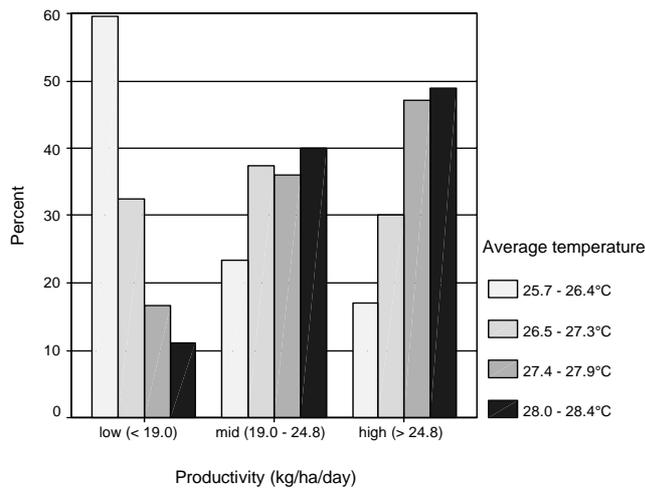


Figure 51 indicates the correlation between average temperature and productivity (see also correlation coefficient Appendix,

Table 51). Observing the low productivity cluster (< 19.0 kg/ha/day), it can be stated that approximately 60% of all cycles within the low average temperature (25.7 – 26.4°C) belong to this cluster., while approximately 12% of all cycles with high average temperature resulted in a low productivity.

It is important to point out that the average productivity for low temperature was 17.9 kg/ha/day, versus 24.2 kg/ha/day for high temperatures (see Appendix, Table 53). This is a difference of 35%. Observing the data set, it can be concluded that the optimum temperature is higher than 28°C.

Correlation coefficients for every variable of all production cycles of the three locations were calculated. The Pearson correlation for the nominal measured variable ‘Farm location’ are significant at the 0.01 level for the following variables: ‘Stocking density’, ‘Average weight’, and ‘Duration of the production cycle’ (see Appendix, Table 52). But no significant correlation was calculated between ‘Farm location’ and ‘Productivity’. For the scale measured variables the Spearman’s rho correlation, shown in Figure 52 has been calculated.

Figure 52: Correlation between scale measured variables

Spearman's rho Correlation Coefficient (N=219)

	Productivity (kg/ha/day)	Stocking density (animals/m3)	Survival rate in %	Average weight (g/animal)	Duration of production cycle
Productivity (kg/ha/day)		*	**	**	**
Stocking density (animals/m3)	.159*			**	
Survival rate in %	.653**	-.057			*
Average weight (g/animal)	.293**	-.347**	.131		**
Duration of the production cycle	-.311**	-.098	.141*	.236**	

*. Correlation is significant at the .05 level (2-tailed).
 **. Correlation is significant at the .01 level (2-tailed).

All highly significant correlations are shaded in the table. The most important correlation is between ‘Productivity’ and ‘Survival rate’. The correlation coefficient amounts to 0.653 and significance is high. Additionally, the correlation is significant between ‘Average weight’ and ‘Productivity’ and between ‘Duration of production cycle’ and ‘Productivity’. There is also a slight correlation with significance at the 0.05 level between ‘Stocking density’ and ‘Productivity’.

6.2.3.3 Multivariate statistics – multiple regression analysis

In addition to the correlation analysis, the regression model discovers dependencies between the variables. It is supposed that the 'Productivity' is influenced by the variables 'Stocking density', 'Survival rate', 'Average weight', 'Duration of the production cycle', 'Average temperature' and the 'Farm location' (see 6.1). The regression equation with these variables will be estimated and afterwards the equation will be tested (Backhaus, et al. 2000, p. 8ff).

The background of the data record are natural growing processes. These processes are often not linear and have to be transformed into log-linear data. According to Tukey, cited in Stahel (1999) logarithmical transformation is called a 'first aid transformation' of the original data. The logarithmical data are shown in Appendix, Figure 102.

The distribution of all the variables 'Productivity', 'Survival rate' and 'Average weight' show a trend over time⁶⁴. This trend is also visible in the logarithmical data (see Appendix, Figure 102). According to Backhaus, et al. (2000, p. 34) linearity is required for a regression model. The variables have been trend adjusted to avoid a possible distortion of non-linearity. The variables have been transformed through the first difference according to the following equation:

Equation 6: Transformation through a first difference

$$\Delta x_t = x_t - x_{t-1}$$

whereas: x_t variable with trend

Source: Stalder 1996

The trend adjustment causes a loss of information. But the aim is to explain the productivity and not the trend over time. The effect of the log-linear data and the trend adjusting are shown in Appendix (Figure 102). The results show the positive effect on the data through the trend adjusting. Table 28 shows information about the variables used in the regression model.

Table 28: Details about variables used in the regression model

Variable	Type of variable	Measurement of original data	Description and variation	Name of the variable in the model
Productivity	endogen	scale measured	In kg/ha/day variation from 4.95 – 37.23 kg/ha/day	D_LN_PRO
Stocking density	exogenous	scale measured	In PL stocked/m ³ , variation from 7.11 – 21.68	D_LN_DEN
Survival rate	exogenous	scale measured	In % of animals harvested from animals stocked, variation from 21.42 – 115.69%*	D_LN_SUR
Average weight	exogenous	scale measured	In g/animal harvested, variation from 6.4 – 16.1 g/animal	D_LN_AWW
Duration of production cycle	exogenous	scale measured	In days, starting with the stocking of PL and ending with the last harvest	D_LN_DAY
Average temperature	exogenous	ordinal measured	Average temperature during the production cycle.	Temp
Farm location	exogenous	nominal measured	A = Cana Brava, B = Aratuá, C = Camarus	Farm

* due to counting failures survival rates over 100% may result. These records are set on survival rate = 100%

⁶⁴ The trend may be due to technology improvement (quality of inputs), and/or learning effect of the production management.

The regression model was estimated first with the original data (model 1 to 3), second with the log linear data (model 4 and 5) and finally with trend adjusted and log-linear data (model 6 and 7). Model 1, 4, and 6 include all farm locations with a number of cases $N = 219$. Model 2, 3, 5, and 7 are only based on the data of farm location A. The first three models show all variables, also non-significant coefficients. 'Survival rate' shows a high correlation with productivity and may also be seen as an endogenous variable in the model. That is the reason for the exclusion of the variable 'Survival rate' in models 3 to 7. The results of the comparison of the models are shown in Table 29.

Table 29: Summary of regression models

Model No.		1	2	3	4	5	6	7
Data record	Original data			Log-linear data		Log-linear data and time lag		
	All variables			significant variables only				
	incl. survival rate			excl. survival rate				
Number of cases		N = 219	N = 168	N = 168	N = 219	N = 168	N = 219	N = 168
Model	Adjusted R2	0.874	0.883	0.397	0.352	0.447	0.236	0.342
	Model sig.	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Durbin/Watson	1.572	1.452	1.247	1.418	1.178	2.69	2.387
Standardized co-efficients	Stocking density	0.308**	0.298**	0.313**	0.329**	0.365**	0.407**	0.518**
	Survival rate	0.753**	0.711**	X	X	X	X	X
	Average weight	0.466**	0.440**	0.507**	0.572**	0.585**	n.s.	0.281**
	Production days	-0.515**	-0.434**	-0.350**	-0.365**	-0.337**	-0.219**	-0.248**
	Average temperature	X	-0.057	0.084	X	n.s.	X	n.s.
	Farm location	0.043	X	X	n.s.	X	n.s.	X

** significant at the 0.01 level

n.s.: no significance

Including survival rate as an exogenous variable, R square and adjusted R square are very high (see model nr. 1 and 2). Without the variable survival rate the adjusted R squares are lower (between 0.236 in model 6 and 0.447 in model 5). The decrease in the adjusted R square from the regression models with original and log-linear data to the trend adjusted data is due to information loss (see Appendix, Figure 102). Considering the Durbin-Watson value, no violation of the premise autocorrelation can be stated. The coefficients 'Stocking density' and 'Production days' are significant in all seven models.

The final estimated model (model nr. 7) with the endogenous variable 'D_LN_PRO' has the following equation:

Equation 7: Regression model

$$D_LN_PRO = 0.518 * D_LN_DEN + 0.281 * D_LN_AVW - 0.248 * D_LN_DAY$$

According to Backhaus, et al. (2000, p. 20-44) the regression equation has to be tested as explained in section 6.2. Figure 53 shows the model summary and the coefficients.

Figure 53: Model summary and coefficients of the regression model No. 7**Model Summary^b**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
7	,595 ^a	,354	,342	,26748	2,387

a. Predictors: (Constant), D_LN_DAY, D_LN_DEN, D_LN_AVW

b. Dependent Variable: D_LN_PRO

ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
7	Regression	6,390	3	2,130	29,770	,000 ^a
	Residual	11,662	163	,072		
	Total	18,051	166			

a. Predictors: (Constant), D_LN_DAY, D_LN_DEN, D_LN_AVW

b. Dependent Variable: D_LN_PRO

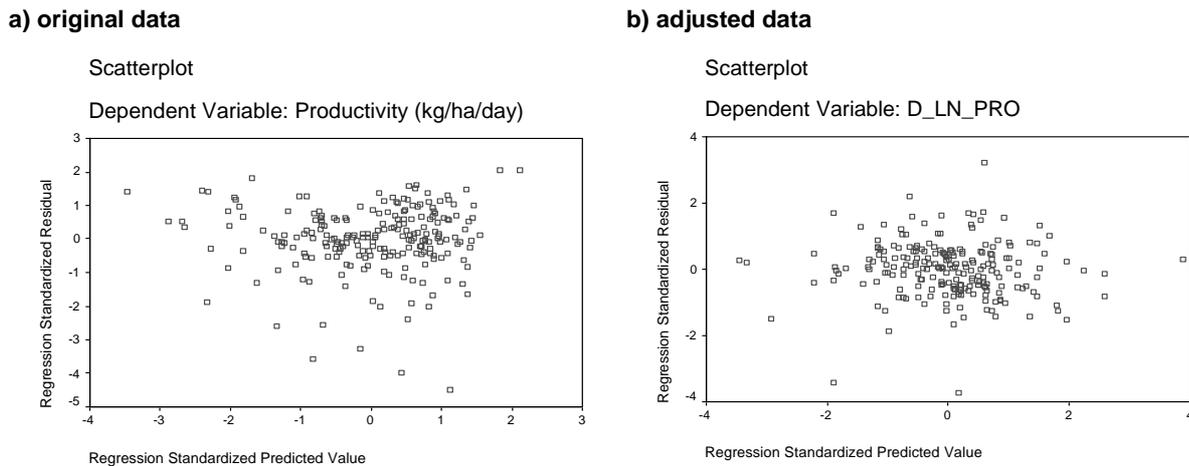
Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
7	(Constant)	-1.28E-02	,021		-,598	,551	-,055	,030		
	D_LN_DEN	,868	,107	,518	8,132	,000	,657	1,079	,978	1,023
	D_LN_AVW	,785	,188	,281	4,180	,000	,414	1,156	,878	1,139
	D_LN_DAY	-,608	,165	-,248	-3,695	,000	-,933	-,283	,881	1,136

a. Dependent Variable: D_LN_PRO

Based on the data set of all regression models shown in Table 29, the conclusion that the variables 'Stocking density', 'Average weight', and 'Duration of the cycle' have a significant influence on 'Productivity' can be drawn. The 'Farm location' and the 'Average temperature' during the cycle do not have a significant influence on productivity. From the practical point of view these influences and correlations are logical.

As the Tolerance values are high (Figure 53), it can be supposed that no multicollinearity between the exogenous variables occurred. According to the test for heteroscedasticity Figure 54 does not show a specific pattern of the residuals which would indicate heteroscedasticity.

Figure 54: Test for heteroscedasticity (standardized residuals of regression)

A regression model with ‘Survival rate’ as an endogenous and ‘Productivity’ as an exogenous variable is also highly significant. Based on a technical understanding of the shrimp farming process, it is more likely that the productivity is a result of the survival rate than the other way around. On one hand the variable survival rate is a key indicator for a high productivity. On the other hand it is an indicator for the state of animal health. The variable survival rate will be deeper analyzed in chapter 6.3.

6.2.3.4 Conclusions from productivity analysis

According to the results presented above the following conclusions can be drawn :

- ⇒ To avoid misleading interpretations of productivity results, the traditional indicator kg/ha/cycle was replaced by the adequate indicator kg/ha/day. To benefit the data analysis and to be able to learn from ‘good’ and ‘bad’ production results, farmers should start using the indicator kg/ha/day.
- ⇒ The most important factor for productivity is survival rate. As a consequence, the farmer should focus on every aspect to avoid loss of animals during production.
- ⇒ No correlation could be found between farm location and productivity. It has to be pointed out that the three observed farm locations are in different stages of their development and the data record is unequal.
- ⇒ Temperature is correlated with the productivity of a cycle. This analysis indicates that temperature sensibility is high, a difference of 35% in productivity between average temperature of 26°C, respectively 28°C was observed. It is supposed, that higher temperature results in higher growth rates and as a consequence in shorter production cycles to achieve the final weight (see also chapter 7.2). The temperature shows a significant correlation with productivity but does not explain the factor productivity (regression model).
- ⇒ Longer production cycles result generally in lower productivity (kg/ha/day). This gives an indication that the growth rate of shrimp is not a linear function. The bigger the shrimp, the lower the growth rate. As a consequence, farmers have to be aware that there is an optimal harvest time for each cycle (see 7.2).
- ⇒ Higher stocking densities lead to higher productivity. This is logical, as long as densities do not affect survival and growing rate on an individual shrimp. In other words, it can be stated, that within the observed limits, the density does not cause stress for the animals (see also 6.3 and 6.4).

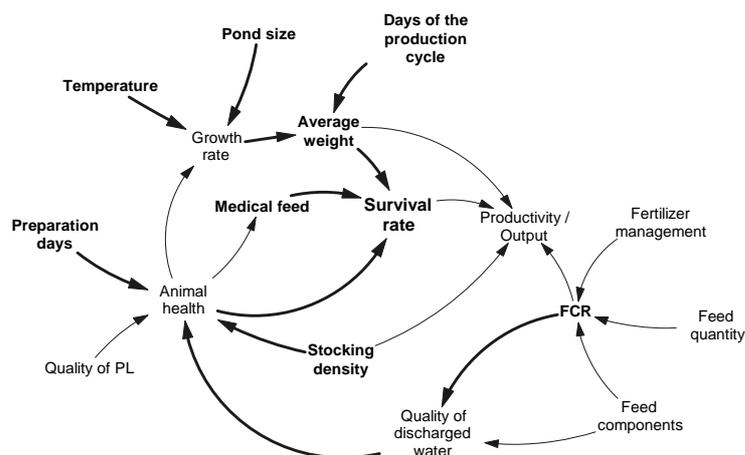
- ⇒ Concerning the hypothesis it can be stated that higher stocking density, higher survival rate, and higher average weight lead to a higher productivity. Survival rate is the most important figure explaining productivity.

6.3 Survival rate

Chapter 6.2 showed the importance of a high survival rate for productivity improvements. According to Clay (1997, p. 34) the net income from ponds could be doubled by increasing the survival of post-larvae from 50 to 70 percent. The economic importance of survival rate could also be shown analyzing the data record of the case study (see Appendix, Figure 103). The crosstabulation showed the following results. 25 percent of all production cycles with the lowest survival rate (average 54.5%) showed an average net margin (index) of 48.8. 25 percent of the production cycles with the highest survival rate (average 93.3%) showed an average net margin of 148.6. This indicates that an increase of 70% survival rate (from 54.5% to 93.3%) results in an increase of 204% of the net margin. Additionally to its economic importance, the survival rate is an indicator for the state of health of the animals during the production cycle. Duraiappah, et al. (2000) show in their statistical analysis the correlation between stocking density and survival rate and also between feed management and survival rate. They argue that survival rate can be improved by an optimal combination of stocking density and feeding strategy. In other scientific works the correlation between disease outbreaks and production management is shown. According to Kautsky, et al. (2000, p. 145) the risk of disease in shrimp farming increases with culture intensity, high stocking density, and when polyculture is replaced by monoculture. The authors also argue that excessive fluctuations in abiotic factors (oxygen, salinity, and temperature) increase stress and susceptibility to disease.

6.3.1 Hypothesis and method of survival rate data analysis

It will be tested by which variables the survival rate of shrimp in a production cycle are most greatly influenced. According to literature correlations are known. Therefore the analysis is a structure tested type of analysis (Backhaus, et al. 2000, p. XXII). According to Duraiappah, et al. (2000, p. 3-4) stocking density and seed quality, feed-, water-, and sediment management are critical factors for the survival rate during a production cycle. The authors explain three reasons for higher stocking densities accompanied by higher mortality rates. First, more shrimp per area translates to a 'crowding' effect which includes high stress levels. Secondly, higher densities produce more waste per unit area of water, which, if not cleaned properly, can become toxic. Thirdly, cultured seed is produced from a limited gene pool which produces inferior quality juveniles (Duraiappah, et al. 2000, p. 3). Some of the correlations described above are illustrated in Figure 55. The light dotted lines represent the correlations that are not directly relevant in the context of survival rate. The bold lines show interactions and indicate variables that are supposed to have a direct or indirect influence on survival rate.

Figure 55: Possible correlation of survival rate and other production variables

For instance the feeding management described by Duraiappah, et al. (2000) is represented in the FCR. Food that is converted to waste results in high loading of nutrients, which causes stress and increases the susceptibility of the shrimp to diseases (shown in the variable ‘Animal health’). The correlation between these factors will be tested based on the record of the case study. All bold variables shown in Figure 55 are part of the data record and are used for the statistical analysis.

6.3.2 Empirical data record for survival rate

Based on the record explained in chapter 6.2.2 (Table 26) variables concerning the survival rate will be examined. As the three farm locations in some aspects have a different management, only farm location A was used. The basic record includes 168 production cycles within the period of 17.03.99 (first stocking) through 22.08.01 (last fishing). Due to changes in the PL supply (shown in Figure 56) and missing information about duration between two production cycles (preparation of the pond) the data set had to be reduced to 122 production cycles. The sample is shown in the following table.

Table 30: Record for survival rate analysis

Farm location	A	Categories		Number of cases
Number of production cycles	122			
Start of first production cycle	28.10.99			
Data of last fishing	22.08.01			
Average survival rate (%)	78.3	1	< 65%	20
		2	> 65 – 90%	83
		3	> 90%	19
Average stocking density (animals/m ³)	13.34	1	7.1 – 12.6	40
		2	12.7 – 14.0	41
		3	14.0 – 21.7	41
Average weight per shrimp (g)	11.5	1	<= 11.0 g	39
		2	11.1 – 11.7 g	40
		3	11.7 – 15.0 g	43
Share medical feed of total feed (%)	20.04	1	No medical feed	2
		2	<= 30%	98
		3	> 30%	22
FCR	1.37	1	0.73 – 1.29	40
		2	1.29 – 1.43	41
		3	1.43 – 2.10	41

Average preparation time (days)	19.84	1	0 - 10 days	12
		2	11 – 20 days	58
		3	> 20 days	52
Average duration of production (days)	100.84	1	59 – 95	40
		2	96 – 107	42
		3	108 – 138	40
Average size of ponds (ha)	4.38	1	< 1 ha	17
		2	1 – 3 ha	15
		3	3 – 6 ha	61
		4	> 6 ha	29
Average air temperature (°C)	27.35	1	25.7 – 26.4	24
		2	26.5 – 27.3	27
		3	27.4 – 27.9	26
		4	28.0 – 28.4	45

The categories shown in the last columns of Table 30 will be used for the bivariate statistics in chapter 6.3.3.2.

6.3.3 Results and conclusions of survival analysis

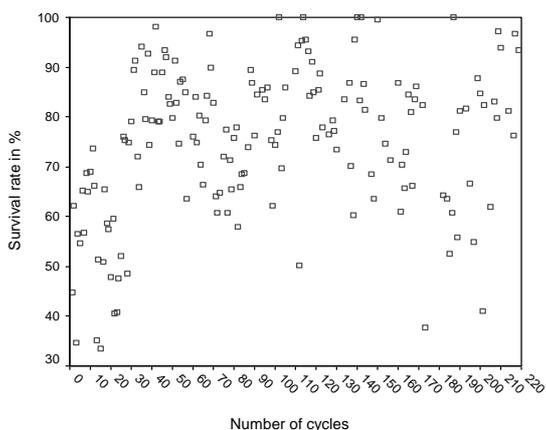
6.3.3.1 Analysis of original data (survival rate)

The variables ‘Stocking density’, ‘Feed management’, ‘Water management’, and ‘Sediment management’ are considered as critical factors for the survival rate (see 6.3.1). These factors are measured in ‘PL/m³’ for the stocking density, ‘FCR’ as an indicator for feed management, ‘days of preparation between the cycles’ as an indicator for sediment management. All cycles are managed in a semi-intensive production method, without aeration and with a water exchange rate of approximately five percent per day. Therefore the water management is the same for all cycles.

The scatter plots in Figure 56 show the development of the survival rate of 168, respectively 122 production cycles.

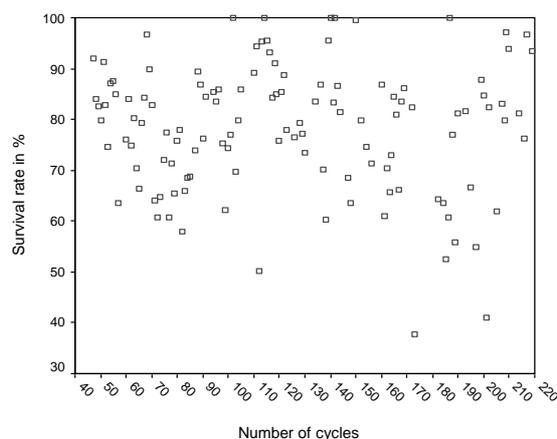
Figure 56: Survival rate of production cycles over time

a) N = 168



Mean 75.1 Min. 33.51
Std.Dev. 15.02 Max. 100

b) N = 122



Mean 78.3 Min. 37.7
Std.Dev. 12.6 Max. 100

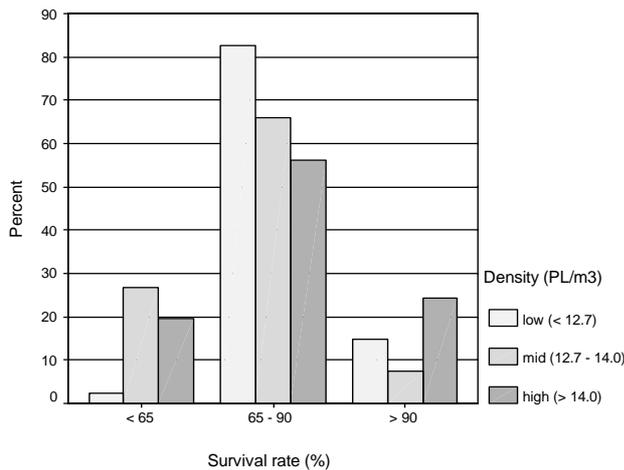
The significant increase of survival (jump) after production cycle 30 (October 1999 to November/December 1999) in the left figure (a) can be mainly explained by an increase of PL

quality (via a different method of the production of PL in the hatchery). It can also be shown in Figure 56 that the variation of the survival rate increased over time. This may lead to the assumption that the survival rate became less stable.

6.3.3.2 Correlations between variables (survival rate)

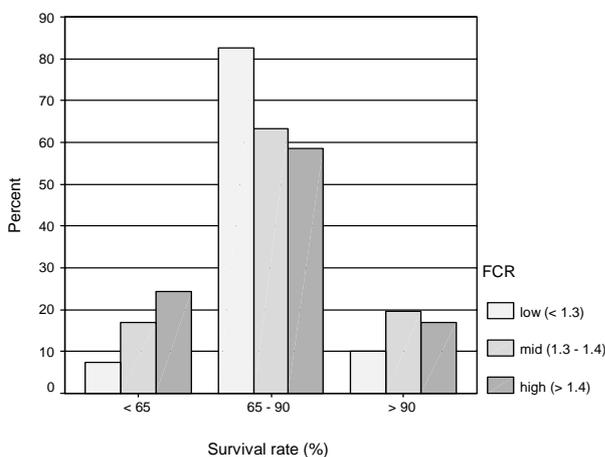
The following figures show crosstabulation between the variable ‘Survival rate’ and the critical factors described above.

Figure 57: Survival rate and stocking density (N=122)



Even no correlation of density and survival rate was observed (see Table 31), Figure 57 gives some interesting indications. Low densities have more stable survival rates and almost no cycles with low survival rate (< 65%) can be observed. High density may lead to high survival rates (approximately 25% of analyzed cycles with high density) but also 20% of cycles had low survival rates of less than 65%. This indicates, that cycles with higher density are less stable and probably more difficult to handle.

Figure 58: Survival rate and FCR (N=122)



Analyzing Figure 58 it can be stated, that approximately 25% of cycles with high FCR show low survival rate. For these cycles, it can be supposed that the shrimps did not die at the beginning of the grow-out phase, but after consuming considerable feed quantities. If shrimp dies as PL, the FCR will not be affected significantly, while close to the harvesting date, the impact can be very high. For learning about FCR-related topics (e.g. feed management, feed quality) it can be useful to separate cycles with poor survival rate and high FCR.

All variables listed in Table 30, p. 122 are used for a correlation matrix. The correlation coefficient is calculated with the original data (all variables metric scaled). The correlations are shown in Table 31. The dark shaded cells show significant correlations at the 0.01 level and the light shaded cells show significance at the 0.05 level.

Table 31: Correlation Coefficients (survival rate)

Correlations Spearman's rho (N=122)

	Survival rate in %	Stocking density (animals/m3)	Average weight (g/animal)	Share of medical feed (%)	FCR	Days of preparation	Duration of production	Pond size (ha)
Survival rate (%)							*	**
Stocking density (animals/m3)	,022							**
Average weight (g/animal)	-,105	-,115					*	
Share of medical feed (%)	-,144	,018	-,092					*
FCR	-,164	,059	,054	,110			**	
Days of preparation	,019	-,110	-,008	,007	-,057		*	
Duration of production	,184*	,118	,229*	-,038	,418**	-,232*		
Pond size (ha)	-,254**	-,484**	,126	,193*	-,002	,040	,049	
Average temperature	-,184*	-,120	,179*	-,044	-,112	,491**	-,528**	,005

*. Correlation is significant at the .05 level (2-tailed).

**. Correlation is significant at the .01 level (2-tailed).

Based on the record, a significant negative correlation exists between 'Pond size' and 'Survival rate'. In other words bigger ponds show higher mortalities. At first glance this is difficult to understand. From a practical point of view, various reasons could have contributed to this result. In bigger ponds for example, it is more difficult to control predators and to maintain homogenous water parameters within the pond.

The positive correlation between 'Duration of production' and 'Survival rate' is also shown, which means the longer the production cycle the lower the mortality. To explain this correlation it has to be stated that shrimp is cultured for a longer period because of high growth rates. Generally healthy shrimp show higher growth rates (compare Figure 55) and therefore higher survival rates.

The third significant negative correlation was shown between 'Average temperature' and 'Survival rate', which means the higher the temperature the higher the mortality. This is surprising, because higher temperatures (within the range of temperatures in NE Brazil) are considered as a more favorable environment for shrimp. A possible explanation can be found in higher disease pressure due to higher temperature⁶⁵. It might also be that temperature variation is higher in higher average temperatures.

The variables which have been stated as critical factors in Duraiappah, et al. 2000 (such as stocking density and FCR), show no significant correlation with the survival rate in the survey (see Table 31). Other significant correlations shown in the table give additional indications about general pond management. Bigger ponds are generally stocked with lower density, which might be due to better control possibilities in smaller ponds. In bigger ponds a higher share of medical feed is applied. Even though this correlation is quite weak (0.193) it is significant at the 0.05 level. The assumption that a higher share of medical feed (more stress and disease susceptibility) is correlated with a higher stocking density, can not be shown from the data survey (the correlation coefficient between medical feed and stocking density is very low and not significant). In relation to the duration of the production cycle, it can be stated that long production cycles are correlated with a higher average weight and a higher FCR. This could be an indicator, that the longer the production cycle, the less efficient the shrimp changes feed into weight. The correlations considering the average temperature during the production cycle can be summarized as following: the higher the temperature, the shorter the production cycle, and the longer the time between two cycles. This second stated correlation is not logical from a practical point of view. It is rather supposed that a high temperature

⁶⁵ Viewed from practical experiences it is stated that the pond water can reach up to 37°C, whereas production is still possible, but with lower growth rates and increasing risk of vibriosis (contribution to the Shrimp discussion group various, 17.05.02).

shortens the preparation time due to better oxidation and sediment removal. An interesting variable in this context would be the rainfall between two cycles or other factors such as scheduling of stocking and availability of PL at the corresponding time.

6.3.3.3 Conclusions from survival rate analysis

According to the results presented above, the following conclusions can be drawn:

- ⇒ The survival rate with an average of 78% is higher compared to survival rate average in Northeast Brazil (see Table 24).
- ⇒ The correlations stated as significant in the literature for stocking density and survival rate could not be shown as significant. This is probably due to the variation of the pond management variables of the case study (stocking density from 7.1 – 21.7 PL/m³).
- ⇒ Cycles with higher stocking densities have less stable survival rates. Therefore the management of these cycles have to be monitored carefully.
- ⇒ The significant negative correlation between pond size and survival rate indicates further necessary investigations considering differences in the management of smaller and bigger ponds, which may have caused this negative correlation.

6.4 Medical feed

The production of shrimp with traditional semi-intensive farming methods cannot be completely guaranteed without the use of medical feed⁶⁶. The application of antibiotics as medical feed is a widely discussed issue (see also GAA 2002). It is important from two points of view, on one hand it is an indicator for the state of animal health of the shrimp in a pond during a production cycle. As Kautsky, et al. (2000) argue, disease outbreak is mainly a consequence of physical stress, the use of medical feed is thought to be an indicator of the health of the shrimp in the pond. On the other hand it is a question of acceptance from the customer point of view (see chapter 3.4, p. 80). The question of acceptance is not objective, nor scientifically proven, but it is a requirement defined from a key stakeholder group. Based on this background some important variables correlating with the use of medical feed will be tested.

6.4.1 Hypothesis and method of medical feed data analysis

One of the main challenges is to detect ways to produce shrimp without using antibiotics. For existing shrimp farms the first step is to understand the production process, and to determine ways to reduce the use of medical feed.

It will be tested in which production cycles medical feed was used in order to detect probable reasons for the need of medical feed application.

6.4.2 Empirical data record for medical feed

The use and application of antibiotics (mixed into the daily feed ration)⁶⁷ is a curative measure in the farm management of this case study. If the share of infected animals in the weekly sample exceed a defined amount, medical feed was applied. In the case of incidence of more than ten percent of Necrotizing hepatopancreatitis (NHP) medical feed was applied for a period of ten days. The application was allowed only up to the 60th day of the production cycle.

⁶⁶ As actual information of the author.

⁶⁷ 'Medical feed' is used as synonymous.

The application of medical feed on the different farms was uneven. At one location (farm B), no medical feed was applied. On farm C, in 40 percent of the production cycles no medical feed was used. The first location (farm A) with 168 production cycles shows a normal distribution with 42% of all cycles in the category 15 – 30% medical feed, 30% in the category 0 – 15% medical feed, 25% in the highest category of > 30% medical feed and only 3% of all production cycles without medical feed. Due to this uneven application the data record of only one location will be analyzed. This analysis should give indications of what the reasons are for medical feed application on working farm locations. Some main figures related to the data set are shown in Table 32.

Table 32: Record for medical feed analysis

Farm location	A	Range	
		Minimum	Maximum
Number of production cycles	168		
Productivity	21.6	5.0	37.2
Average survival rate (%)	75.1	33.5	100.0
Average stocking density (animals/m ³)	13.5	7.1	21.7
Average weight (g/shrimp)	10.9	6.4	15.0
Share medical feed of total feed (%)	22.1	0.0	64.4
FCR	1.4	0.7	2.7
Average preparation time (days)	22.6	4.0	41.0
Average duration of production (days)	101.5	57.0	138.0
Average size of ponds (ha)	4.3	0.3	7.4

6.4.3 Results of medical feed analysis

Figure 59 shows the correlation between medical feed and productivity. The columns reflect the level of productivity, categorized as low – mid – high productivity of the production cycles. The use of medical feed is grouped in four groups, whereas the first group is ‘no medical feed’, the second group 0 - 15% medical feed, the next group 15 – 30% medical feed and the last group over 30% medical feed.

Figure 59: Medical feed and productivity (N=168)

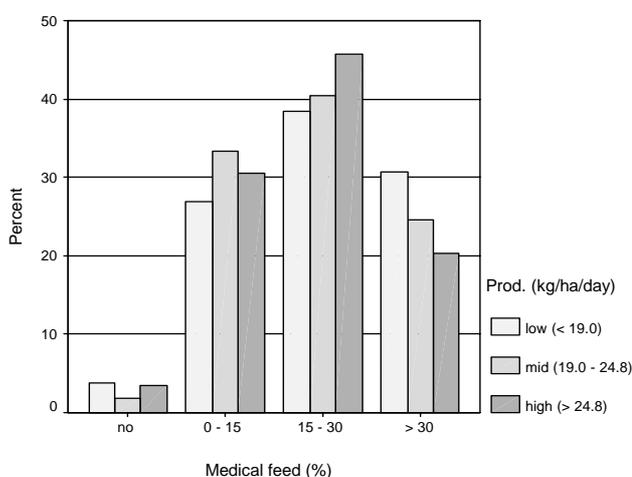
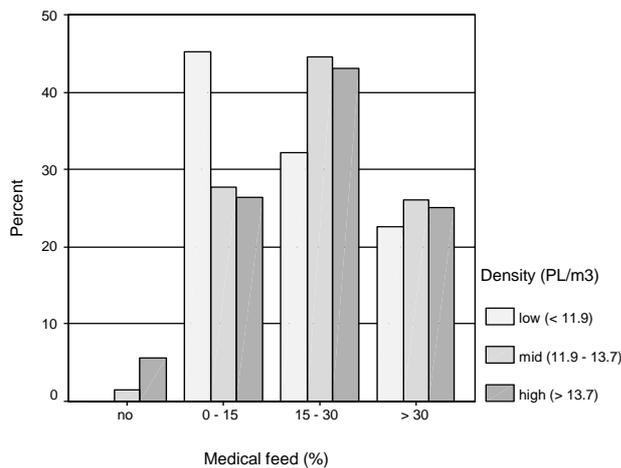


Figure 59 shows that only in a few cycles no medical feed was applied. Therefore almost all cycles suffered some diseases during their grow-out phase. While cycles without medical feed and low productivity may be a result of missing treatment / attention, cycles with high productivity and no treatment are possible cases for learning better management. It can also be stated, that cycles with a high share of medical feed could either result in high or low productivity.

Those cycles with high productivity indicate a successful treatment with medical feed (recuperation). As shown in Table 31 no significant correlation exist between medical feed application and survival rate.

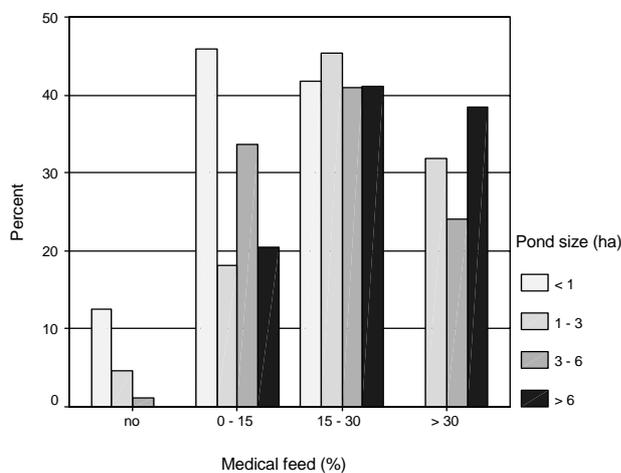
No correlation could be shown between medical feed and stocking density (see Appendix, Table 55). It is possible, that the observed range of densities was too small to detect such a correlation. Nevertheless it is analyzed in Figure 60.

Figure 60: Medical feed and stocking density (N=168)



High share of medical feed (>30%) can be observed in approximately 25% of all cycles, independent of the stocking density. This could be a result of a constant rate of failed treatments, independent of stocking density. Approximately 45% of all cycles with low stocking density are in the group of 0 – 15% medical feed.

Figure 61: Correlations between medical feed and pond size (N=168)



The calculations of correlation coefficients between variables showed one significant correlation (at the 0.01 level). Between ‘Pond size’ and ‘Medical feed’, the spearman’s rho correlation coefficient is 0.252 (see Appendix, Table 55). This indicates that in bigger ponds more medical feed was applied than in smaller ones. This can be attributed to various reasons: 1) bigger ponds may have less stable parameters and the risk for diseases is higher, 2) it is more difficult to avoid an external contamination in bigger ponds,

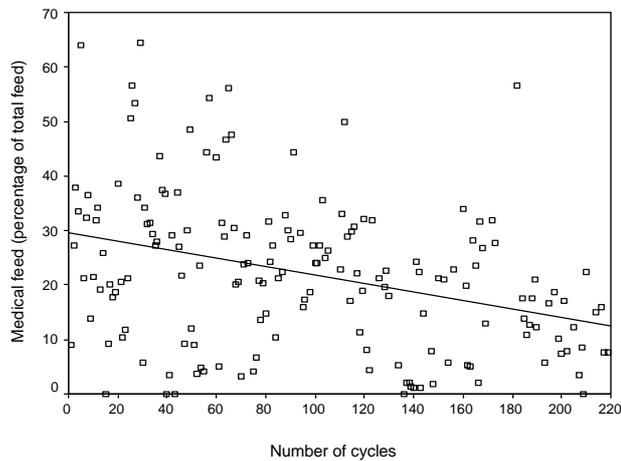
- 3) incidence of disease depends on population size within a pond, rather than on density, and
- 4) more attention is given to bigger ponds because production failures would be economically more painful than in smaller ponds.

Analyzing the set of 168 production cycles from farm location A is shown in Figure 62. A trend of reduction of medical feed application is demonstrated, within 18 months from approximately 30% to approx. 15% of the total feed applied⁶⁸. Taking into account higher productivity over time (see Appendix, Figure 105), it can be stated that through better management practices medical feed application can be reduced without having negative impact on

⁶⁸ Type and concentration of medical feed was the same over time.

productivity. The management practices include stress reducing measures such as low variation of water parameters, constant monitoring of animal health and standardization of proceedings (e.g. transfer of PL to the pond). In Figure 62 a reduction of the variation of the share of medical feed applied over time can be shown. This indicates that health status became more stable.

Figure 62: Application of medical feed over time (N=168)



The following conclusions relating to the application of medical feed can be drawn:

- ⇒ Medical feed application can be reduced through better management practices, maintaining the production results of a farm.
- ⇒ The farm location (site evaluation) is very important in creating an environment that does not request high input of medical feed or to completely avoid the use of medical feed.
- ⇒ In bigger ponds more medical feed is applied. The reasons discussed above are only assumptions and not yet understood.
- ⇒ It is possible to have good production results without using medical feed. Such cycles should be used as part of the learning process. Tests should be conducted with production cycles not applying medical feed, but incorporating alternative products (e.g. immunostimulators, natural bacteriocins, etc.).
- ⇒ No correlation between medical feed and stocking density could be found. This might be due to the relatively small range of analyzed densities (analogous to stocking density and survival rate).
- ⇒ Medical treatment – even in high dosages – does not always recuperate the health status of the animal. Alternative treatments may be necessary in such cases.
- ⇒ The use of medical feed may result in more stable production, through efficient application infections can be combated with medical feed and losses may be avoided, which is a clear risk reducing measure. But for long-term development this is not preventative measures which may help to reduce and avoid the necessity of medical feed. This reflects a possible conflict of goals with relation to the use of medical feed and its long term sustainability. (stable production results vs. no application of medical feed).

6.5 Feed- and waste management

This chapter will point out some interactions of feed management in relation to sustainability requirements. One part includes the efficiency of feed, measured with the indicator feed conversion ratio (FCR) and also the discussion about feed waste in effluents⁶⁹. The second part (chapter 6.5.2) deals with protein source as one crucial feed component.

6.5.1 Feed conversion ratio and waste management

The feed conversion ratio (FCR) measures the input of feed divided by the output of shrimp. Generally the FCR is measured in kg feed and kg shrimp without considering the level of protein. Boyd (1999, p. 12-13) describes the impact of feed as one source of nutrients in shrimp pond effluents⁷⁰. In this context the 'DIN load' is often stated. DIN stands for dissolved inorganic nitrogen concentration. Authors such as Rivera-Monroy (1999) calculated a generalized nitrogen budget to estimate the required area of mangrove forests to remove the DIN load from effluents produced by shrimp ponds.

6.5.1.1 Hypothesis and method of FCR data analysis

It will be analyzed which variables have a correlation with the FCR of the production cycles. Additionally to the FCR, the nitrogen and phosphorus impact of the feed will be analyzed. Boyd (1999) calculates the amount of nitrogen and phosphorus entering the water pond by using FCR, feed content, and dry matter of feed and shrimp. Boyd states an example with a FCR of 1.5 and a feed with 35% crude protein and 1.2% phosphorus. The author states that in this example, each kilogram of live shrimp would result in 56.5 g nitrogen and 15 g of phosphorus in wastes. By not exchanging water during the production cycle the main part of this nitrogen and phosphorus will be removed through biological processes from the water⁷¹. The issue of reducing the water exchange rate based on the facilities of the case study is discussed in Schwab, et al. (2002, p. 24).

6.5.1.2 Empirical data record for FCR

Similar to the data of the survival rate and the medical feed analysis, differences between the three locations can be stated. The record is therefore based on location A, with 168 production cycles (see Table 32). In addition to the data used in the analysis of medical feed, the amount of nitrogen and phosphorus entering the pond water are calculated using the nitrogen and phosphorus content in the corresponding feed (named as 'Waste N' and 'Waste P'). These numbers are calculated according to Boyd (1999). The mean, minimum and maximum values of the sample are shown in the following table.

⁶⁹ Because organic nitrogen and phosphorus can be transformed to soluble inorganic form by microbes, the eutrophication potential of pond effluents increases as the total concentration of nitrogen and phosphorus increases (Boyd 1999, p. 12).

⁷⁰ The fertilizer feed input is the main source of nutrients applied to ponds.

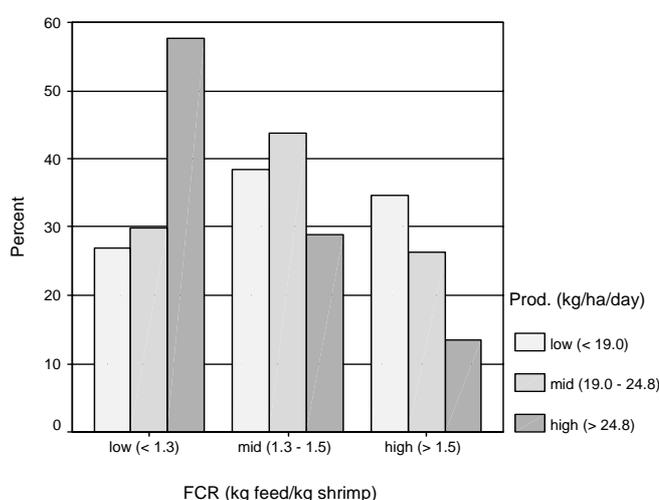
⁷¹ Boyd (1999, p. 13) states that approximately 50% of the nitrogen and 65% of the phosphorus added in feed could be removed from the water of a pond without water exchange through physical, chemical, and biological processes.

Table 33: Record for FCR

Farm location	A	Range	
Number of production cycles	168	Minimum	Maximum
FCR	1.4	0.73	2.7
Waste N in g/kg harvested shrimp	50.29	13.14	124.23
Waste P in g/kg harvested shrimp	6.68	1.95	15.84

6.5.1.3 Results and conclusions for feed management

The variables 'FCR', 'Waste N', and 'Waste P' in their original data all show a normal distribution. The waste of N and P per kg harvested shrimp is calculated based on the FCR. If the combination of different types of feed (e.g. different contents of crude protein and phosphorus) does not change in the various production cycles, the variables 'waste N' and 'waste P' are correlated with the variable 'FCR'⁷². This was also shown by the spearman's rho correlation coefficient (see Appendix, Table 56). This correlation was also stated in Casavas 1994, cited in Rivera-Monroy (1999, p. 17) where the authors argue that approximately 78% of the N in the shrimp feed is wasted due to poor feed conversion ratios and loss of nutrients through leaching. According to this correlation both waste variables also have the same correlations with other variables. The only exception is the correlation between 'waste N' and 'medical feed'. The correlation matrix is shown in Appendix, Table 56. The significant correlations will be shown in the following figures.

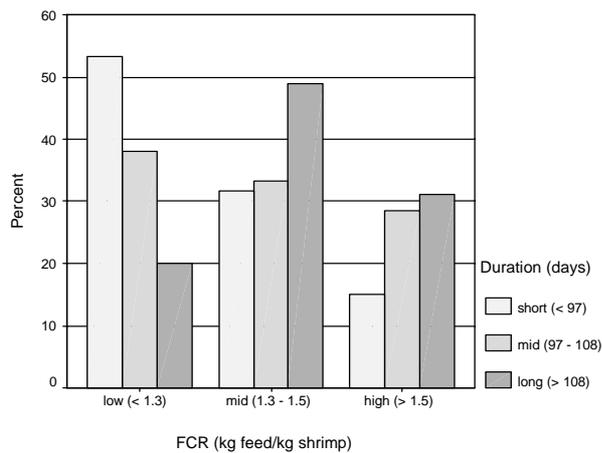
Figure 63: Feed conversion ratio and productivity (N=168)

'Productivity' and 'FCR' have a spearman's rho correlation coefficient of -0.295 , significant at the 0.01 level. The higher the productivity the lower the FCR. For instance in the group with low FCR (< 1.5) almost 60% of the production cycles with high productivity are in this cluster. This may be explained as follows: To achieve high productivity, the shrimp has to be healthy and well fed, which enables a higher growth rate and less risk of infections. Such production cycles show low FCR.

The correlation coefficients between 'productivity' and 'waste N', and between 'productivity' and 'waste P' are -0.323 , respectively -0.295 and both significant at the 0.01 level (see Appendix, Table 56). This means that in production cycles with a higher productivity less waste of N and P per kg shrimp is produced.

The duration of production is classified in three groups of the same size. The correlation coefficient between 'duration of production' and 'FCR' is 0.327 , significant at the 0.01 level. Figure 64 illustrates, that low FCR is achieved by approximately 53% of short cycles. As a contrast only approximately 20% of long cycles achieved this low FCR.

⁷² This is can be explained based on the dependence of N from FCR.

Figure 64: Feed conversion ratio and duration of the production (N=168)

The correlation of FCR and duration of production can be explained by two reasons: 1) shorter production cycles, result in lower average weights and as a consequence in lower FCR, due to decreasing FCR depending on weight, and 2) longer production cycles within the same farm are often related to health and growth problems in the grow-out phase.

‘Waste N’ and ‘Waste P’ have a similar significant correlation coefficients as FCR (see Appendix Table 56). One additional correlation between waste N and medical feed could be shown (Spearman’s correlation of 0.166 and significant on the 0.05 level). This indicates that medical feed has a higher share of protein and therefore more waste is produced (see also Figure 106 in the Appendix).

Based on the considerations of FCR and waste in the pond water through feed input the following conclusions may be drawn:

- ⇒ If the feed strategies (types of feed) and the water exchange rates are constant, wastes of nitrogen and phosphorus can be replaced by the figure of FCR. FCR is therefore a good indicator for the waste of nutrition in the effluents.
- ⇒ Employees in charge of feeding need to understand the importance of their task and the importance of the figure ‘FCR’ both as a cost indicator and as a waste indicator.
- ⇒ External factors influencing natural feed production, such as quality of intake water (rich in nutrients), sunshine, etc. should be considered when comparing FCR between farms.
- ⇒ A higher productivity is correlated with a better feed conversion ratio and as a consequence with less waste of nitrogen and phosphorus in the pond water.
- ⇒ Shorter production cycles have generally better FCR than longer production cycles.
- ⇒ The input of feed is only one component causing nitrogen and phosphorus in the effluent water. Other sources are fertilizers applied to pond water and organic nitrogen and phosphorus as components of living plankton.

6.5.2 Animal protein and vegetable protein

One third of the world’s fish production is not used for direct human consumption, but is processed into industrial fishmeal and fish oil to be used as animal and fish feed and for fertilizers (Williams 1997, p. 6). Aquaculture currently uses 35% of the world fishmeal supply. By the year 2010, it is expected to increase its share to 56% (GAA 2001). In this context aquaculture is often blamed to cause over fishing problems (see Naylor et al. 2000, cited in GAA 2001). This topic is controversial depending on the species used for fishmeal and on the species cultured in aquaculture systems. Ackefors (1997, p. 151) argues that most western people prefer to eat carnivorous species such as salmon, rainbow trout, etc. The competition with other consumers of fish (fish for the human consumption and for the animal consumption) is one important point of the discussion. In the context of availability of feed resources which

could impact the development of aquaculture industry, De Silva (1997, p. 222) has defined the term ‘fishmeal trap’. The second point focus on the farm level, illustrating the impacts of animal protein in the nutrition of aquaculture species. Bernal (1997, p. 114) states that two aspects of nutrition are critical for the sustainability of aquaculture: First, the need for alternative protein sources and secondly the need to develop diets that reduce the inputs of nitrogen and phosphorus into the environment. Various authors focus on the feed composition and its environmental impacts through effluents (De Silva 1997; Ackefors 1997). New 1996, cited in De Silva (1997, p. 235) reports that protein levels in balanced shrimp diets could be halved without any loss of performance. A decrease of protein and an increase of fat level in the feed composition could reduce the ammonia concentration in effluents (Ackefors 1997, p. 164).

6.5.2.1 Hypothesis and method

Soybean, as a component of feeds for avian and mammalian species, is commonly used as a substitute for fish meal (Bernal 1997, p. 114). The author also states that fish meal does not have a substitute in cultured fish of crustacean nutrition. Even though, soybean is already used in shrimp feeding, it is usually used as a complementary feed component rather than a fishmeal substitute. According to the internal information of the American Soybean Association (ASA), a strong increase of soybean sales to the Chinese aquaculture industry has been reported.⁷³ The species *L. vannamei* is an omnivore species. The percentage of possible substitution of animal protein with vegetal protein is not known yet.

Ex-post analysis of secondary data and an experimental trial in the case study will be analyzed to verify the poor knowledge considering additional soy in the feeding. The following hypothesis will be tested: The use of soy as a complementary feed leads to:

- Decreased use of medical feed
- Better monetary feed conversion rate (mFCR)⁷⁴

6.5.2.2 Empirical data record for feed management

The first part includes secondary data from production cycles from April until October 1999. In 19 out of 23 production cycles of the case study soy was used as a complementary feed. After an average size of 8 g per animal, 10% soy was added to the common feed. The record of these 23 production cycles is shown in Table 34.

Table 34: Record for secondary data soy application

Farm location A		Range	
Number of production cycles	23	Minimum	Maximum
Productivity (kg/ha/day)	13.95	6.24	19.50
Average survival rate (%)	54.45	33.5	73.8
Soy as percentage of total feed (%)	3.88	0.0	8.2
Average weight per shrimp (g)	9.45	7.8	10.6
Share medical feed of total feed (%)	24.98	0.0	64.0
FCR	1.44	1.0	2.1
Monetary FCR (R\$/kg harvested shrimp)*	1.50	1.04	2.26

* Assumptions feed costs (prices 1999): common feed: 1.04 R\$/kg;
 medical feed: 1.16 R\$/kg
 soy: 0.38 R\$/kg

⁷³ For further information see: <http://www.oilseeds.org/asa/index.html>.

⁷⁴ mFCR is measured in adding all feed costs divided per kg shrimp harvested.

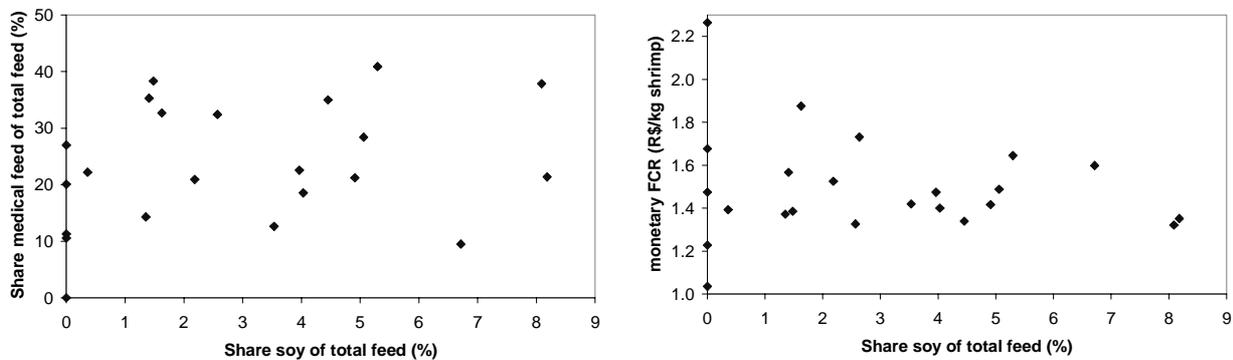
The second part includes an experimental trial in four production ponds. It started in February 2000. For this purpose the ponds were stocked with PL from the same larvae production lot and with identical stocking densities. Due to technical reasons the date of stocking had to be shifted in one pond. The pond size is different and as a consequence differences in soil condition, topography, design of the ponds, etc. existed. Though, two ponds (A and B) are similar in size and location. The experimental trial was repeated three times, which represents production for a whole year. Due to organizational reasons one pond had to be changed for the repetition of the experimental trial.

6.5.2.3 Results of using soy

Secondary data analysis

Based on the record score pairs of ‘Soy as a percentage of total feed’ and a ‘monetary FCR’ (which is calculated as feed costs per kg harvested shrimp) were developed. The results are shown in Figure 65.

Figure 65: Soy and medical feed; soy and monetary FCR



Visually no correlation can be seen between the medical feed and the input of soy, nor between the monetary FCR and the input of soy. Based on the results of the 23 production cycles and on the actual prices for feed, the hypothesis cannot be confirmed. Though, depending on the price development of soy and fish meal the additional use of soy could become an economically viable and ecologically useful alternative.

Primary data analysis

Table 35 shows the production results of the experimental trails described in 6.5.2.2. The first stocking took place on February 02 2000, the second on June 02 2000⁷⁵ and the third on October 10 respectively 13 2000. This data set illustrates the variation over the year and the differences associated with winter and summer production cycles.

⁷⁵ In this trial no control pond without soy application was made.

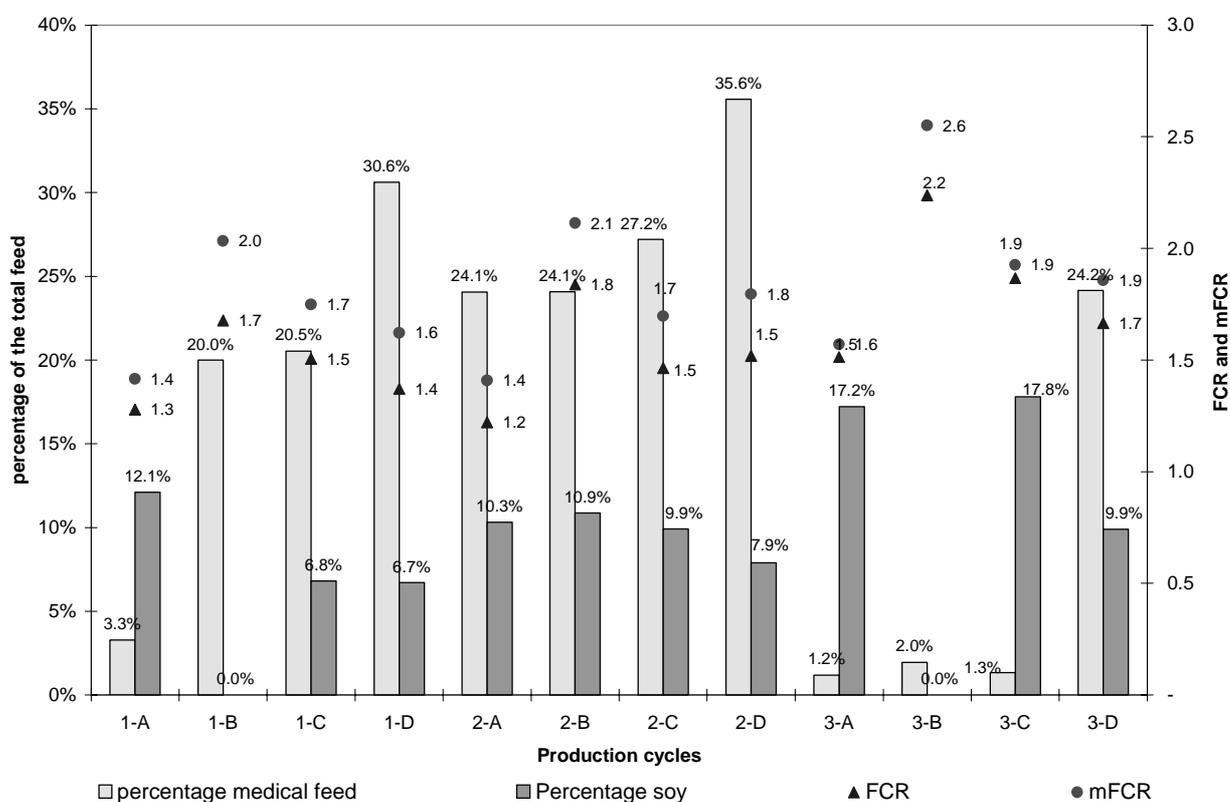
Table 35: Production results of Soya trials

Pond identification		A			B			C			D		
Pond size	ha	0.68			0.43			0.335			5.0		
Trial number		1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
medical feed (% of total feed)	%	3.3	24.1	1.2	19.9	24.1	2.0	20.6	27.2	1.3	30.6	35.6	24.2
Soya (% of total feed)	%	12.1	10.3	17.2	0.0	10.9	0.0	6.8	9.9	17.8	6.7	7.9	9.9
FCR		1.28	1.22	1.51	1.68	1.84	2.24	1.51	1.46	1.87	1.37	1.52	1.66
Average weight	g	10.7	11.1	10.7	10.8	11.3	12.4	10.6	10.0	11.6	11.3	11.2	12.6
Productivity (kg/ha/day)		23.86	20.38	27.22	28.31	21.82	17.69	27.06	27.71	25.99	25.96	17.78	24.64
Survival rate	%	82.87	74.39	107.1	96.64	76.96	60.34	89.79	110.0	95.44	84.24	69.60	83.29
mFCR	R\$	1.42	1.41	1.57	2.03	2.11	2.55	1.75	1.70	1.93	1.62	1.79	1.86

The first experimental trial shows differences between the ponds with or without soy in the feed conversion rate and the use of medical feed. The results of the second trial did not confirm the assumptions of the first trial. The differences of feed conversion rate and survival rate between the ponds are higher than in the first trial. The lower level of productivity in the second trial compared to the first can be explained by the temperature influence (production cycle during the winter months) and the lower growth rate of the shrimp.

Figure 66 shows the results of the three experimental trials in a graph.

Figure 66: Feed, FCR and mFCR



The feeding costs are influenced by the FCR and the feed composition (e.g. high percentage of expensive medical feed). Figure 66 shows that the feeding costs vary parallel to the feed conversion rate. This variation is less pronounced in the case of a high share of soy in feed composition (see 1-A). Further analysis of feed costs of the case study are illustrated in Schwab, et al. (2002, p. 23-24).

According to the analysis of soy as a feed complement the following conclusions can be drawn:

- ⇒ Considering the existing feed prices the use of soy has no negative effect on the feeding costs (independent of the additional labor associated with mixing the feed components).⁷⁶
- ⇒ There is no obvious economic motivation for not using soy as a feed component.
- ⇒ The input of soy as an additional feed complement raises the question of the availability of GMO-free soy on the market. This issue is raised as a requirement (see Table 19, p. 83).
- ⇒ Such tests should be done in controlled environments, to avoid or reduce lateral effects of external factors.

⁷⁶ Oral information from responsible person for feeding on the case study farm, January 2001.

7 Economical evaluation of production correlations

7.1 Net margin

According to Clay (1997) some improvements in the production process can lead to an increase of profitability and sustainability. One example the author states is the movement towards closer systems which is a way to increase profitability and sustainability (Clay 1997, p. 34). For this reason the production cycles will be analyzed according to their economic results. For this analysis the net yield of every production cycle will be analyzed. The net yield represents a calculated margin and is defined as shown in Equation 8.

Equation 8: Net margin of production cycles

$$\text{Net margin} = \text{harvested shrimp (kg)} * \text{average selling price} - (\text{costs for PL} + \text{costs for feed} + \text{costs for fertilizer} + \text{costs for processing} + \text{fix costs}^{(*)})$$

() fix costs are calculated as a fix factor * pond size (ha) * days of the preparation and production cycle*

The net margin can be calculated for every single production cycle. If the net margin is divided per ha and day of the corresponding pond, the economic results of the cycles can be compared with each other. For the calculation of the financial result of every production cycle costs were divided in direct costs which are distributed to every single production cycle (PL, fertilizer, feed) and costs which can not be directly distributed (including labor, energy, maintenance, administration, transport, etc.). These costs are summarized in one factor, called a ‘fix factor’ which is calculated in ‘R\$/ha/day’. Through this factor indirect costs are distributed to every single production cycle. Longer production cycles (incl. days of preparation), and bigger ponds cause a higher share of indirect costs. The processing costs are considered as variable costs in the case of N=109 (see 7.1.3.1) and in the second analysis (N=219) it is assumed that the processing costs are included in the fix factor (see 7.1.3.2)⁷⁷.

7.1.1 Hypothesis and method of data analysis

The development of the net yield over time will be analyzed first. To analyze the correlation between net yield and other production factors, external factors such as price fluctuations for inputs and selling prices have to be adjusted. The correlations will be calculated with bivariate statistics. Based on practical experiences and presumptions the following hypothesis will be tested:

The net margin/ha/day (R\$/ha/day) is positively correlated with productivity, and stocking density. A further positive correlation is expected between net yield and relative variable costs⁷⁸.

⁷⁷ This classification is due to differences in the data collection. Initially the processing costs have been calculated according to each production and processing lot. This procedure became more difficult because of more locations, bigger processing lots, etc.

⁷⁸ Kubizta (2001) describes this correlation as following, (referring to the feed costs as variable costs): “Quando a piscicultura opera com boa eficiência, os custos fixos são minimizados e a participação da ração nos custos de produção tende a aumentar”.

7.1.2 Empirical data record for net margin

For the development of the actual gross and net margin, the company's records with prices and sales information were used. The records of valid data includes 109 production cycles from April 1999 (first stocking) to January 2001 (last harvesting). The records include prices of input (feed, PL, fertilizer, etc.) and selling prices. According to Shang and Tisdell (1997, p. 133) the farm price of aquaculture products is mainly affected by size, form, and quality of the product in the competitive seasonal markets. The results of this development are shown in 7.1.3.1.

To test the hypothesis stated above, a more comprehensive record was used. This record included 219 production cycles in the time frame from March 1999 to August 2001. It is the same record as described in Table 26, p. 110. Compared to the first record (N=109) the second record is adjusted by average prices and average costs. This means that the amount of input (e.g. kg feed, fertilizer, etc.) is multiplied with the average price of the corresponding input in the record's timeframe. With this adjustment of the data record, the costs are independent of price fluctuations of the inputs. The selling price is also adjusted by an average price which is independent of quality and seasonal or external price fluctuation. The price only depends on the size (average weight) of the shrimp. These assumptions for the input prices and the selling prices are shown in the Appendix (Table 58 and Figure 107).

7.1.3 Results and conclusions of net margin

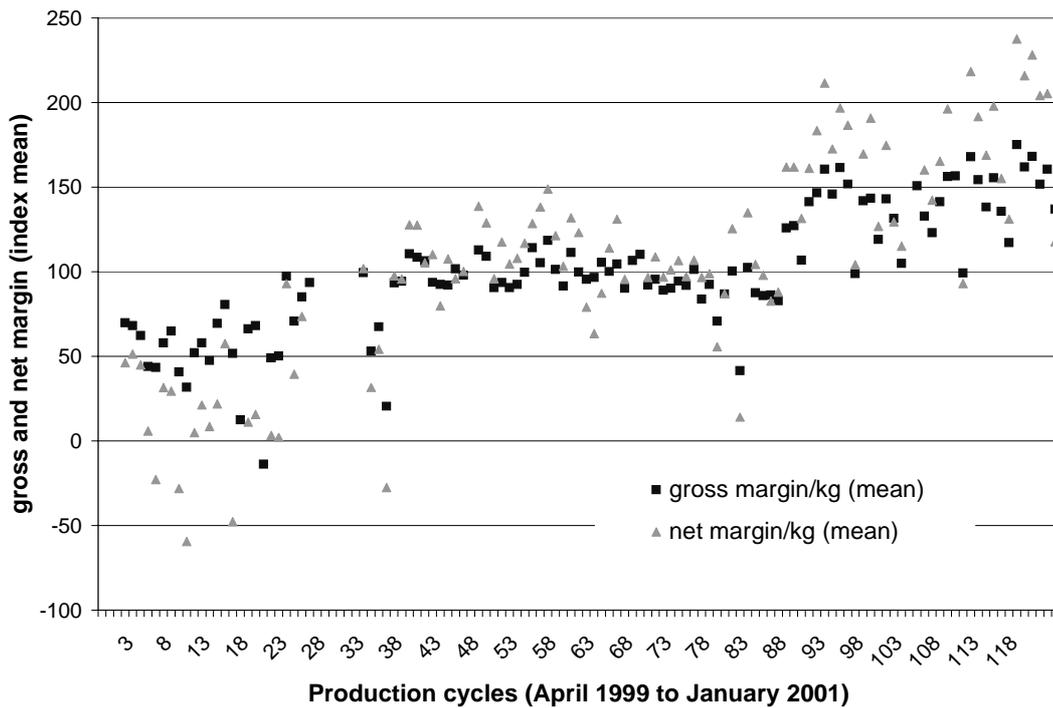
7.1.3.1 Net margin per kilogram with corresponding costs and prices (N=109)

The development over time of gross and net margin is shown in Figure 67. On the X-Axis the continuous number starting with the first production cycle in April 1999 and ending with the harvest of the last production cycle in 2001 is shown. The gross margin is calculated as total value of sales minus direct costs of PL, fertilizer and feed, divided by total production in kg. The net margin is calculated as gross margin minus processing, commercialization and fix costs, divided by total production in kg. The index equals 100 for the mean value of the margin⁷⁹. This means that all production cycles over 100 are above the average of the margins in the corresponding time frame.

It can be shown that the margins are increasing over time. The net margins of the last cycles are doubled to the average net margin (=100). The margins include trends in price fluctuations of inputs and also in selling price fluctuations.

⁷⁹ The data is based on actual farming results of the case study. Therefore all economical results presented in the thesis are calculated in an index form.

Figure 67: Gross and net margin of production cycles, Index 100 = mean (N=109)



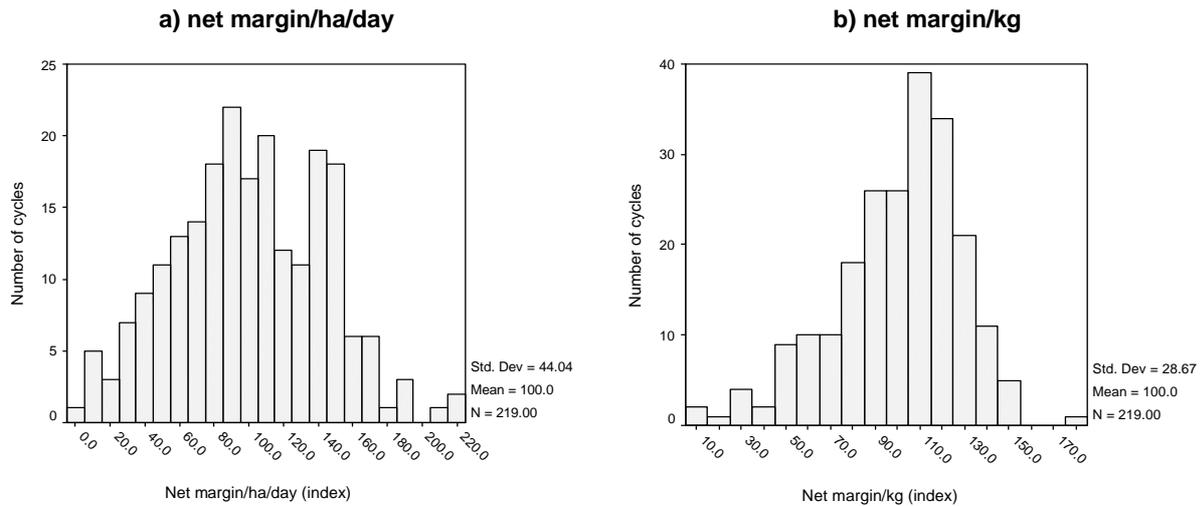
The increase of the margins in the last third of the figure can be explained through the implementation of the direct export activity of the company. Increasing variations between the results of the production cycles may be due to several reasons. For instance variation of results in the production process, such as productivity and survival rate, variation in the distribution and in prices of main inputs such as PL and feed.

In order to compare the financial results of each single cycle, constant prices for inputs and constant selling prices over time were assumed. With this adaptation market trends are eliminated and the production results can be compared with each other. In contrast to the output figures which were used for the calculations in chapter 6, the monetary figures allow the measurement of effects of different kinds of inputs, such as various types of fertilizer or feed.

7.1.3.2 Net margin per hectare and day with calculated costs and prices (N=219)

The net margin can be calculated per ha and day, or per kg. The histograms of the corresponding data are shown in Figure 68. The data is indexed with the mean at 100.

Figure 68: Histogram of net margin (N=219)



The comparison of the histograms show the differences between the economic evaluation of the production cycles. The standard deviation of the net margin in figure a) is higher than in figure b). The measure ‘net margin/ha/day’ is a monetary measure for productivity. It includes the land resource and time used for the production. The measure ‘net margin/kg’ is an efficiency measure of a production cycle, including the output and its value. The main difference between the two concepts is the focus. In the first case (a) the underlying concept is the maximization of the margin based on a given area (ha) and time (days). The second concept (b) aims at the maximization of the net margin/kg. This approach is based on the restriction of a given quantity to be produced (e.g. quote).

In the following statistics the measure net margin/ha/day will be used to evaluate correlations between net margin and other production specific variables stated in the hypothesis above (see 7.1.1).

Figure 69: Net margin/ha/day over time, N=219 (mean = 100)

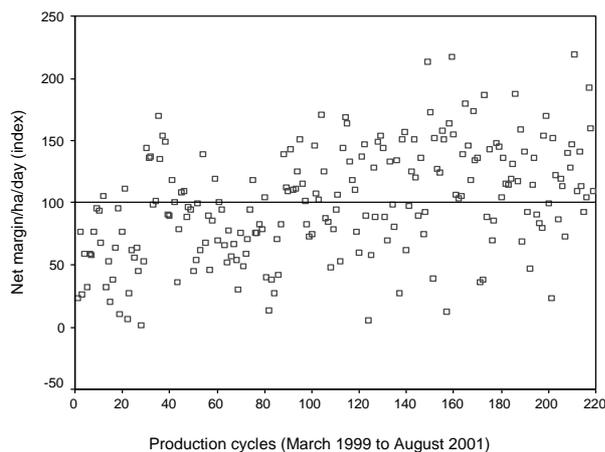


Figure 69 shows the development of the net margin over time. This figure is corresponding to Figure 67, but the data refers to 219 production cycles and the prices are reviewed with standardized selling prices and costs. However, the increase mainly in the first third of the record is visible. As the prices are constant it can not be explained by better prices or lower input costs. It indicates better production results and the experience curve of the management.

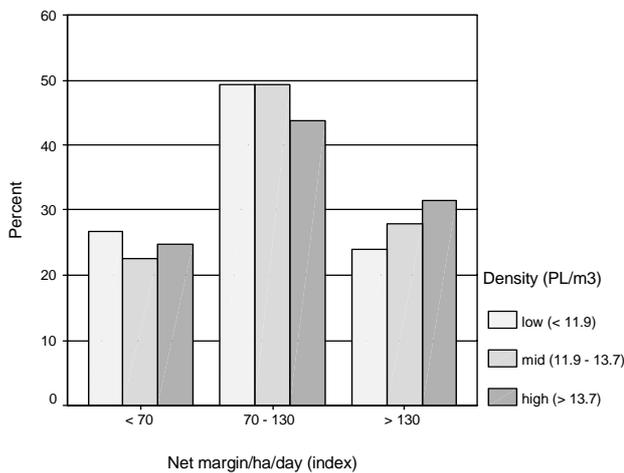
The correlation (see Appendix, Table 57) between productivity and net margin/hg/day amounts to 0.905^{**80} . This correlation confirms the statement above that net margin/ha/day is a monetary measure for productivity (kg/ha/day), which can be expected from logical under-

⁸⁰ ** stand for a significance at the 0.01 level.

standing of the production process. Also the Spearman's rho correlation coefficient between productivity and net margin/kg is significant and amounts to 0.656**.

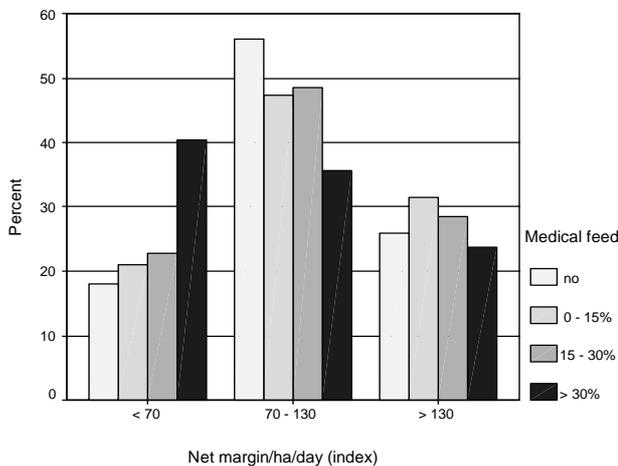
As shown in Figure 52, p. 116 the correlation between productivity and stocking density was slightly positive and significant. The correlation between net margin/ha/day and stocking density is not significant (see Appendix, Table 57). This means that within the production management of the case study, higher stocking density are not economically valuable.

Figure 70: Net margin/ha/day and stocking density (N=219)

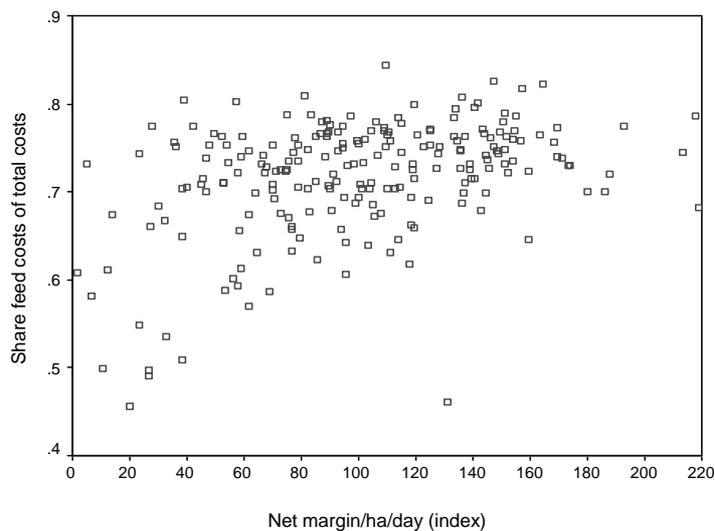


As already stated in Figure 57, p. 124, ponds with higher stocking densities are less stable and more difficult to handle than ponds with lower stocking densities. The challenge is to reduce the variation in the results of production cycles with high stocking densities and therefore get more cycles with higher net margins. One possible measure may be installation of aerators to minimize the risk of high losses as a consequence low net margins.

Figure 71: Net margin/ha/day and medical feed (N=219)



Based on the graphical analysis of Figure 71 an interesting correlation can be shown between net margin/ha/day and medical feed. It is important to point out, that 40% of cycles with a high share of medical treatment resulted in low economic results (< 70% of mean). Various reasons may explain this: first, medical feed is a relatively expensive feed, compared to other feed. Secondly, unsuccessful treatment with medical feed resulted in low production results with high costs. Furthermore medical feed is not used preventively, but only curatively.

Figure 72: Net margin/ha/day and share of feed costs (N=219)

As expected the data record shows a positive correlation (Spearman's rho: 0.503**) between net margin/ha/day and the share of feed costs from total costs (see also Appendix, Table 57). It confirms the statement of Kubizta (2001) which says that with good efficiency the share of feed costs from total costs is increasing.

On the other hand the share of preparation- and PL costs is lower in production cycles with higher net margins.

Preparation costs and PL are generally independent of the duration of production, the growth rate, and the average weight. They can be categorized as fix costs from the point of view of one production cycle.

According the results shown above the following conclusions in relation to the net margin can be drawn:

- ⇒ The measure 'net margin/ha/day' is an important figure to measure the profitability of the productivity of a production cycle. It is suitable for the comparison of economic results within the same farm management, but different duration of production cycles.
- ⇒ Based on the indicator 'net margin/ha/day' various strategies, such as feeding, duration, stocking densities, etc. can be evaluated. It is the only indicator to define the optimal harvest time of a cycle.
- ⇒ Within the analyzed cycles, it is not profitable to use higher stocking densities, as long as the risk of production failures can not be reduced.
- ⇒ In relation to the medical feed application the effectiveness of this application has to be economically evaluated.
- ⇒ The measure net margin/kg is only useful if the production cycles have the same duration, or if quantity is limited by quota.
- ⇒ Further economic investigations (costs and benefits) for the use of alternative products and preventive measures are indicated.

7.2 Growth rates of shrimp

Based on the share of feed costs from production costs and the varying prices according to the final size of harvested shrimp the growth rate of shrimp during their production cycle was analyzed. The following data are based on results discussed in Schwab, et al. (2002) and data are collected during the research project.

7.2.1 Method and empirical data record for the growth rate analysis

The most common commercial size of shrimp for production in the case study was of approximately 12 g. The monitoring of growth rate during the production cycle is quite difficult.

After thirty days of grow-out phase samples of animals are taken. This is done every week at various places of the pond⁸¹. The state of animal health is recorded (see 6.4, p. 126), animals are weighed, and the number of total shrimp is estimated. Based on these samples the total biomass in the grow-out pond is estimated and various production measures (such as biomass, or curative measures such as input of medical feed or increase of water exchange) are based on results of these weekly samples.

The record includes 86 production cycles from August 1999 to September 2000 (data of stocking). The production cycles will be divided according to temperature during the cycle. The division is done according to the average temperature during the production cycle explained in Table 27, p. 114. In the cooler period (average air temperature from 25.7 – 27.3°C) 40 production cycles are analyzed. The warmer period (27.4 – 28.4°C) includes 46 production cycles.

Based on the results of growth rate during grow-out phase, the costs of longer and shorter production cycles will be simulated.

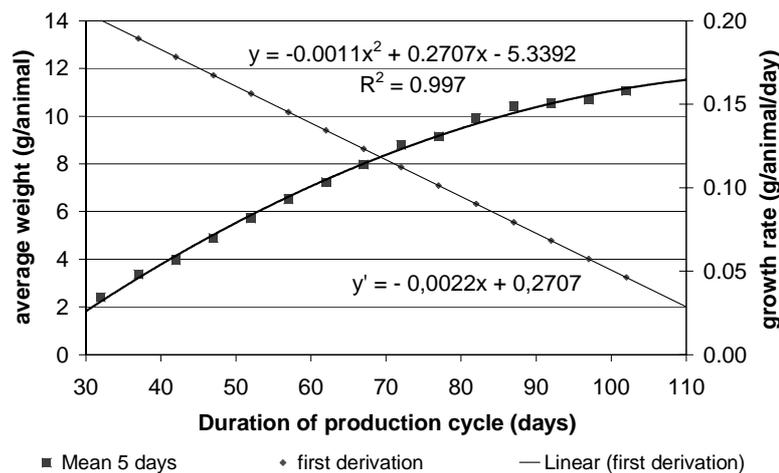
7.2.2 Results and conclusions concerning the growth rate

The results are divided in two parts. In the first part (7.2.2.1) the analysis of empirical data of the 86 production cycles will be shown. The second part (7.2.2.2) shows results of a simulation by varying the duration of production cycles.

7.2.2.1 Growth pattern and growth rate

For the analysis, data of 86 production cycles from August 1999 until September 2000 were taken. The recorded weights of these animals during their production cycles are shown in Figure 73. The duration of the production cycles is shown on the X-Axis, starting with day 30 which usually represents the first sampling. It is shown that the last sample, which equals the final average weight is between 100 and 110 days.

Figure 73: Pattern of growth and growth rates of 86 production cycles

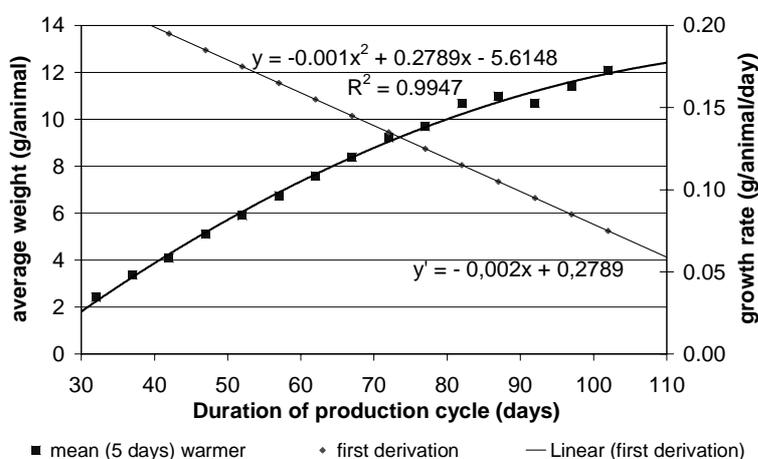


⁸¹ It has to be pointed out that the method of weekly sampling may not reflect the average of all shrimp in the ponds. It is not known if much bigger shrimp are in the sample or not. Comparing the sampling results and the estimation of final weight after processing it can be observed, that the last sampling before harvesting shows higher than average sizes after fishing. The transport and water loss may also influence this variation.

The dark square points represent mean values⁸² of the average weight of samples. Based on these means a polynomial trend line is estimated⁸³. The line has the function specification of $y = -0.0011x^2 + 0.2707x - 5.3392$. The first derivation of this polynomial function represents the growth rate in g/animal/day. As expected for natural growth function the growth rate is decreasing over time. Therefore, at the beginning of the production cycle the animals grow up to 0.2 g/day. After 100 days of grow-out phase the growth rate amounts to approximately 0.05 g/day. It has to be noted that the function is only valid within 30 to 110 days of the production cycle⁸⁴.

The growth rate in relation to temperature is shown in the following two figures. Figure 74 shows 46 production cycles of the warmer period. The first derivation, which represents the growth rate has the form of $y' = -0.002x - 0.2789$

Figure 74: Growth rate of production cycles during warmer time period (N=46)



The dark square points in the figure show the mean values of the average weight of 46 production cycles in the warmer period. The polynomial trend line shows the pattern of growth of these production cycles. The first derivation of this function reflects the growth rate in g/animal/day.

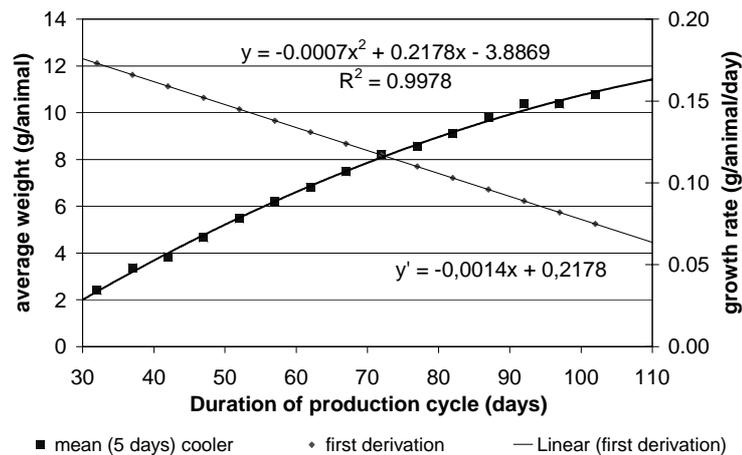
Figure 75 shows the growth rate of 40 production cycles of the cooler period. Based on the data it can be shown that the growth rate in the cooler period is lower than in the warmer period. Moreover, the slope of the growth rate line is lower for the production cycles of cooler period. According to the growth pattern of warmer days the average weight of animals reach 12.275 g after 100 days of grow-out. In the cooler period the average weight after 100 days of production is 10.893 g.

⁸² The values are calculated as a mean over five days.

⁸³ The polynomial trend line showed a higher R square than the logarithmical function.

⁸⁴ If the quadratic trend line is forced to have an intercept point of zero, the R square is lower.

Figure 75: Growth rate of production cycles during the cooler time period (N=40)



Because of missing data for longer production cycles, growth rate could not be verified for production cycles over 110 days. The distribution of sizes of the shrimps (uniformity) would give additional information to evaluate the growth rate in these two different periods. Harvests with a good uniformity are easier for processing and have generally higher quality. Another important issue considering longer production cycles is the feed conversion ratio during the production (see Figure 64, p. 132).

7.2.2.2 Simulation of longer production cycles

Related to the theoretical usefulness of longer production cycles (to produce shrimp with higher average weight) a simulation model was built by using case study data from early 2000. Three simulations based on different production periods, survival rates and final average weight have been calculated. The duration of production and the average weight rely on the growth pattern shown in Figure 73 and the assumption for feed conversion ratio are based on the results shown in Figure 58. The assumptions for the simulation are shown in Table 36.

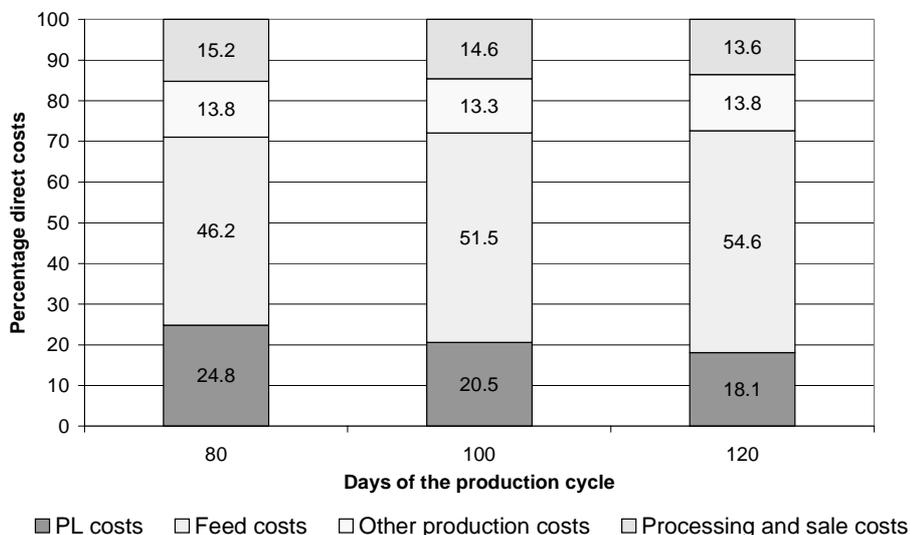
Table 36: Assumptions for the simulation

Simulation	1	2	3
Duration of the production (days)	80	100	120
Average weight (g/animal)	9.28 g	10.73 g	11.30 g
Average selling price (R\$/kg)	7.93	9.11	9.54
Survival rate (%)	80	80	80
FCR (kg feed/kg shrimp)	1.2	1.4	1.6
Productivity (kg/ha/day)	23.2	21.5	18.8

The productivity (*italic*) is calculated with the assumptions shown in the table. Stocking density (25 PL/m²) and days of preparation (20 days) are constant for all production cycles. According to these assumptions absolute and relative costs are calculated. Figure 76 shows relative costs according to the simulations. The share of feed costs increases in longer production cycles mainly because of the higher FCR, but the share of PL costs decreases in longer cycles. PL costs are based on the perspective of one single production cycle considered as fix costs, whereas feed costs are variable. The fix costs (which are calculated with a ‘fix factor’ (see

7.1)) are not considered in the cost distribution, because they are calculated in R\$/ha/day, and stay constant for all simulations.

Figure 76: Share of costs depending on the duration of production cycles



To calculate the net margin, a logarithmical selling price function (Appendix, Figure 107) which results in product-prices shown in Table 36 is assumed. Based on prices and total costs the margin for the three different production cycles was calculated. Analyzing productivity the simulation shows the best productivity in kg/ha/day. Considering the costs and the sales of the production cycle the key figure is the net margin. As listed in Table 37 the net margin per kg is 1.3 times higher for the longer production cycle (120 days) than for the production cycle of 80 days. This is mainly due to higher prices for bigger shrimp and the lower costs per kg produced shrimp (variable part of PL and preparation is divided by more produced shrimp).

Table 37: Productivity, total costs and margin of the simulation

Simulation	1	2	3
Duration of the production	80	100	120
Productivity (kg/ha/day)	18.6	17.9	16.1
Total costs (R\$/ha/day*)	87.3	89.3	86.5
Net margin/kg (index)	100	128	130
Net margin/ha/day (index)	100	124	113

* days of production and preparation

According to these assumptions, it would be more profitable to invest in cycles longer than 80 days. The net margin per kg is the highest in the third simulation and the net margin/ha/day is the highest in the second simulation. However, the difference of net margin/kg is small between simulation 2 and 3. To improve the net margin/ha/day, the second simulation (100 days of production) shows the best result. This indicates that considering the growing rate (see Figure 73), the prices assumed (see Figure 107), and the cost structure of the case study the highest net margin/ha/day result through production cycles of 100 days⁸⁵.

⁸⁵ One additional – not economic – aspect has to be pointed out: Longer production cycles (120 days) lead to less production cycles per year (2.6) than the shorter ones, which results in less water discharge because of less frequent harvesting.

According to the data material of growth rate and duration of production cycles the following conclusions can be drawn:

- ⇒ The season (average temperature during the production cycle) is an important factor for the growth rate of the shrimp. A higher average temperature leads to an increase of growth rate of shrimp. It would be worthwhile to have longer production cycles during the cooler period and shorter cycles in warmer period⁸⁶.
- ⇒ In both seasons (see Figure 74 and Figure 75) the growth rate reaches approximately 0.06 g/animal/day⁸⁷ after 110 days of production. This may indicate a 'biological limit' of growth of the species *L. vannamei*.
- ⇒ Consideration of temperatures during the production cycle may give important indications about the sensitivity of the animals to temperature variations during their production cycle. This means that the production manager of a shrimp farm should optimize the timing of stocking and harvesting also according to the biological limits of the animals. Further investigation is needed to find out whether temperature sensitivity is higher for smaller/younger shrimp.
- ⇒ The size (average weight) influences the net margin, which indicates the necessity of optimal harvesting timing.
- ⇒ Investigation and experimental trials with longer production cycles would be useful for a better understanding of growth pattern.
- ⇒ The range of average weight and duration of production cycles is relatively small in the existing data record. Therefore, a possible correlation between stocking density and growth rate could not be confirmed in the analysis⁸⁸.

⁸⁶ This is already an common practice within Brazil, in the southern areas the production cycles are longer than in NE.

⁸⁷ Cooler period: 0.0638 g/day; warmer period: 0.0589 g/day.

⁸⁸ Vale (2000) states in his studies that the stocking density has a direct influence on the growth rate of the shrimp.

8 Socio-economic impacts of a shrimp farm

The analysis of the socio-economic impacts includes various aspects and can take place on different levels, such as company, region, country (see 3.1.1, p. 48). First, the term 'socio-economic' has to be defined. In the United States annual household income is usually used as a single variable for the socio-economic situation. This would best summarize spending power. In Latin America, household income is problematic due various reasons (hyper-inflation, unsteady cash flows, no household financial bookkeeping, etc.)⁸⁹. In a number of Latin American countries, the definition of socio-economic level was formulated under the guidance of the national marketing associations. Typically, the definition is given in terms of a point-scoring algorithm. For example in Brazil a point-scoring scheme is based upon the number of television sets, radio sets, automobiles, domestic employees, vacuum cleaners, washing machines and bathrooms, and the educational achievement of the head of household (see Zonalatina 2001).

In analyzing the socio-economic situation, the context and state of development (e.g. rate of illiteracy, average family income, unemployment rate, etc.) has to be considered (see chapter 2.1.4.2, p. 30). Therefore, the level of income, social welfare and the educational level is taken into account. The differences within the country (as it will be shown later on) also have to be taken into account. The Brazilian gross domestic product (GDP) in 2000 amounts to 595.5 billions US\$ (World Bank 2001). According to the same source the average annual growth of GDP was 4.5% and 3.2% for the GDP per capita⁹⁰ in 2000.

The report of the states secretary of planning and finances (Secretaria de Planejamento e Finanças, Fundação Instituto de Desenvolvimento do Rio Grande do Norte), IDEC (Instituto Brasileiro de Defesa do Consumidor) and IEP (Instituto de Estudos e Pesquisas) points out the relative position and underdeveloped situation of the state Rio Grande do Norte as a Brazilian Northeastern state (Table 38).

Table 38: GDP in Brazil, the Northeast and the state Rio Grande do Norte

	Brazil			Northeast			Rio Grande do Norte		
	GDP (billion US\$)	Per capita (US\$)	Index per capita	GDP (billion US\$)	Per capita (US\$)	Index per capita	GDP (billion US\$)	Per capita (US\$)	Index per capita
1980 ¹⁾	441.6	3,729	101.4	66.3	1,905	86.1	2.7	1,441	58.1
1994 ¹⁾	565.1	3,676	100	98.9	2,212	100	6.4	2,479	100
2000 ²⁾	595.5	3,500							

Source: ¹⁾IEP 1996; ²⁾World Bank 2001

According to World Bank (2001) the GDP composition by sector is, Agriculture 7.4%, for Industry 28.6% and Services 64.0% in 2000. Concerning the labor force, 23% are occupied in the agricultural sector, 24% in the Industry sector and 53% in Services.

The rate of illiteracy in Brazil is 13.3% and in the Northeast it was 26.6% for 1999 (IBGE 2000). For the state Rio Grande do Norte the rate of illiteracy was 22% in urban areas and 34% in rural areas (IEP 1996).

⁸⁹ Further explications concerning this topic see Zonalatina (2001).

⁹⁰ Population of 170.1 million.

influenced by the company, and these impacts are also called ‘spill-over’, which have an impact on a region initiated through management decisions of a company.

The main focus in this chapter will be on social and socio-economic key factors defined in Table 18, p. 82. These requirements for more sustainable management of a shrimp farm are summarized as:

- Creation of job opportunities
- Contact to local community (employer, which allows participation)
- Education possibilities for the staff
- Adequate wages

These key management factors will be transformed into measurable indicators.

8.2 Indicators and methods of analysis

The main focus will be on the development of the indicators over time. Unfortunately, the comparison of such indicators with other companies is almost impossible because of poor availability of data. Focusing on the development over time has the following advantages:

- An aim can be defined and the improvement can be monitored, which allows for an evaluation of whether the management is moving towards the ‘right’ direction.
- The different stages of the development of a company can be illustrated.

According to IDEMA (2001) indicators influencing socio-economic situation of a region can be classified in three parts. These parts embrace the requirements listed above and are illustrated in Table 39.

Table 39: Classification of factors of socio-economic situation

	1. Education	2. Employment and wages	3. Families and home facilities
Content	<ul style="list-style-type: none"> • Population and illiteracy • Years of study • Graduation 	<ul style="list-style-type: none"> • Activities and positions (hierarchy) • Population working (unemployment) • Wages 	<ul style="list-style-type: none"> • Families income • Home and facilities • Equipments
Measured as	<ul style="list-style-type: none"> • Percentage of illiteracy depending on age, sex, location • Years of study depending on age, sex, region • Graduation depending on sex, location 	<ul style="list-style-type: none"> • Activities in different sectors depending on region, development over time • Type of work (employee, employer) • Contribution to social security depending on sector, wage, hierarchy • Unemployment rate depending on age, sex, location • Qualification level of working people • Salary distribution depending on sex, age, location 	<ul style="list-style-type: none"> • Household income, salary per family depending on region • Lack of houses • Facilities in the house such as sanitary facilities, water-, energy-supply, etc. depending on location • Equipments in the household such as cooker, water filter, television, refrigerator, etc.

	1. Education	2. Employment and wages	3. Families and home facilities
Objective	<ul style="list-style-type: none"> • Decrease the percentage of illiteracy (through illiteracy programs for adults and increase in the quality of education) • Increase the years of study and the graduation • Better family / household income to keep the children at school 	<ul style="list-style-type: none"> • Decrease percentage of children working • Increase the percentage of active working population (mainly 25-29 years) • Decrease the unemployment rate • Decrease the percentage of people receiving less than two minimum salaries • Increase creation of new job opportunities (has to be combined with better qualification of labor) 	<ul style="list-style-type: none"> • Decrease the number of families that have no remuneration • Increase the number of houses (living space) for families • Increase the facilities that improve the health situation of the population (sanitary facilities, disposal) • Increase the number of necessary equipments such as refrigerator in the households
Contribution of a single enterprise	<ul style="list-style-type: none"> • Training, courses • Sponsorship for schools • Empowerment of employees • Demand for qualified labor • Possibility to combine work and education (for teenagers) 	<ul style="list-style-type: none"> • Creation of new jobs • Reliable jobs, decrease fluctuation rate • Salary and salary distribution • Involvement of local people as employees 	<ul style="list-style-type: none"> • Non-monetary incentives for the families • Education in domestic and health issues

Source: Adapted from IDEMA 2001

Table 39 gives an overview of the key factors (first row). In the second row the measurement of these factors is illustrated. The next row shows the objectives for a socio-economic development, and the last row gives possibilities for a single enterprise to contribute to these objectives of a socio-economic development (compare explications in chapter 2.1.3.1, p. 23). Some of these points will be analyzed further in the sub-chapters as shown in Table 40. The main part is chapter 8.3 which analyzes the wage-development and the distribution of wages.

Table 40: Content of chapter 8

		Method and data record	Results & Conclusions
Employment and wages	8.3	8.3.1	8.3.2
Families and home facilities	8.4	8.4.1 Local community and local employees	
		8.4.2 Equipment and home facilities	

The relevance of the educational question in the region and for the farm can be emphasized with the situation of the rate of illiteracy. In 1991 the average rate of illiteracy for the population of Rio Grande do Norte older than 15 years was 36.3 percent. In the municipality where the case study is located the rate of illiteracy amounted to 51.6% (IBGE, cited in IEP 1996). Based on the data of the case study the question of education can not be quantitatively analyzed. At this point however, the education situation of the case study will be shortly described.

Basically two ways for a company to influence the educational situation exist. The first measure is to offer training, and empowerment programs for the employees. This can be done directly by the company or by sponsorship of an educational institution. Within the 'Social Accountability'⁹² of SAI (Social Accountability International) an educational campaign of public interest reflects also the relationship between the company and the local community. The second way is an indirect influence on the educational level through the demand for qualified labor, requirement for qualification levels and incentives for skilled labor.

⁹² see: <http://www.cepaa.org/sa8000.htm>.

In 1999 the first literacy program for employees of the case study farm was initiated. The co-operation of the employees (high participation) and the observed success encouraged the management of the farm to continue with this kind of program. The farm started a co-sponsorship with a local non-governmental organization that offers activities and education programs for preschoolers, teenagers, and adults (Schwab Züger 2001a, p. 95). The program of this organization is organized independently of the farms' activities. But their employees have the possibility (mostly financed by the farm) to participate in the courses and trainings offered by the association. Outsourcing these activities has many advantages for the company. In the case of literacy program, employees and their families attend classes with community members not associated with the industry, thus broadening their exposure and social circles. In addition, the financial sponsorship of the company allows it to contribute not only to the development of employees, but also to the local community at large. This alliance is an important step in assuring a high standard for these programs and the evolution of additional community programs in the future (Schwab Züger 2001a, p. 95). Furthermore, the case study company has a sponsorship with an athletic sports group for poor children, and an education program for litter-removal in other cities.

The educational aspect through the work is a further positive socio-economic impact. Employees may learn how to deal with machines, how to repair broken instruments, how to treat a fresh-product, etc. These are some aspects which may have a strong impact mainly in areas with a high share of unskilled labor force.

The monitoring and evaluation of such activities is rather difficult and mainly based on long-term development, whereas causalities are difficult to evaluate.

8.3 Employment and wages

The wages are the remuneration for the factor labor. On one hand it reflects the 'value' the company gives to labor. On the other hand it is also determined by job alternatives in the surrounding region (see Figure 77). The salary is a direct monetary flow between employer and employee. The definition of Social Accountability (SA8000) says: "The company shall ensure that wages paid for a standard working week shall meet at least legal or industry minimum standards and shall always be sufficient to meet basic needs of personnel and to provide some discretionary income" (SAI 2002). The wages can be influenced by variables such as policy regulation of minimum salary, education of qualified labor, availability of labor, unemployment ratio, etc. Variations in the salary policy of a company over time can be an interesting indicator for the socio-economic impact of a company. It may give a more detailed idea of what the influence of the companies policy on the employees in particular and on the region in general is.

Based on the data record of the case study the following questions will be analyzed:

1. Has an expansion of a company been a positive impact on the socio-economic development in terms of wages?
2. Did the case study company become a 'better' (measured in salary) employer over the years?

8.3.1 Method and data record

The data is based on the employees of the original location since 1983. In Addition to the farm of 119 ha of ponds, it includes a processing plant which was constructed in 1997 and expanded in 2000 (see Figure 41, p. 102). This original location serves also as a training center for the other farms. Mainly the skilled people (technicians, leaders, etc.) pass a training

before they start their activities on the other farm locations. Therefore a ‘history’ in the socio-economical context of this company in location A already exists. In the timeframe from 1983 to 1997 figures about the labor situation are available (number of employees). Detailed information, such as working sector, salary, incentives, etc. are available only after 1997. Table 41 shows the development of the employees and the total wages from 1997 until 2001. The number of employees and the wages are calculated on an average over twelve months. The total wages include all payments made for the employees (basic salary, productivity payment, overtime and holiday remuneration, and family income supplement).

Table 41: Number of employees and sum of average wages

	1997	1998	1999	2000	2001*
Number of employees (average)	54	75	90	132	252
Average total wages (index)	100	143	183	277	613

* January until September 2001

Source: Payroll Camanor

In the first step the development of production, employees and wages will be shown. The expansion of the farm can be shown based on these developments. The monthly data will be summarized in three month averages to reduce seasonal variation. Average wages will be analyzed via three different kinds of salary indices. The pattern of salary distribution within the company will be compared with the state’s average (Rio Grande do Norte) and depicted over time. In this context the involvement of local employees in relation to the distribution will be illustrated further in chapter 8.4 (Families and home facilities). The fluctuation rate of employees is presented in the chapter 8.3 (Employment and wages).

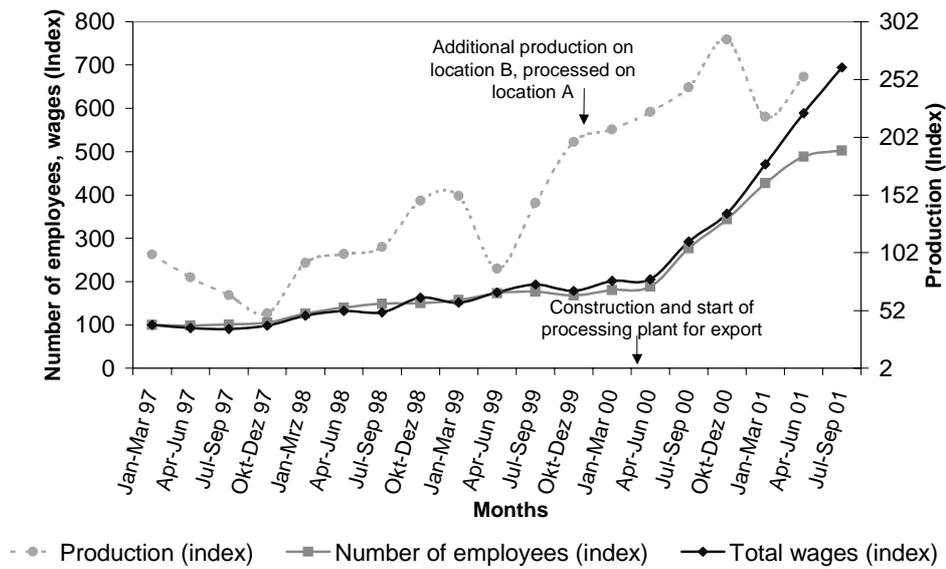
8.3.2 Results and conclusions of employment and wages analysis

The results include the analysis of total wages, average wages, wage distribution, and fluctuation rate (8.3.2.3).

8.3.2.1 Total wages and average wages

Figure 78 shows the development of production volume, number of employees, and total labor costs since 1997. It can be shown that until the end of 2000 the development of number of employees and total wages occurred parallel. An increasing number of employees resulted in higher labor costs. From the beginning of 2001 the total wages raised more rapidly than the number of employees, mainly due to hiring skilled employees requiring higher salaries. Compared with the average production, the development of employees and wages was not parallel. This can be explained due to other variables influencing the production and mainly the production timing (harvesting date in function of market situation, cash necessities of the company, growth rate of animals, etc.).

Figure 78: Wages, number of employees, and production (index Jan-Mar 97 = 100)



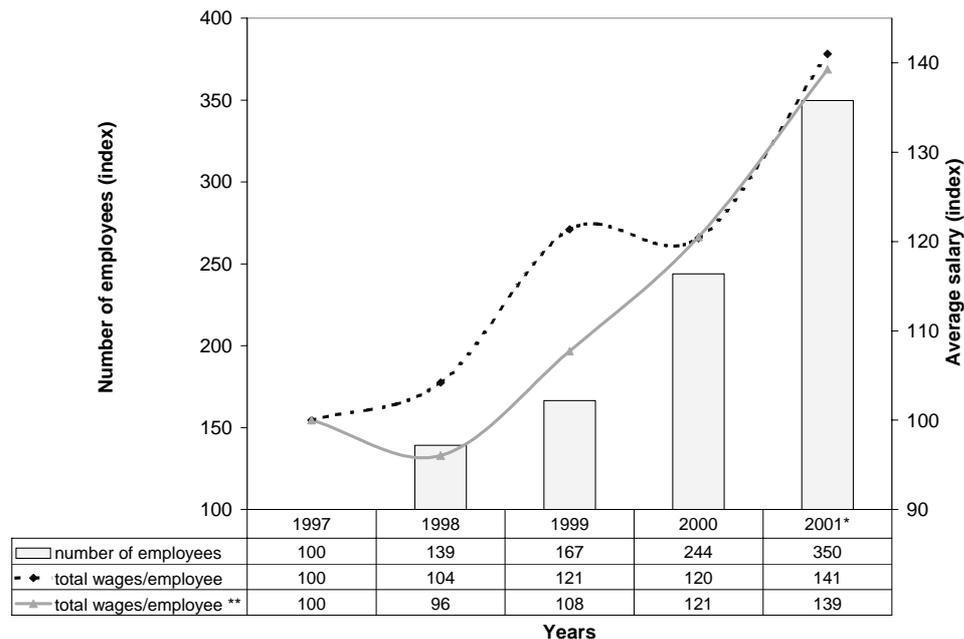
Source: Own calculation, Camanor 1997 - 2001

Since January 2000 people were hired to prepare for the planned expansion phase of the enterprise. The strong increase (almost quadruplicated) of the total wages within one year (2000 – 2001) indicates the impact that the company had on its socio-economical environment. To estimate this impact it would be necessary to separate the percentage of the total value (paid as salaries) which remains in the region (multiplication effect). An approximation of this effect can be done through the analysis of local employees (chapter 8.4.1).

The argument of the creation of new jobs and increasing salaries is very common in the discussion of the socio-economical impact of shrimp farming (see chapters 3.1.1.1, 3.1.1.2, and 3.1.2.2). The increase of the salary per employee from 1997 to 2001 (development of average wages) is shown in Figure 79. In 2001 3.5 times more jobs were offered than in 1997 (columns). The average wage per employee (basic salary) increased almost 40% in the same period. The dark dotted line shows the average over the whole staff, and the light drawn line represents the average of total wages excluding the highest ranges⁹³. The ‘number of employees’ and the ‘total wages/employee’ represent average data over 12 months of the corresponding year⁹⁴. The increase of the average wages is continuous from 1998 to 2001. The development of total wages per employee is strongly influenced by high wages for few highly skilled employees. This is the reason for the exclusion of this wage class in the light drawn line.

⁹³ Based on the Payroll record, wages and employees earning ten times (or more) the minimum wage are excluded.

⁹⁴ The total wages per employee is based for 1997 and 1998 on the monthly data of September, and for 1999 until 2001 on the average of the months March and September.

Figure 79: Average salary and number of employees

* from January to September 2001

** excluding wages higher than ten times minimum wage

Source: Own calculation, Camanor 1997 - 2001

External changes such as inflation rate are not considered in the average numbers shown in Figure 79. This is the reason for the calculation of 'salary indices'. The minimum salary is a legally defined salary for unskilled labor. It reflects the rise in prices and the basic needs of the economy. For further analysis three different kind of 'salary indices' are used.

- **Salary index 1:** Sum of all basic salaries (payroll) divided by employee and actual minimum wage.
- **Salary index 2:** Sum of total payments (payroll) divided by employee and actual minimum wage.
- **Salary index 3:** Sum of all employee costs (internal account) divided by employee and actual minimum wage.

All indices reflect costs per employee and are divided by the minimum wage. The salary indices – compared to the average wages – are better indicators for the purchasing power of the employees. The difference between the indices is the base for the calculation. In 'salary index 1' all basic salaries are used, without payments for productivity, social security and so on. 'Salary index 2' includes additional payments turning up on the payroll (productivity, payments for overtime and holidays, family income supplement, etc.). The last index 'salary index 3' is based on the record of the account (income statement), including all labor costs like expenses for training, education, uniforms, alimentation, etc. These non-monetary incentives (which are included in salary index 3) are important for underdeveloped areas and poorly educated people. The rise of prices, the minimum salaries, and the salary index 2 are shown in Table 42.

Table 42: Development of number of employees and salaries

	N° of employees (average listed per month)	Rise of prices**	Minimum salary in R\$ (average per month)	Total salary indexed***	Salary Index 2
1997	54	7.0	117	100	2.66
1998	75	3.5	127	143	2.53
1999	90	9.0	134	183	2.56
2000	132	4.5	146	277	2.43
2001*	252	5.4	167	460	2.46

* January to September 2001

** see www.idema.m.gov.br (2000-2001), and <http://www.forum-brasilien.de/> (1997-1999)

*** total payroll

Source: Camanor 1997 - 2001, Internet

Table 42 gives an overview of the development of the labor situation from 1997 to 2001. The minimum salary per month is calculated as an average of the corresponding year. The total salary includes the gross salaries (incentives, social securities, productivity payments, etc.). The increase of the total salary is strong from 2000 to 2001 (shown graphically in Figure 108). The last column in Table 42 is adjusted with the minimum salary of the corresponding year. Supposing that the minimum salary reflects the rise of prices it can be stated that the average wage paid in the company is 2.5 times the minimum salary. The interpretation of this index must be done over time and corresponding to the distribution of the salaries in the company.

The development from 1997 until September 2001 of 'salary index 2' is shown in the Appendix (Figure 108). No tendency of the index can be observed. This is mainly due to changing constitution of the employees, for example contracting a manager with a salary 10 times higher than the minimum salary leads to a strong increase of this index. In months with a high fluctuation rate (due to selection and training) the index decreases due to the employment of more unskilled employees. Comparing salary index 1 and 2, can be shown that the variation of salary index 1 is lower than the variation of the salary index 2 (see Appendix, Figure 109). This difference is a result of additional payments such as incentives, additional hours, etc. For example in December 1998 almost 50 percent of the total salary was paid by incentives, additional hours, and holiday salary. In January 1999 the share of additional payment relative to the basic salary was only 25 percent. Differences in the salary indices are shown in Table 43.

Table 43: Salary index 1 and 3

	1997	1998	1999	2000	2001*
Total number of employees (index)	100	139	167	244	350
Total value payroll (index)	100	143	183	277	460
Average total wages/employee	100	104	121	120	141
Salary index 1	1.80	1.74	1.91	1.74	1.78
Salary index 1**	1.61	1.44	1.52	1.56	1.58
Salary index 3	3.31	3.25	3.59	3.42	n.a.
Salary index 3**	2.91	2.86	3.39	3.35	n.a.

* from January to September 2001

** excluding wages higher than ten times minimum wage, respectively excluding management wages (salary index 3)

n.a.: no data available

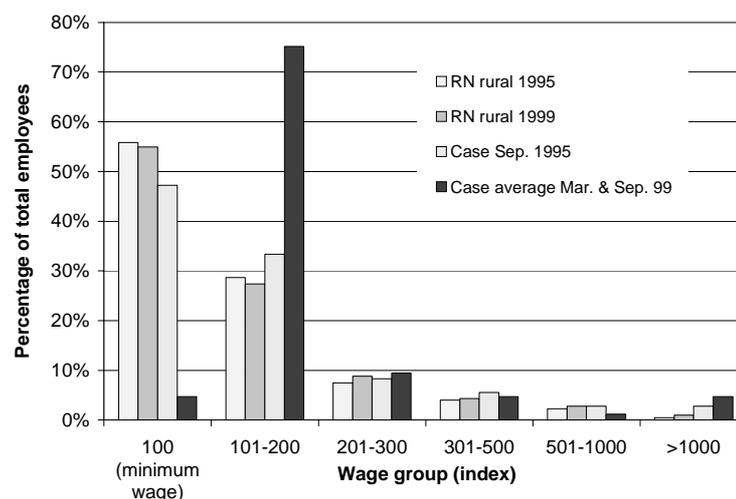
Source: Own calculation, Camanor 1997 - 2001

For the interpretation of the salary index, the constitution of the employees should be considered. Compared to the 40% increase in Figure 79 (summarized in the third row of the table) no continuous increase of the salary can be observed. Focusing on the period 1998 to 2001 a 10% increase (1.44 to 1.58) of the 'salary index 1**' can be shown. The salary index 3 varies between 2.86 and 3.59. This means that with the inclusion of all labor costs and services the annual average is about three times the minimum salary. The salary index 3** can be calculated as a percentage of salary index 3. It can be shown that this percentage is increasing over time. As the share of management jobs compared to all jobs remained within the same level (approximately 5%), it can be interpreted that the share for the management decreased relative to the total payments for all employees.

8.3.2.2 Wage distribution

In chapter 8.3.2.1 all interpretations were based on the average salary of the whole payroll or total labor costs. The distinction with and without management costs already showed some interesting results. In this chapter the wages will be divided into several groups to discuss the salary distribution. The salary distribution in rural areas of the state of Rio Grande do Norte in 1995 and 1999 will be used as a reference.

Figure 80: Distribution of salary in wage groups

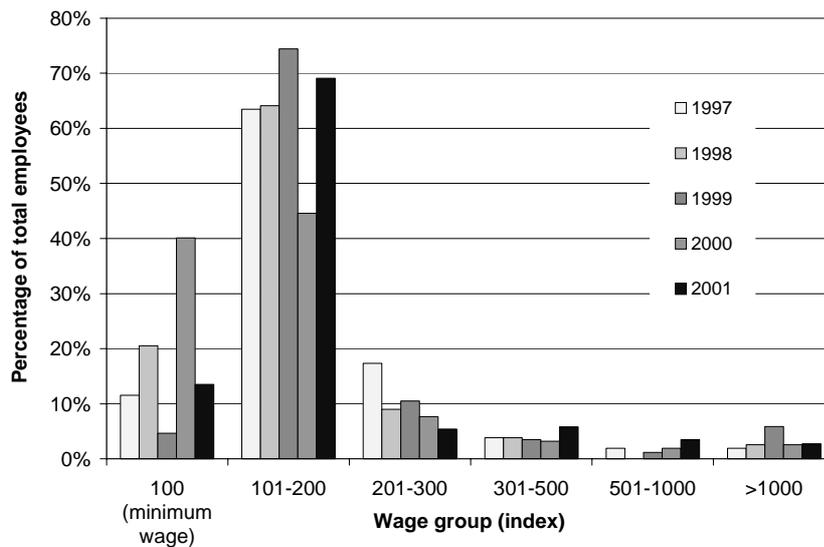


Source: IDEMA 2001, Payroll Camanor

The salaries up to twice the minimum salary (until 200) are considered "poor income" (IDEMA 2001). In 1995 and 1999 85%, respectively 82% of the working population in the rural areas of Rio Grande do Norte received up to twice the minimum salary (-200). In the same period 80% of case study's employees were classified in this group. The main difference between the average of the state and the case study in these two wage groups is the fact that in 1999 only 5% of all employees were working for the minimum salary. The wage groups above 200 (> twice of the minimum salary) are similar in the states average and the case study. A significant difference exists in the wage group '>1000'. In 1999 5% of the employees of Camanor received more than ten times the minimum salary, which is far more than the states average.

Figure 81 shows the development in the case study of these wage groups for the period of 1997 until 2001. The month of September is considered to be representative for the corresponding year.

Figure 81: Development of relative distribution of the wage groups in the case study



Source: Own calculation, Camanor 1997 - 2001

The percentage of employees in the lowest two wage groups varies from 75% (1997) to 85% (1998). There is a significant decrease of wage group ‘201-300’ in this time period and an increase of employees in the wage groups ‘301-500’ and ‘501-1000’. The high percentage of 6% of the employees in the wage group ‘>1000’ is unique for 1999. The variation from 2000 to 2001 in the first two wage groups is a consequence of a management decision in the salary policy⁹⁵.

A more detailed comparison can be made with the ‘Lorenz-line’ (see Appendix, Figure 110). This analysis illustrates the relationship between the percentage of employees and the percentage of total wages paid. The line shows for each percentage of the employees the share of earned salaries. If the line becomes straight, this means that all employees have the same salary. In the average of 1997 to 2001, 10 percent of the employees earned approximately 35 percent of the total salaries (based on basic salary, without additional payments). And 30 percent of the total salaries were earned by 60 percent of the employees. Concerning the development from 1997 to 2001 no tendency is visible. It is important that the ‘Lorenz-line’ is not analyzed and interpreted isolated from the general development of the company.

8.3.2.3 Fluctuation rate

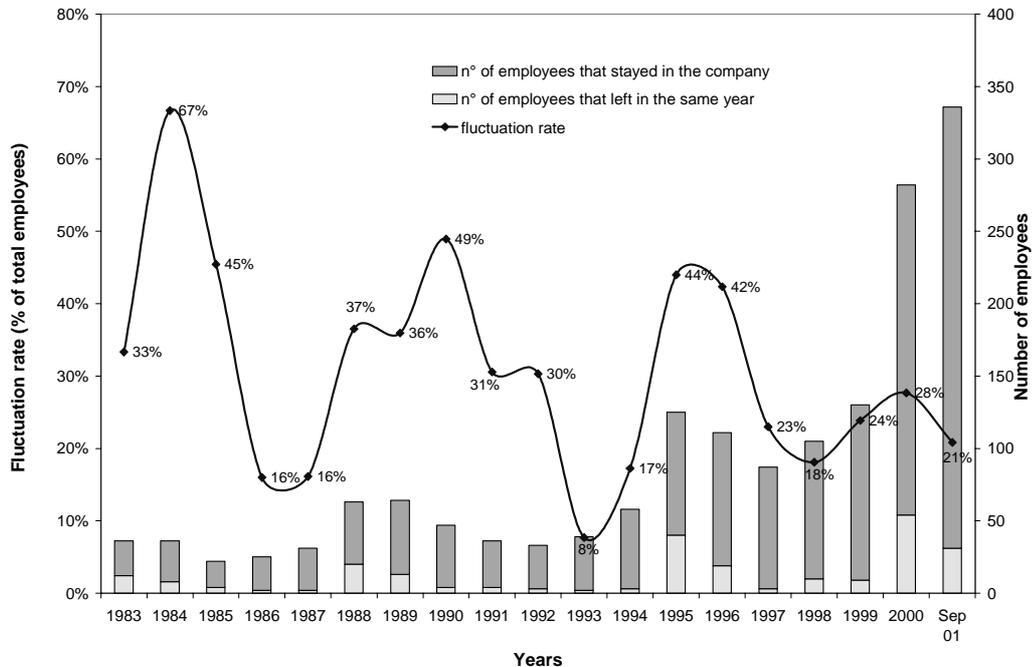
The fluctuation rate is calculated by the number of employees which leave the company as a percentage of total employees which stay in the company over a defined period. The fluctuation rate of the employees in the company may give an idea of the attractiveness of the work place. However, it is not the only measure for attractiveness, mainly because the fluctuation rate is influenced by various factors and not just a result of the attractiveness of the work place. It is important not to compare this rate (variation) with other industries or even other countries. But it can be an interesting figure for the development of the company. The analyzed data base includes the employees contracted from 1983 until September 2001 and only focuses on one farm location. With the expansion (construction and the production at new locations) transfers of employees had taken place. The training of leaders and technicians mainly occurred at the original location. The employees transferred to the new location were

⁹⁵ It was decided that a newly hired employee should be evaluated after six months of experiences. And after this time he/she should either be fired or ranked into a higher wage class.

considered to have ‘left the company’, this fact has to be considered in the interpretation of the results. Others are still contracted by the original location but also provide services at the other farm locations. These employees are taken into account as part of the original location.

Figure 82 shows the annual fluctuation rate and number of employees. It is the number of all employees that worked on the farm during the corresponding year. The number of employees which stayed less than one year are shown in the lower part (clear) of the column.

Figure 82: Average number of employees and annual fluctuation rates



Source: Own calculation, from data base 1983-2000

Figure 82 shows that from 1983 to 1993 the labor situation was unstable. Three peaks of fluctuation can be shown: in 1984/1985, 1990, and 1995/1996. In this years almost half of the whole team left the company. After 1996 the fluctuation rate stayed below 30 percent. The share of employees which left the company in the same year as they were hired was high in 1983 (33%), 1988 (32%), 1995 (32%) and 2000 (19%). These high percentages of hiring and firing in the same year give indications of the human resource policy. For instance in 2000 an employee ranking (screening) was done to get prepared for the expansion phase. In the long-term development of an enterprise (in the stage of mature company), the fluctuation rate should decrease.

The unstable situation until 1995 can be explained by the following reasons: Senior management problems, financial problems, unstable production, etc⁹⁶. In addition to the fluctuation, the variation in the absence of employees due to illness may give further indications about the attractiveness of the working place.

Concerning chapter 8.3 ‘Employment and wages’ the following conclusions can be drawn:

- ⇒ The Creation of new jobs and an increase of the total wages are important criteria for the impact on the socio-economical environment of a company.
- ⇒ Index wages can serve as an indicator for the development of a company relative to the general development (e.g. share of minimum wages). Additional external factors have to

⁹⁶ For further explications see Schwab, et al. 2002, p. 11.

be considered for the interpretation of the salary index. It is a good indicator for relatively stable situations of a company (low fluctuation rate).

- ⇒ The segmentation of wage classes (for instance higher than ten times the minimum wage) helps to reduce distortion based on the distribution of the employees relative to the income categories.
- ⇒ The inclusion of non-monetary services for the employees is important to usefully measure the impact of a company's activity in this context.
- ⇒ The distribution of the employees of the case study differs from the states average mainly in the low wage groups. However, the kind of work – e.g. the necessary skills – have to be considered.
- ⇒ The share of employees working for the minimum salary is lower in the case study than in the states average. This fact may have two different interpretations. On the one hand the company has a defined salary policy, which offers a salary increase for long-time employees. On the other hand it could be interpreted that the company – compared to other rural activities – needs more skilled employees which are paid with a higher salary.
- ⇒ Wage and fluctuation analysis has to take into account development stages of a company. Drastic changes in the senior management are often correlated with high fluctuation rates.

8.4 Families and home facilities

One of the objectives concerning the criterion 'Families and home facilities' is the decrease of families without remuneration (see Table 39). For this purpose the involvement of local employees in the company (chapter 8.4.1) will be analyzed. The second part (chapter 8.4.2) focus on some home facilities of the employees compared with the average equipment of home facilities of the rural population of the state.

8.4.1 Local community and local employees

The requirement of local labor is listed in Table 18, p. 82 and outlined in Figure 35, p. 89. As mentioned in 3.1.1.1 this requirement is generally based on problems created due to the construction and implementation of a new shrimp farm (displacement, destruction of traditional life basis etc.). Nevertheless, the relationship to the local community is also a key issue for existing shrimp farms. The measurement of this relationship may be done according to various questions, which are outlined in ETHOS (2000)⁹⁷. One example of how to express social activity would be an evaluation of the expenditures of a company for social activities in the region as a percentage of the profit. These figures can be measured and may indicate the social activity of a company and its relationship to the local community. The following analysis will focus on the involvement of local community as employees of the company. The underlying assumption is a positive socio-economical impact due to a participation of local employees. It is supposed that the main part of the earned money is spent in the region and families with a guaranteed wage generally have more possibilities to facilitate an education for their children.

⁹⁷ Instituto ETHOS empresas responsabilidade social: is a Brazilian association of companies developing their activities in a socially responsible manner, in a permanent process of evaluation and improvement. Further information on <http://www.ethos.org.br/>.

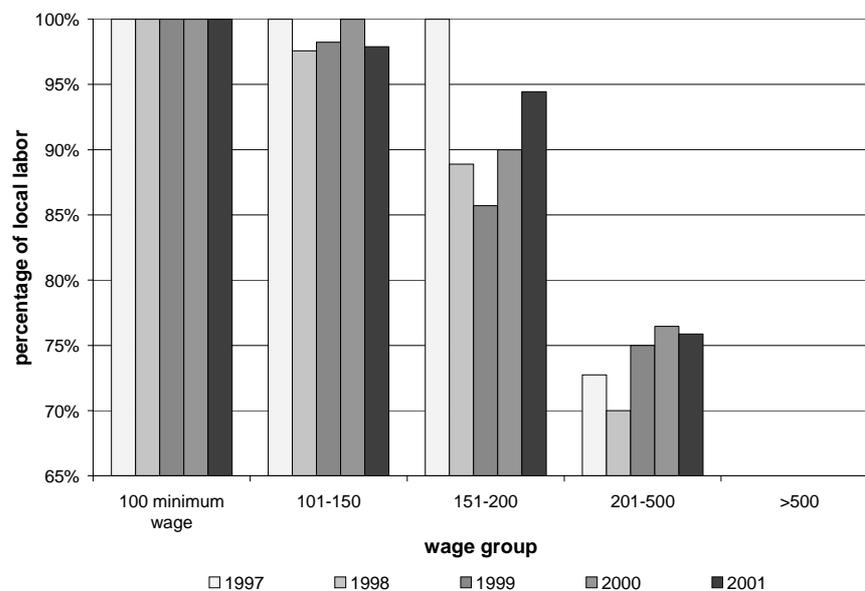
8.4.1.1 Method and data record

The local community includes the three villages in closest proximity to the farm⁹⁸. 89.7 percent of all employees listed in September 2001 were local employees. The wage groups shown in 8.3.2.2 are divided in smaller groups than in Figure 80 and Figure 81. The number of employees of the corresponding wage group is shown in relative figures, to show the percentage of local labors in each wage group. The data are based on the monthly payroll of September of the corresponding year from 1997 to 2001.

8.4.1.2 Results and conclusions of local employees

Figure 83 shows the percentage of local labor working in the corresponding wage group by year. It can be shown that in the first wage group 100 percent are local employees. In higher wage groups the percentage of local employees is strongly decreasing. The wage group '>500' contains no local employees. The variation over the year can be shown in the last two wage groups ,151-200' and ,201-500'. The share of local employees after 1998 was increasing in these two wage groups.

Figure 83: Percentage of local employees in wage groups



Source: Own calculation, payroll Camanor, oral information Human Resource department Camanor

The analysis of this data reflects the fact that skilled labor for shrimp farms in underdeveloped areas comes mainly from outside. The increase of local employees in higher wage groups may have various interpretations. The first interpretation presumes that the company has an internal educational and empowerment program to improve the career opportunities for local employees. The second interpretation presumes that the educational institutions in the region improved within the observed period, and the company may find qualified labor in the region⁹⁹.

⁹⁸ Barra do Cunhaú, Canguaretama, and Vila Flor.

⁹⁹ These presumptions could be tested by analyzing the time local employees already stayed in the company.

8.4.2 Equipment of home facilities

The infrastructure and home facilities of employees are reported through interviews and home visits¹⁰⁰. These visits and interviews are part of the company's program called 'Education in Health', overseen by a nurse who works under contract for the company. The questionnaire is shown in the Appendix (Table 59 and Table 60). The goal of Education in Health is to improve the quality of life for employees and their families through good health practices. The four-step program includes an assessment of the current health situation of all employees and their families, which is achieved through an interview and personal visit at home. The information is analyzed to define any diseases or conditions that may exist. Considering input from company and employee, the nurse then draws up a plan of action for treatment and a strategy for achieving the plan's goals. With the exception of special situations, the company's medical consultants then assume the responsibility for subsequent care. A parallel program highlights the importance of health practices at home and business place. The nurse organizes special events where issues such as hygiene, drugs, sex education, stress in the work place, and human diseases can be discussed. Accurate information is separated from myth, and responsibility for self and to the community is stressed (for further information see Schwab Züger 2001a, p. 95).

8.4.2.1 Method and data record

The results from the interviews and the visits were summarized and used for the analysis. Data does not include all employees¹⁰¹. In the period 2000/2001 data is available for 230 employees (either from the interview or from the home visit). The educational level and the equipment and facilities in their homes are analyzed.

Table 44: Record for socio-economical analysis

Total number of employees interviewed or visited	230	Categories		Number of employees	
				absolute	relative
	sample				
Educational level	130	1	Illiterate, pre-school	72	55%
		2	First grade, basic school	38	29%
		3	Second grade	20	16%
Wage group	218	1	100, minimum salary	25	11%
		2	101 – 150	133	61%
		3	151 – 200	36	17%
		4	201 – 500	22	10%
		5	> 500	2	1%
Toilet facility	186	1	Yes	156	84%
		2	No	30	16%
Water filter	190	1	Yes	93	49%
		2	No	97	51%
Number of children	179	1	1 – 2	97	54%
		2	3 – 5	70	39%
		3	6 – 9	12	7%
		4	> 9	0	0%

Source: Own calculation, survey of the farms' nurse

¹⁰⁰ Deviation between the statements of the interviewer and the observed facts at home have been used for the data validation.

¹⁰¹ The interview partner during the home visit was often not the employee of the company. It was either his wife / her husband or the parents.

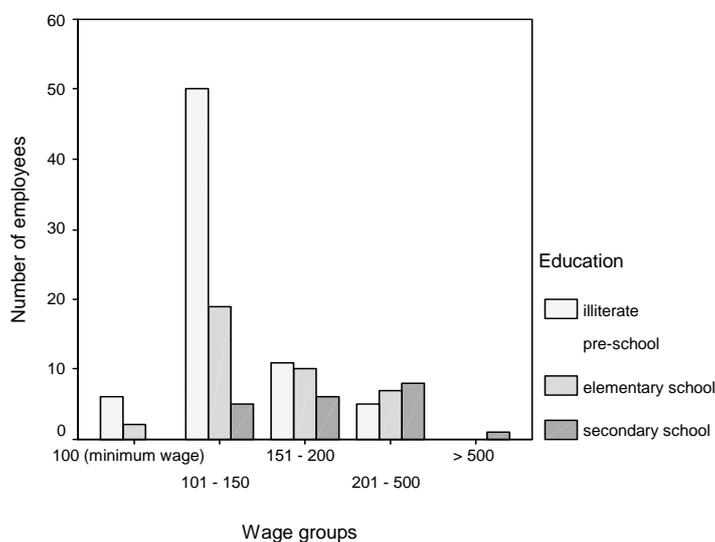
Table 44 shows the record of data. In the column 'sample' the unequal sizes of samples can be seen. Information about wage group exist for 218. The educational level instead was answered by only 130 employees.

No repetition of the data collection exists and therefore no monitoring of the development over time can be done. The results presented in the following chapter are a first insight of the existing situation of the actual employees. Based on these data the management of the company may define its strategy according to socio-economical improvement of its employees.

8.4.2.2 Results and conclusions of home facilities

Figure 84 shows the education of the employees – divided in three groups – and the wage groups (same as in Figure 83).

Figure 84: Education and wage group of 130 employees of the case study



55% of the 130 employees recorded shown in Figure 84 have no school education. 67% of the employees without education work in the salary category from 1.0 to 1.5 times minimum wage. In this category 26% of the employees have elementary school education and 7% have secondary school education. 40% of employees with secondary education are classified in the wage group 2 to 5 times minimum wage.

Figure 85: Education and number of children for 106 employees of the case study

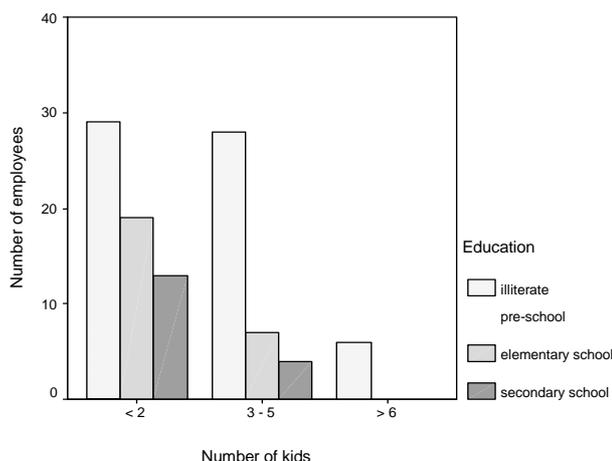
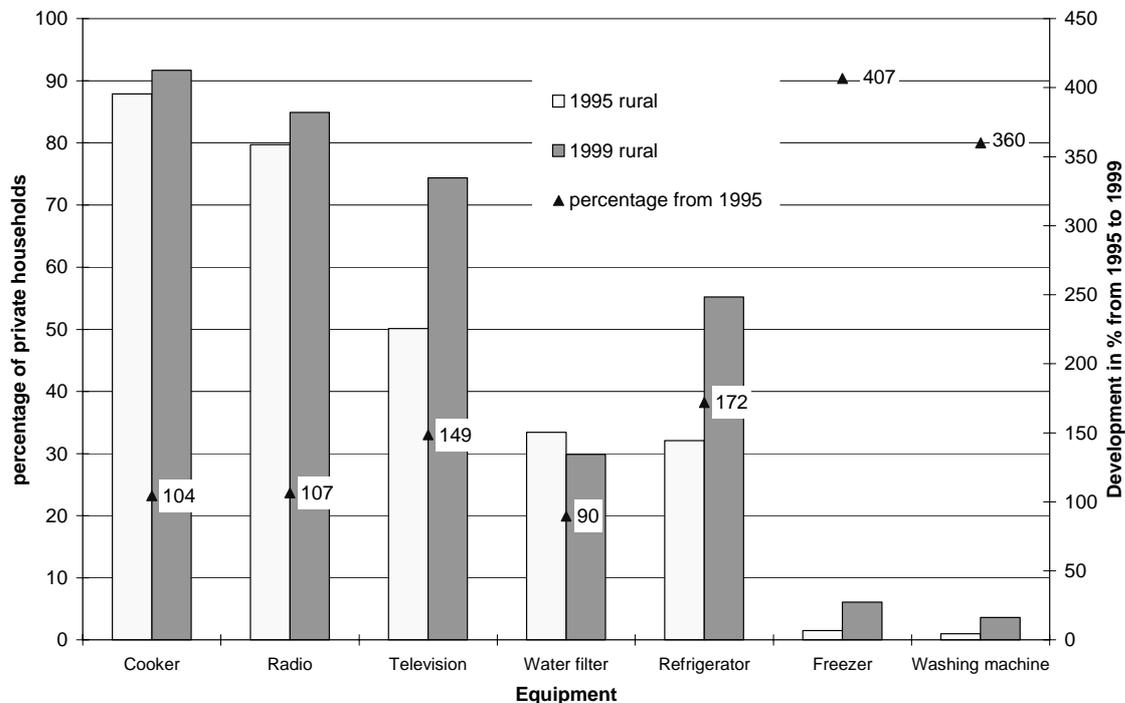


Figure 85 shows the number of children per family and the level of education of the employee (which is in most parts father or mother). 100% of the families with more than 6 children have no education. And 77% of the employees with secondary school have one or two children. According to IBGE (2000) the average number of family members is 3.7 for the Northeast in 1999.

Figure 86 shows the equipment in private households for the rural area of Rio Grande do Norte in 1995 and 1999. The most widespread equipment in private households is the cooker in around 90 percent of all households. Freezers and washing machines exist in less than 10

percent of all private households in the rural areas. However, these two equipment register the highest increase from 1995 to 1999 (4 times, respectively 3.6 times). A decrease took place with water filters. In 1999, 30 percent of all private households in the rural area had a water filter.

Figure 86: Equipment in private households



Source: Adapted from data IDEMA 2001, p. 62

Considering the equipment in the case study, only data for the availability of ‘water filter’ and ‘toilet’ was collected. 49 percent of the 190 employees interviewed have a water filter. This number is above the states average. Toilets exist in 84 percent of the registered households, which means that in 30 households no toilets are available. It can be supposed that a positive effect of household facilities exists. The positive effect may be reached through better hygiene, lower risk for infections, better nutrition, etc. For more detailed analysis questionnaires have to be designed aiming at the evaluation.

Considering these observations the following conclusions may be drawn:

- ⇒ The share of local employees in higher wage groups is a valuable indicator for positive socio-economic impact of an enterprise and has to be done over time (time series analysis). This indicator may describe the company’s relationship to the local community and be a measurement for the internal empowerment activities of a company.
- ⇒ The criterion of local employees in higher wage groups may not be analyzed separately from other factors of the company. For instance, it may be that a company with a high expansion rate needs skilled labor which is not available in the short-term on the local labor market. However, it should be a long-term objective of the company to increase this share.
- ⇒ Analogous to the conflict of aims within the production process (see 6.4.3 concerning medical feed and productivity) similar conflicts may exist within the integration of local employees. It is based on subjective values and norms whether the creation of new jobs or

higher wages for the existing employees is more important for sustainability (see also chapter 3.1.2.2).

- ⇒ Improvements in the equipment of private households may help to improve the living standards and health of the employees families. Such improvement may have a positive impact on absentee rates and motivation.
- ⇒ The data availability in the socio-economic field is difficult. On the municipality level not all inhabitants were registered. For the farm level the strong expansion phase required a lot of new employees who have not been interviewed yet.
- ⇒ Many impacts in the socio-economic field are rather qualitative. They include activities such as the health-education program and the co-sponsoring of the educative institutions. These activities are difficult to evaluate but nevertheless may be strong and sustainable.
- ⇒ The evaluation of activities in the socio-economical field have to be monitored over time. Relative comparisons are more important than absolute figures.

D MONITORING AND CONCLUSIONS

*It isn't the strongest species that survive,
nor the most intelligent...
but the most responsive to change.*

Charles Darwin

Part 0 is divided in two main chapters. The first chapter includes monitoring tools for a shrimp farm to move towards sustainable management. In the second chapter action recommendations are stated and conclusions are drawn.

9 Monitoring of Key Management Factors

The results and conclusions presented in part 0 and mainly part C are summarized and presented in a balanced scorecard. For this purpose the balanced scorecard (BSC) is adapted according to Bieker, et al. (2001) to a sustainability balanced scorecard (SBSC). It will be a summary of the KMF shown and analyzed in part C and at the same time a monitoring and controlling tool for the management of the case study. The following research question will be answered in this chapter:

What tools are required to monitor the performance of a shrimp farm on its way towards sustainable management?

9.1 Sustainability Balanced Scorecard

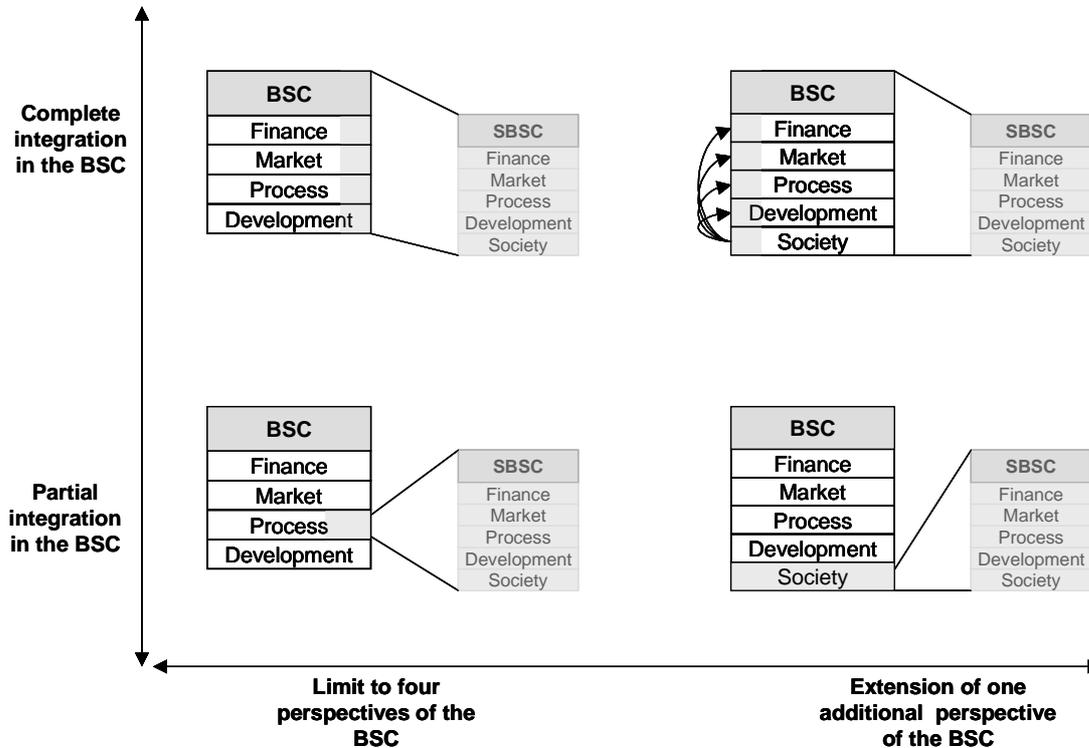
The Balanced Scorecard (BSC) is a framework to understand certain relationships of cause and effect, within a company. The functionality and the method of a BSC are described in part 2.2.5.2. Bieker, et al. (2001, p. 50) develop a Sustainability Balanced Scorecard (SBSC) with an additional society perspective¹⁰². This perspective includes an extended number of stakeholders which are not represented in other perspectives. These stakeholders are for instance: community, state and public authorities, NGOs, and stakeholders along the supply chain. The extended pool of stakeholders covers aspects which are not directly linked with mechanisms at the market. Bieker, et al. (2001, p. 43-46) define the following aims for the society perspective, for example: 'Improvement of the enterprises image in the public', 'covering of the own brand in the society', 'legitimacy of the enterprises strategy through stakeholders', 'generate ideas for innovations through the community', and 'improvement of capabilities through strategic cooperation and joint ventures'.

The four different ways to integrate a SBSC into a traditional BSC are described in Bieker, et al. (2001) and illustrated in Figure 87. They distinguish two different dimensions for the integration. One dimension (vertical axis) is about total or partial integration, and the second dimension to be considered is the question of limiting to the traditional four perspectives or extending a fifth 'society' perspective. Whatever form is chosen, SBSC is basically a planning and monitoring instrument. It becomes a management instrument and has its impacts if it is

¹⁰² Other authors developed a concept for an 'ecological balanced scorecard' (see Schmid 1999, p. 290).

integrated into the business and business activities (Bieker, et al. 2001, p. 49). For the purpose of this study a complete integration of the SBSC into the BSC, limited to the four traditional perspectives is chosen (upper left corner in Figure 87)¹⁰³.

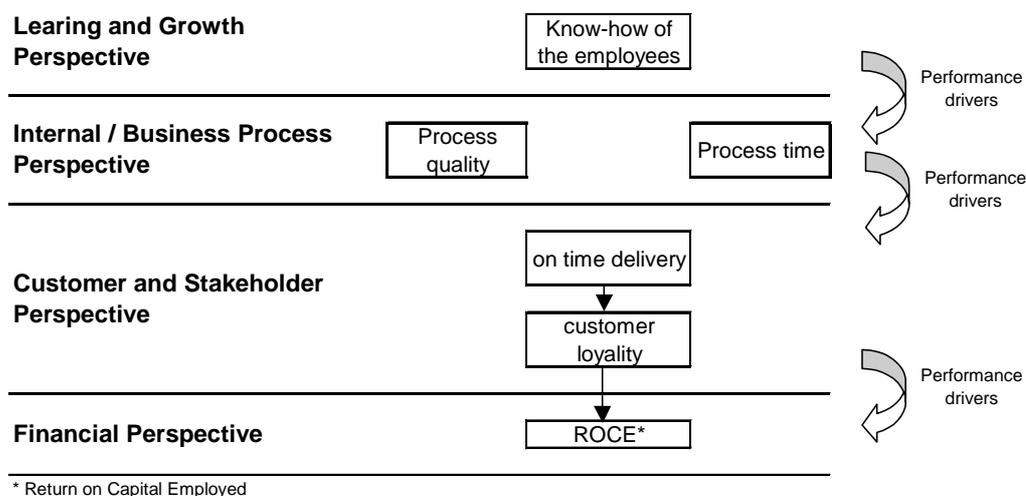
Figure 87: Four possibilities for the integration of a SBSC in a BSC



Source: Bieker, et al. 2001, p. 50

In a first step each perspective may be analyzed independently of the others. But by focusing on the entire enterprise there exist interactions between the perspectives. In Figure 88, an example of the functionality of the cause and effect chain in the traditional BSC is illustrated.

Figure 88: Example of the functionality of a cause and effect chain in the BSC



* Return on Capital Employed

Source: Kaplan and Norton 1997, p. 29

¹⁰³ The implementation of the SBSC in the business activity of the case study was not the focus of the research.

The financial perspective is the last perspective in the cause and effect chain, representing that the final results can be measured in financial measures. This hierarchy does not indicate the importance of this perspective relatively to other perspectives and it is not an opposition to the tendency towards more-dimensional measurement in the performance management (shown in 2.2.4). According to management levels and pre-controlled factors shown in Figure 19, p. 38, lower level outcomes may be driven by higher-level results.

9.2 A Sustainability Balanced Scorecard for a shrimp farm

Table 45 gives an overview of the four perspectives of the SBSC, which was developed for the farm under study. For the case of the shrimp farm the society perspective is included in the market and customer perspective (see Table 45). The aims, drivers, and outcome measures listed in the table are deduced from the previous chapters. ‘Learning and growth’ perspective is based on the factors analyzed in chapter 8. The ‘internal business process’ refers to the presented results of chapter 6. The ‘customer and stakeholders’ perspective relates to the requirements of chapter 3. The ‘financial’ perspective is based on value creating aspects, which are outlined in 9.3. In addition to the management tasks¹⁰⁴ the logical levels of management are shown in the first column of the table. The definition of a vision is part of the tasks of the normative management. It is dealing with the development of a company or a business activity. The definition of strategic aims is part of the strategic management level. And the action plan is on the level of operative management. The key management factors (KMF) are called performance drivers in the language of balanced scorecard. The drivers (illustrated in the list with ⇒) are defined as necessary factors for achieving the strategic aims (•). The outcome measures (✓) are indicators to monitor the development towards the strategic aims.

Table 45: Management levels and four perspectives of the SBSC

Management Levels	Process of Balanced Scorecard				
Normative Management Company's desired future situation (development and viability)	Vision	To be the leading enterprise towards sustainable shrimp farming			
	Perspectives	Learning and Growth	Internal Business Processes	Customer and extended number of stakeholders	Financial
Strategic Management New and extant value potentials, Doing the right things	Strategic Aims (How will we differ?) <ul style="list-style-type: none"> • AIMS 	<ul style="list-style-type: none"> • Be a reliable partner for employees and the community • Develop core capabilities for eco- and socio-efficiency 	<ul style="list-style-type: none"> • Reduce negative environmental impacts • Improve eco-efficiency 	<ul style="list-style-type: none"> • Reliable relationship with customers • Increase customer benefit and guarantee of traceability • Image, and social acceptance (relationship with wider range of stakeholders) 	<ul style="list-style-type: none"> • Increasing value of the enterprise

¹⁰⁴ The management tasks are divided according to Figure 20, p. 41.

	Perspectives	Learning and Growth	Internal Business Processes	Customer and extended number of stakeholders	Financial
Strategic and operative Management	<p>Key Management Factors (KMF)</p> <p>(What are the factors for achieving the strategic aims?)</p> <p>⇒ DRIVERS</p>	<p>⇒ Wages and wage distribution (integration of local labor)</p> <p>⇒ Education, training and qualification</p> <p>⇒ Home facilities for improved health and nutrition</p> <p>⇒ Motivation and identification of employees</p> <p>⇒ Example of the management (corporate culture)</p>	<p>⇒ Productivity</p> <p>⇒ Improve the state of animal health</p> <p>⇒ Feed-, and waste management</p> <p>⇒ Chemical input</p> <p>⇒ Site evaluation</p>	<p>⇒ Contact with customers (visits, audits, etc.)</p> <p>⇒ Quality improvements</p> <p>⇒ Contact with supplier of (main) inputs</p> <p>⇒ Publicity, active communication</p>	<p>⇒ Growth (sales)</p> <p>⇒ Profit margin</p> <p>⇒ Marginal tax rate</p> <p>⇒ Investment in fix and working assets</p> <p>⇒ Cost of capital</p>
	<p>Strategic Measures (measures and goals)</p> <p>(What critical measurement indicate the strategic direction?)</p> <p>✓ OUTCOME MEASURES</p>	<p>✓ Increased share of local employees in higher wage classes</p> <p>✓ Increased share of employees participating in education programs</p> <p>✓ Decrease of fluctuation rate</p> <p>✓ Decrease rate of absence</p> <p>✓ Increase the number of households with necessary facilities (toilet, etc.)</p> <p>✓ Number of suggestions from employees</p> <p>✓ Number of activities to improve corporate culture</p>	<p>✓ Increase of productivity (kg/ha/day)</p> <p>✓ Growth rate</p> <p>✓ Margin/kg (with constant selling prices and input costs)</p> <p>✓ Decreased share of medical feed</p> <p>✓ Increase of survival rate</p> <p>✓ Decrease of FCR^{a)}</p> <p>✓ Monitoring of effluents quality</p> <p>✓ Variation of biodiversity</p>	<p>✓ Reduce number of complaints</p> <p>✓ Number of customers and sales per customer</p> <p>✓ Repeat purchase</p> <p>✓ Market share in target markets</p> <p>✓ Number of contacts with customer and important stakeholders</p> <p>✓ Certified production, label</p> <p>✓ Price premium</p> <p>✓ Positive press coverage</p>	<p>✓ Increase of Net margin</p> <p>✓ Solvency</p> <p>✓ Company value</p> <p>✓ Share of costs (fix, variable)</p> <p>✓ WACC^{b)}</p> <p>✓ FCF^{c)}</p>
Operative Management doing the things right	Action Plan	See chapter 10.1			

^{a)} FCR: Feed conversion ratio

^{b)} WACC: Weighted average cost of capital

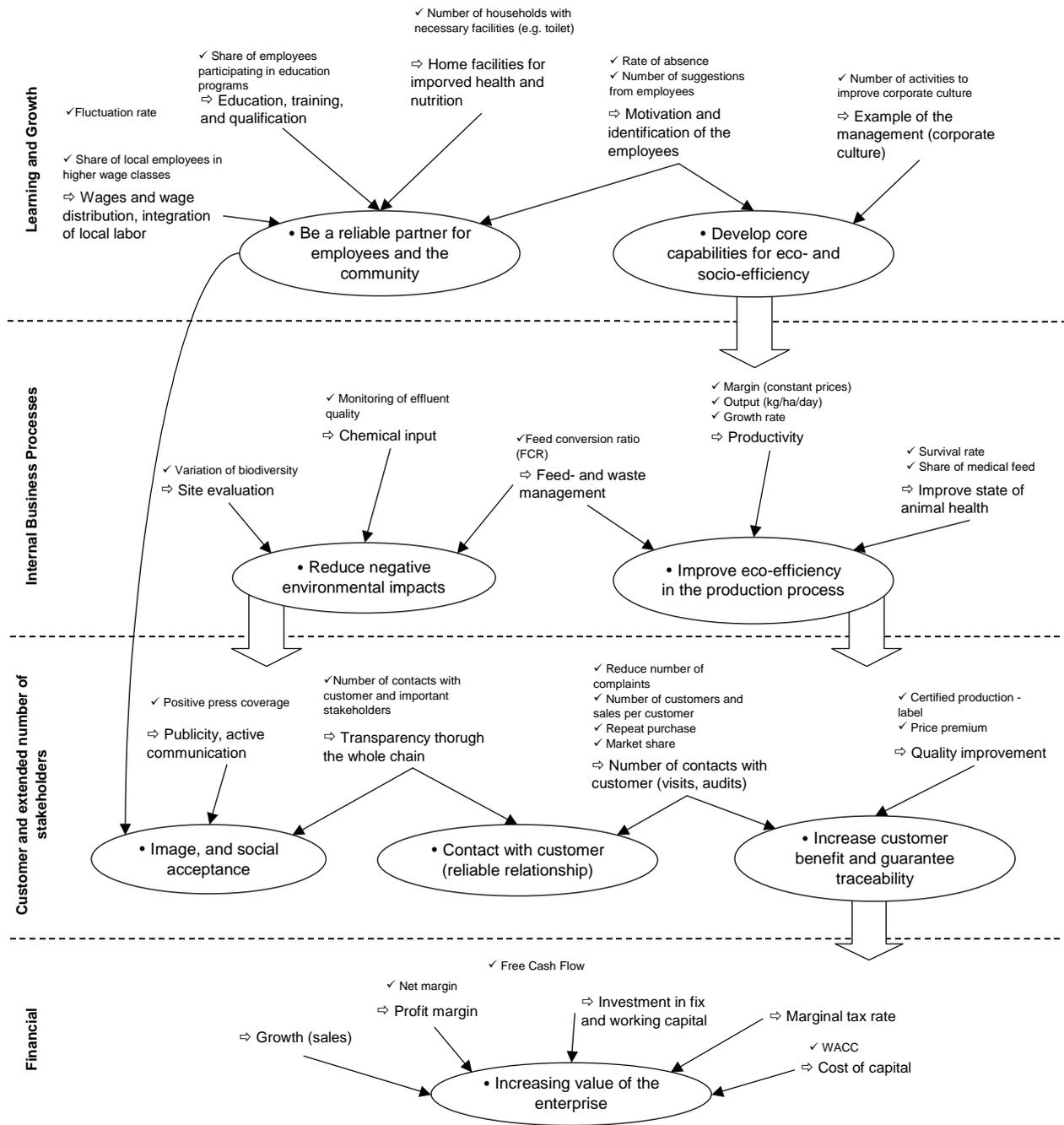
^{c)} FCF: Free Cash Flow

It can be shown that the sustainability issues are integrated into the strategic aims according to Figure 87. The perspective ‘learning and growth’ traditionally include labor competence, potential for information systems, and employees motivation and empowerment. Bieker, et al. (2001, p. 31) state eco- and socio-efficiency as additional aspects for a SBSC. The two strategic aims ‘be a reliable partner for the employees and the community’, and ‘develop core capabilities for eco- and socio-efficiency’ have been defined for the case study. These strategic aims can be achieved through various key management factors which are listed in Table 45. For instance through a higher share of local employees in higher wage groups the company becomes more respected and reliable in the local community. The strategic aims of the internal business process are the reduction of negative environmental impacts and the improvement of eco-efficiency. The third perspective (market) traditionally includes market share,

customer satisfaction and customer loyalty as measures. As shown in Table 45 the perspective is extended with further stakeholder groups, including part of the society perspective described in 9.1. The pure customer and market perspective has less importance because of two reasons, shrimp are a commodity good internationally traded on the world market and because of the market structure. The actual situation during the time of the survey in the case study was that the Brazilian shrimp market was a sellers market. Possibilities for the export became valuable due to the currency devaluation and disease problems in other important production countries (see 5.2.1, and 5.2.3.3). Marketing activities are widespread in industries where the market is changing from sellers market to buyers market (Strecker, et al. 1996, p. 12; Seiler 2000, p. 29). As the demand on shrimp (and particularly for certified label shrimp) is still increasing it can be supposed that the shrimp market will continue to show characteristics of a sellers market. The last column (financial perspective) includes traditional financial measures. According to Kaplan and Norton (1997, p. 47 - 61) the aims and measures of the financial perspective depend on the phase of development of the company.

Figure 89 shows the aims, drivers and measures outlined in a cause and effect chain. Most measures can be found also in the network outlined in Figure 37, chapter 4.2.3.2.

Figure 89: Cause and effect chain of aims, drivers and measures of a SBSC for shrimp farming



Creating value is not a result of financial manipulation. Increased value is a result of developing strategic and operational plans (Copeland, et al. 2000, p. 17). This is also implied in the cause and effect chain shown above. The increase of value of the enterprise is a consequence of various measures on lower levels.

Increasing value also refers to the generation of value and is unrelated to the distribution of this additional value. The network shown in Figure 37, p. 91 indicates possibilities for the distribution of additional value. It is illustrated that higher profit results in higher incentives for the employees.

9.3 Simulation with monitoring tool

To calculate financial impacts as a result of different strategies a simulation tool has been developed¹⁰⁵. The tool is based on the financial situation (financial- and income statement) of the case study company for 1998 and 1999¹⁰⁶, and serves as a model of the shrimp farm.

In the following simulations some of the points relating to opportunities and threats of sustainability are summarized. The focus is rather on factors which can be influenced by the management than on external factors. In this context the term ‘simulation of strategies’ rather than simulation of scenarios will be used¹⁰⁷. The simulation tool allows for an estimation of the income statement and other financial details of the company based on previous production and cost structures. Such production and cost structures are deduced from normative and strategic management level (see Figure 21, p.44). The simulation tool therefore allows for the inclusion of aspects of sustainability requirements (see chapter 3) and measures of the SBSC.

All simulations will be compared with a standard scenario (base case) which refers to the planned development and growth of the enterprise¹⁰⁸. The assumptions of the base case have been validated by information of the owner/general manager of the company. The comparison with the internal account (financial- and income statement) of 2000 was an additional validation of the assumptions. Some selling prices, input costs and rate of expansion have been adjusted according to the financial statements of 2000.

9.3.1 Assumptions for the simulations

The simulations provide estimates concerning the future financial situation of the case. Assumptions for a period of ten (year 2000 – 2010) years have been defined. The assumptions for the simulations are shown in Table 46. The assumptions for the base case are shown first. Afterwards three other strategies are listed (1-3), their assumptions are expressed in relative terms (differences from the standard (base case)).

¹⁰⁵ The simulation tool was developed by Michael Weber for a case study in his Ph.D. and together with the author of this study adapted to the situation of the case.

¹⁰⁶ Further information concerning the simulations can be read in Schwab, et al. (2002).

¹⁰⁷ The simulation of scenarios includes changes of factors which can not be influenced by the main actor (management). For instance the effect of viral disease or a strong increase of input prices. Management strategies include active changes of the management either as a preparation for external changes or as an internal optimization under constant conditions.

¹⁰⁸ The entire enterprise is taken into account for the simulations, including the processing plant.

Table 46: Assumptions for the simulations (index year 2000 = 100)

N°	Strategies	Assumptions from 2000 to 2010
0	Standard (base case)	<ul style="list-style-type: none"> • Product prices: until 2002, decrease of 15% to 26% (depending on product) • Growth of area: until 2003, increase of 200% • Yields/ha/cycle: according the data record of chapter 6.2 (N=219), mean 2,244 kg/ha/cycle; standard deviation: 601.27* • Feed conversion ratio: according the data record of chapter 6.2 (N=219), mean: 1.45; standard deviation: 0.28* • Increase of direct product exports until 2002 98% of the total production; re-requests an increase of the processing capacity of +200% • Number of employees: 2000: 140, 2003: 380 employees • Labor productivity: constant** • Changes in input costs: Employees: average wage per employee: steady increase of 100% within ten years Land: price constant*** PL: until 2003 decrease of 22% Feed: constant Interest rates (real): constant
1	Production Process	<ul style="list-style-type: none"> • Increase of PL costs: +10% • Productivity: + 5% (2,356 kg/ha/cycle) • Increase of feed costs: +10% • FCR: -5% (1.38 kg feed/kg harvested shrimp)
2	Labor costs, social activity	<ul style="list-style-type: none"> • Labor costs (average wage): +100% (better qualification, training on the farm, health assistance, home facilities, family education, etc.)
3	'Sustainable operation' combination of all scenarios with the additional assumption of higher land and construction costs, and certification of a label product	<ul style="list-style-type: none"> • Productivity +5% • Increase of PL costs: +10% • FCR -5% • Increase of feed costs: +10% • Labor costs +100% (better qualification, training on the farm, etc.) • Site evaluation: appropriate land for sustainable production increased land price (+ 50%) • More expensive construction: + 50% • Certification of the whole operation: investment costs of 500,000 (year 2000) and annual costs of 100,000 • 50% of total production sold as label product after one year • Selling price of product, sold as label +10%

* Normal curve distribution of Productivity and FCR are shown in the Appendix (Figure 111)

** Due to difficulties in quantification of labor productivity, the productivity is assumed to be constant; even though it can be assumed that research improvements and experiences will result in a productivity decrease over time.

*** Land purchase only until 2002

The standard strategy (base case) is based on the expansion planed by the owner/general manager of the company. It is validated with financial statements and production results of the company in 2000. The first strategy 'Production process' concentrates the efforts 'towards sustainable management' on production aspects and is based on the calculations in chapter 6.2 (Productivity) and 6.5 (FCR). The necessary conditions for the improvements necessary to move towards more sustainable management are the increase of productivity¹⁰⁹ and a decrease of the FCR. The assumed improvements in productivity and FCR are shown in Table 46, and can be reached through various measures. Considering the improvement of FCR, one measure might be a qualitatively better feed or changes in the feeding management¹¹⁰. In relation to productivity, stress reducing measures during grow-out phase or especially at the beginning of

¹⁰⁹ For the productivity figure the unit 'kg/ha/cycle' is used, because in the monitoring tool all cycles are assumed to have the same duration.

¹¹⁰ For instance it could be shown that the implementation and use of feeding trays on the case study resulted in better FCR (see Schwab, et al. 2002).

grow-out (e.g. start with nursery ponds) can increase productivity (through increase of survival rate), (see chapter 6.2). Furthermore, productivity increases may be reached through improvements of external factors such as breeding progress. Better feed and stress reduction measures are reflected in a 10 percent increase of the input costs of PL and feed.

Strategy 2 focus efforts are related to the human resources of a company. It is assumed that the average wages per employee are 100% higher than in the standard scenario. This assumption is based on the idea of educational and training possibilities, investment in the home facilities of employees, health assistance, general empowerment, etc. The investment in human resource is a rather long-term activity. In the assumptions no return (e.g. higher labor productivity) is assumed. The labor productivity is supposed to stay constant because no experiences about the quantification of such changes exist¹¹¹.

In the last strategy (3 'Sustainable operation') all assumptions of the previous strategies are summarized. Two additional conditions are assumed in the sustainable operation. First, the costs for land and construction are higher compared to the base case. This may be due to longer evaluation of the land before the purchase, higher construction costs because of sedimentation in the pond, re-circulation facilities, additional filter facilities, etc. The second assumption in the third strategy is the assumption of certification. It is supposed that the company wants to certify its activities and start to sell part of the production with a label for sustainable production. An initial investment to get the certification (e.g. for necessary adaptations in the process, traceability, administration, etc.) and annual costs for the certification (e.g. reports, control, administration) are assumed. One year after the investment, 50 percent of the production is sold under this label. A 10 percent higher price is assumed for the certified production.

Therefore, the sustainable operation includes improvement in the production process (strategy 1), investment in human resource (strategy 2), the additional constraint of better site evaluation, and added value through the certification of the process (included in strategy 3).

9.3.2 Results of the simulations of sustainability strategies

All strategies have been calculated based on these assumptions and compared with the standard strategy (base case). The following outcome measures were used to compare the strategies (see also cause and effect chain, Figure 89).

- Sales
- Return on Sales (ROS)
- Free Cash Flow (FCF)
- Discounted Free Cash Flow (DCF) (according to Equation 3, p. 35)

The DCF method is calculated with a WACC (weighted average costs of capital) of 17.7%¹¹². Projections for the base case are shown first, followed by other strategies. Projected results from other strategies are expressed in terms of their differences from the standard strategy. All results are shown in indexed figures with standard strategy equals 100¹¹³. The results of the Standard (base case), and the chosen strategies are shown in Table 47. For a better distinction of the effects, the partial results of the strategies are shown in the table. For instance in No. 1

¹¹¹ This is a rather cautious and pessimistic assumption. For long-term development (probably already after five years) positive effects may be expected.

¹¹² This reflects the Brazilian market situation (risk). It is in the range of common expected IRR for the investment in sustainable projects (terra capital fund).

¹¹³ The data is based on actual farming results and financial statements of the enterprise (case study). Therefore all economical results presented in the thesis are calculated in an indexed form.

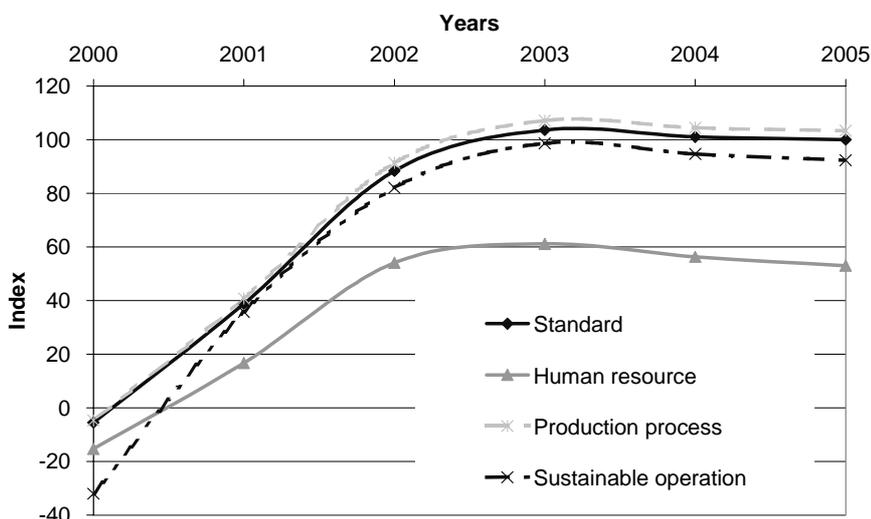
(Production process) the strategy was first divided into the aspects productivity respectively FCR, and afterwards the combination has been simulated.

Table 47: Results for the simulations (index standard, 2005 = 100)

N°	Strategies	Results				Comments
		Sales	ROS	FCF	DCF	
0	Standard (base case)	100	100	100	100	
1	Productivity +5%, PL costs: +10%	+ 5	+ 1	+ 7	+ 8	The increase in productivity leads to a higher need of labor in the processing plant: + 5% employees in the processing
	FCR -5%, feed costs: +10%	equal	- 3	- 3	- 4	
	Productivity and FCR	+ 5	- 2	+ 3	+ 4	
2	Labor costs +100%	equal	- 47	- 47	- 61	Higher labor costs without changes in productivity or long-term effects (through increased motivation and identification) result in lower outcome measures compared with the base case.
3	Site evaluation	equal	- 1	equal	- 6	The site evaluation has main effects on investment costs for land and construction.
	'Sustainable operation'	+10	- 17	- 8	- 24	Analyzing the sustainable operation (combination of all assumptions) only sales show better results than the standard strategy (base case)

All results presented in Table 47 reflect the situation in 2005. The development of FCF over time is shown in Figure 90. On the Y-Axis the indexed FCF is shown as an outcome measure of the annual financial statement.

Figure 90: Free Cash Flow for simulations (index standard, 2005 = 100)



The increase of the FCF over time in all scenarios is shown in Figure 90. The main increase is in the period from 2000 to 2003 and levels off afterwards. This can be explained by higher production as a result of farm expansion and economies of scale. The level off and slight decrease after 2003 is due to constant production results and higher labor costs for all strategies (see Table 46). Analyzing the results of the strategies relatively to the standard strategy, the strategy named 'Production process' reaches the same FCF as calculated for the standard. In

other words, a 10% increase of feed and PL costs is compensated for as long as the productivity and FCF are improved by approximately 5% each.

The strategy ‘Human resource’, where labor costs are doubled by investments in the improvement of the social and economic situation of the employees, the FCF reaches only approximately 50% by 2005 of the standard level. It is important to point out, that in the assumption of this strategy no positive effects, such as higher labor productivity, lower fluctuation, higher qualification, higher motivation and identification, etc. were assumed. Such impacts could also be simulated in the model and serve for the management as a tool to discuss and analyze various assumptions.

The sustainability strategy (‘sustainable operation’) reaches almost the same level of FCF as the standard. The difference can be seen as a result of additional costs for sustainability, which are not paid through the market, or as the effect of not included improvement of labor and process efficiency according to the assumptions.

Regarding the results of the simulations the following conclusions can be drawn:

- ⇒ Farm models based on real and actualized production results and cost structure are an adequate tool for the simulation of different strategies towards sustainability practices.
- ⇒ The inclusion of impacts through ‘soft-factors’ is the most challenging and controversial task for the simulation. In shrimp farming the control of the production process and the technologies is very important for success. Therefore, investment in labor qualification and motivation is crucial for the control of the process and for success. A simulation requires the quantification of such effects.
- ⇒ The simulations indicated that increases in important input factors (feed and PL) can be compensated as long as productivity and FCR can be improved.
- ⇒ It was possible to calculate an economically viable alternative for the actual strategy, defined by measures towards sustainability and including additional costs and moderate higher product prices.

9.3.3 Simulation of instability: higher FCR and productivity variation

To analyze the effect of a higher variation of production results in financial terms, an altered normal distribution of the production variables FCR and productivity was defined. This scenario was called ‘variation’ (see Table 48). The normal distribution is defined by the mean and the standard deviation. For the simulation, standard deviation was increased by 50%, while mean value was maintained. Higher variation of productivity and FCR represents lower stability in the production process. This can be a result of numerous impacts caused by environmental and / or management changes. The original data of productivity and FCR and the normal distribution is shown in the Appendix, Figure 111.

Table 48: Variation of productivity and FCR

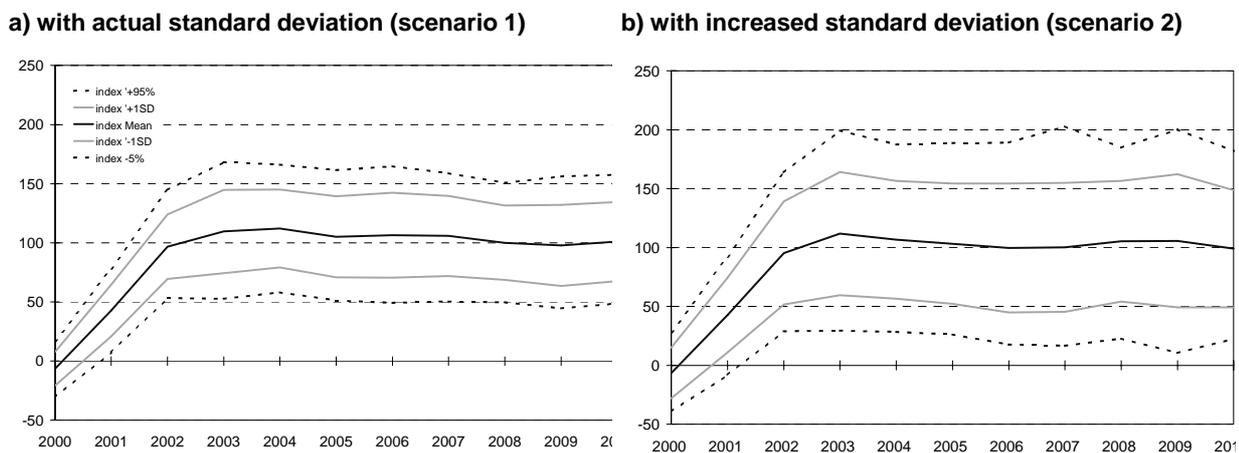
N°	Scenarios	Variable	Mean	Std.dev.
1	Standard	Productivity (kg/ha/cycle)	2,244	601.27
		FCR (kg feed/kg shrimp)	1.45	0.28
2	Variation	Productivity (kg/ha/cycle)	2,244	901.91
		FCR (kg feed/kg shrimp)	1.45	0.42

Higher variation of productivity and FCR represents lower stability in the production process. There is no effect on the outcome measures, because of the same mean value as in the base case. All outcome measures (sales, ROS, FCF, and DFC) equal the standard scenario. But the variation of the outcome measures increases. For this reason a Monte Carlo Simulation (300 simulation runs) of the two scenarios ('standard' and 'variation', shown in Table 48) are calculated.

The result referring the enterprise value (DCF) is shown in the Appendix (Figure 112). A higher variation of the DCF can be shown in the simulations with higher variation in productivity and FCR. Which indicates that the value of the company may be higher but also lower compared to the scenario 1.

Figure 91 shows the FCF of the simulation over time. It can be shown, that higher variation of production variables have a direct impact on the variation of the expected FCF. While the mean value is the same, variation is different. In 95 percent of all simulations the FCF vary within 20 and 200, whereas the variation with the actual standard deviation is only within 50 and 160.

Figure 91: Free cash flow over time (index 2010 = 100)



Index '+95%': upper range for the simulation – 95% of all simulations will be within this range (analogous for Index '-5%')

Index '+1SD': upper range for simulation to be within the mean value plus one standard deviation (analogous for Index '-1SD')

Concerning the simulations with increased standard deviation the following conclusions can be drawn:

- ⇒ The elaborated simulation tool is adequate to analyze instabilities within a company and its key factors and also simulate variations of these factors.
- ⇒ Changes in the variation of production variables such as FCR and productivity do have consequences on the variation of financial indicators such as enterprise value and FCF.
- ⇒ Financial stability and thus economical sustainability depends directly on (relatively) stable production variables. As a consequence, companies with a strong focus on sustainability should be rather risk avoiding in production management.
- ⇒ From a logical point of view, such companies should choose conservative and low risk management strategies.

10 Conclusions

The conclusions of the research project are divided into two parts. Action recommendations for shrimp farmers will be stated in 10.1. The methodological discussion of the thesis follows in chapter 10.2.

10.1 Action recommendations

Main research question:

What are the recommendations for a single shrimp farm towards sustainable management?

Recommendations for improvements are particularly effective because the shrimp industry is still a relatively new activity with relatively little experience. A large scope for changes in production technology exists. Such changes may lead to significant improvements of results. The research question will be answered based on the investigations in part 0 and C, and in chapter 9. The action recommendations are divided into five parts focusing on different aspects worked out in the research project. At the beginning of every part the central statements and findings are summarized, then concrete implications for the management of a shrimp farm are stated.

10.1.1 *Involvement of stakeholders' opinions*

The primary- and desk-research shows the contradictory opinions about shrimp farming (chapter 3). Impacts are stated and evaluated differently depending on the stakeholders. Furthermore, the main challenge is to define ways to emphasize the positive and to avoid or at least diminish the negative. The continuous involvement of stakeholder opinions reflects trends of the environment in which the shrimp farm is active and give indications of the concerns. Involving stakeholders is a pro-active procedure.

The Delphi method showed that possibilities for consensus building exist. It was also possible to initiate a dialogue through the Delphi survey. Ways of achieving a common understanding of sustainability issues of shrimp farming can be found on examining the arguments of various stakeholders.

Consequences for the management of a shrimp farm:

- ⇒ The management has to define a group of stakeholders which affect - or may in the future affect - its enterprise. The management should cultivate active communication with these stakeholders. With local stakeholders (employees, governmental organizations, etc.) the communication could be institutionalized through recurrent meetings or discussion groups. With stakeholders such as traders, retailers, media, NGOs, scientists, etc. (which are probably far away from the farmer) meetings may be organized by industry associations, or through written communication.
- ⇒ The management should take into account most important stakeholders' demands. The interaction in such communication will give credibility to the shrimp farmer and support the long-term development of his farm.
- ⇒ Demands from customer organizations and other NGOs from consuming countries are key requirements for the management of a shrimp farm. Such requirements can be hard to un-

derstand for farmers living in another context/environment. The most important criteria stated by the experts are traceability, control and monitoring of applied additives, control of effluents, efficient use of resources, and involvement of local employees. The farm needs to try to implement these requirements in its management and start a reporting system involving such aspects.

- ⇒ Transparency in the communication policy is a central issue for the success involving stakeholders in the discussion. Certification of the production process and audit through an independent institution is a possible instrument to improve credibility.

10.1.2 Understanding the interactions of a farm

A shrimp farm can be understood as a system with various interactions within the system and between the system and its environment. This is a way to illustrate the complex interactions of the reality in a model-based approach. Such systems are powered by central cycles. The environment of the farm is important for its sustainability, because sustainable management strategies may be different, depending on the location of the farm and its environment. If the land resource is scarce, a less intensive production system may be considered less sustainable than a closed intensive production system with water re-circulation. This example also indicates that technological developments (e.g. possibility of implementing water re-circulation) can change the understanding of what is considered to be sustainable management and therefore the direction 'towards' sustainable management.

The interactions within the system are important to facilitate management decisions. Sometimes management has to make decisions without knowing or being aware of all consequences and the extent of the decision. These decisions are often related to soft factors. For instance, changes in the salary policy may have long-term consequences on the quality of the labor force, which are difficult to forecast.

The risk of failures can be limited through better understanding of such interactions or designing a system which is more tolerant to changes in the environment/context. This means that an enterprise giving high priority to sustainability has generally lower risk than other enterprises.

Consequences for the management of a shrimp farm:

- ⇒ The environment (number of neighbor farms, potential future neighbor farms, industries, other resource users, etc.) has to be taken into account, when planning and implementing a shrimp farm. The infrastructure, particularly the water system, influences the decisions of the strategy (intensity, re-circulation) chosen. Numerous neighbor farms or other water polluting activities, demand closed water systems.
- ⇒ Such environment related aspects show the necessity of governmental regulations such as zoning and defining land use (Integrated Coastal Management). The members within the shrimp industry have to admit this necessity and support such governmental efforts.
- ⇒ The management needs to understand factors, which reinforce or weaken the main process. Knowing the central cycle (which powers the system) and knowing how it can be influenced is a key issue for the management. In addition to the main cycles, the possible repercussions of actions have to be considered. The best way to understand interactions is to build a network which reflects the individual farm.
- ⇒ Soft factors should also be considered in the activities of management. For instance motivation and identification of employees, their educational level and health status are critical factors to reinforce a farm's system.

- ⇒ The farmer should implement a long-term perspective in the corporate government through a common vision and related strategies. This also implies strategic controlling concerning the aims, the success of implementation, and changes in farm's environment.

10.1.3 Improvements towards sustainability through the production process

Efficiency improvements are a possible way of optimizing the production process and reducing negative impacts on the environment (eco-efficiency). The improvement of productivity, and survival rate are critical issues for eco-efficiency. Furthermore, the reduction of the feed conversion ratio and the reduction of medical feed application are important challenges towards sustainable production practices.

Consequences for the management of a shrimp farm:

- ⇒ Improvement of survival rate in a production cycle – avoiding or reducing mortality, is a main factor improving productivity. Stress reducing measures are indicated for the improvement of survival rate. Stress reducing measures are indicated in critical phases of the production, such as transfer of PL to grow-out ponds, minimizing the variation of water parameters, etc. Within the semi-intensive production of the case study, the common known correlations (e.g. stocking density) influencing survival rate could not be shown. The range of the stocking density variation may be too small to show a significant correlation.
- ⇒ Preventive measures (stress reducing measures) should also be undertaken to reduce the application of medical feed. Based on the record of the case study, the application of medical feed is mainly related to the size of the pond, whereas in bigger ponds generally more medical feed was applied than in smaller ones. As medical feed is only applied curatively this indicates that bigger ponds have a higher incidence of diseases.
- ⇒ Improvement of the feed conversion ratio (FCR) increases efficiency and reduces environmental impact through waste reduction (based on N and P inputs). To draw conclusions from the FCR to the quality of the discharged water, the water exchange rate has to be considered, because nutrient loading in the water can be removed through biological processes in the ponds.
- ⇒ Monitoring of FCR and inputs in general may be done on either a 'biological balance' (measurement of nutrients input and outcome – in the product and discharged water) or on a financial level (using monetary FCR, including fertilizer input). The monitoring on these levels would be more precise to evaluate the impacts from an environmental- respectively economical point of view than the FCR based on kilogram.
- ⇒ Factors of the feeding management depend on technological improvements such as feed quality and feed components. The management of a shrimp farm should be interested in feed improvements such as reducing the share of fish meal. In doing so, the question of GMO-products such as soy have to be taken into account. Feed suppliers have to be verified and carefully chosen.
- ⇒ An optimal timing of stocking and harvesting based on growth rate leads to better financial results of a production cycle (net margin/ha/day). The timing is first of all based on experience, because the financial measure (net margin/ha/day) can only be calculated after harvesting. The monitoring of growth rate and feed consumption may give indications for the timing.
- ⇒ For an economical analysis of production cycles, the indicator kg/ha/day should be replaced by net margin/ha/day to consider input costs.

- ⇒ Decisions relating to the production process should try to minimize risks to make the process more stable. For this reason an evaluation by trials and experiments should be conducted before implementing adaptations on farm-level.

10.1.4 Inclusion of human resource potential

Investments in the human resource of a farm do not show results in the short term. Nevertheless the needs of employees and the consideration of society/community must be part of the strategy towards sustainable management. Understanding the needs and the reality of the community and local labor force is necessary to define measures and activities of the management.

Consequences for the management of a shrimp farm:

- ⇒ If the farmer wants to build up a long-term operation, the farm can not act as a separate 'satellite' within its environment. It has to play an active role in the society where it is operating. This can be done through educational-, and professional trainee programs.
- ⇒ Involvement of local labor force helps the farm to become more integrated in the society. It is a stabilizing factor, because local labor are embedded in the community. To become integrated in the location, it is important to know the needs of employees and their situation. Management should be part of - and if possible - involved in this 'reality'.
- ⇒ A possible monitoring of the success of social activities can be done through a comparison of the development in the environment (e.g. by analyzing the municipality, state, or other companies - through benchmarking) or through a time series analysis of farm data. The advantage of a time series analysis is that it gives an indication of the development "towards" sustainable management.

10.1.5 Monitoring of improvements

The integration of sustainability aspects in a Balanced Scorecard is an appropriate tool for the monitoring of improvements towards sustainable management. The monitoring of key figures in a balanced scorecard is an evaluation of and for the management (checking) about moving towards strategic aims. In addition to serving as a strategic monitoring tool, the balanced scorecard has the advantage of forcing the management to become aware of interactions within the company, of what its real mission is, its strategic aims, drivers, and outcome measures.

With the simulation tool (based on financial statements) various strategies could be simulated. In considering all requirements for sustainable operation (see chapter 9.3) the value of a sustainable enterprise is lower compared to the base case. This can be explained through higher costs associated with sustainable production, and which are probably not covered by a price premium of certified products.

Consequences for the management of a shrimp farm:

- ⇒ Based on the vision (which includes aspects of 'sustainable management'), strategic aims, drivers, and measures for a sustainable balanced scorecard have to be defined. This forces the management to work on a long-term plan and define its mission. Concrete content of such a mission depends on the location and the development stage of the enterprise.
- ⇒ Based on financial statements, a simulation tool for the evaluation of management strategies can be created. This helps to estimate financial outcomes (costs, revenues, etc.) of simulated strategies towards sustainability.

- ⇒ The simulation tool should be built in a way, which allows a change in production variables, also not only on the level of financial results. For instance, the model should include the possibility for a varying FCR or varying feed costs, etc.
- ⇒ Results of such simulations can serve to estimate what share can be covered through increased efficiency/better management – and what should be passed on to the consumer.
- ⇒ The conclusions of such a monitoring should periodically be documented in reports by the management. Not only financial results should be stated in these reports. Such reports support and facilitate the communication with customers and other stakeholders interested in production. The reports can be the first step towards certification of the production process.
- ⇒ The lower value of the enterprise resulting from ‘sustainable operation’ simulation indicates that the management of a shrimp farm has to 1) try to get a higher price premium for its certified products, 2) differentiate its products by creating value-added products, or 3) consider the relationship between risk and return. This implies that in the sustainable operation long-term effects (e.g. productivity improvements through higher motivation of employees, or longer utility of the operation compared to a standard operation) are not included.

10.1.6 Marketing aspects

By involving customers as stakeholders, the importance of commercialization and marketing could be shown. Activities towards sustainable management call for action along the supply chain from production to consumption.

Consequences for the management of a shrimp farm:

- ⇒ The demand of customers – like from other stakeholders – are changing over time. For this reason farmers should try to keep in contact with them. Important customer aspects include certification, declaration, additives used in the production and processing, and transport.
- ⇒ The traceability of the product and the way it was produced is a main challenge in relation to trading activities in this sector. At the same time it is a basic condition to guarantee credible marketing, particularly in the communication aspect of labelled shrimp.
- ⇒ The records of the efforts towards sustainability should be provided by the farmer. Particularly for retailers such information can be very useful for their communication strategy.
- ⇒ Certification is an appropriate instrument for products with a strong willingness amongst consumers to pay an additional price associated with adaptations in the process along the supply chain (e.g. changes in the supply, production process, distribution). Even if no price premium can be achieved a certification may be a basic condition to supply and/or open up a new market.
- ⇒ The market potential for certified products is still relatively small, but it is increasing due to scandals in the food sector (e.g. residues of antibiotics). Furthermore, such certified products may convince potential consumers who are currently apprehensive about purchasing/consuming shrimp due to perceived negative impacts.
- ⇒ All actors along the supply chain should benefit from certification. It might be in the form of efficiency and productivity, protection of market share, increased marketing opportuni-

ties (product differentiation), reduction of environmental risks, better access to financial markets for loans, or improved image in a 'green-' conscious market.

10.2 Methodological discussion

The conclusions concerning the methodological procedure focus on the applicability of the methods used to answer the research questions. Advantages and disadvantages of the methods applied in the research project will be pointed out in this section. The chapter is divided into sections relating to the research questions.

10.2.1 Concept to evaluate performance

The concept was evaluated, based on the state of the art in sustainability and performance theory, with a special focus on corporate level (see chapter 2). Based on this, literature parallels in sustainability and performance analysis have been pointed out. These parallels have been used to elaborate an adequate concept for the question focus. The analysis of literature was a good method in recording changes in sustainability- and performance understandings over time. It is important to evaluate the literature based on the question focus. This allows precise focus on relevant literature, which is fundamental in a broad field of theories and notions such as sustainability and performance. In the research project the concept of corporate sustainability was used. A more-dimensional performance instrument was adjusted to measure efforts towards sustainable management. This approach allows one to focus on the challenges and recommendations towards sustainable management from a defined perspective. The 'business case', which considers the long-term viability of an enterprise and defines improvements of socio- and eco-efficiency as management tasks, is considered as an adequate concept in the research. More detailed focus on natural science interactions within the production process, or relationship between the shrimp farm and the local community could provide further findings (see 10.2.5).

10.2.2 Impacts and requirements

The analysis of impacts and requirements was examined in part 0. In addition to the analysis of literature (desk research), three methods were used to evaluate and outline the requirements. The applicability of these methods is illustrated in the following sub-chapters.

The desk research was useful in providing an overview of the often-stated impacts and requirements. It showed that the subject is broad, controversial, and a wide call for action is required. This call for action is targeted at various groups, government and legislation, industry organization, single farms, traders, and consumers. Within the study, the focus was on impacts and demands on single farms. However, this also includes the aspect of contribution to sustainability goals on a society level (see 2.1.3.1).

10.2.2.1 Expert interviews

Through the expert interviews, the reality of Brazilian shrimp farming has been taken into account. The direct communication process during an open interview is an important advantage compared to other methods of empirical data collection. Additional information and information 'between the lines' are important for the survey. Furthermore, the possibility of checking incomprehensible parts of the interview exists. The investigator becomes an active part during the interview and is able to act as a guide. The disadvantages of an open questionnaire, without standardized questions, are costly. This was the reason for limiting the number of people interviewed. Another disadvantage of the open interviews is the possibility that the

interviewed person can be influenced by the interviewer. However, it emerged to be an adequate method to explore new aspects stated by the interview partners. The validation of the results was undertaken in written form.

The realization of expert interviews was valuable in considering specific Brazilian aspects of shrimp farming. The constitution of the expert group was approved, because various aspects of stakeholder groups were represented through the experts.

10.2.2.2 Delphi study

The study aimed toward the necessity of including customer perspectives with their demands. The Delphi study is an appropriate method of including controversial opinions about a topic. A further advantage is the anonymity during the survey. It can be assumed that the participants and also competitors answer the questions with a high degree of frankness, which probably would not be possible in an open discussion. Furthermore, the experts receive the results which lead to reflection. The participants have the possibility of re-evaluating their opinion and to start to consider opinions of other participants. A Delphi study may initiate a communication process which may not be initiated otherwise because of fixed positions and lack of feed-back.

The method is time-consuming which might have been the reason for experts not participating. Specialized and also technical knowledge was also required in this survey. These two arguments have been the main arguments for experts not participating or failing to complete the survey. Nevertheless thirty participants agreed to become part of the panel for the Delphi survey.

Based on more than one round, it was possible to 'create a common language' and to clarify misunderstandings or misinterpretations. For instance, the question of closed production cycles may be understood in two different ways: it may be in reference to the water cycle (no water exchange during the production process and no uncontrolled water discharge into the eco-system) or to the animal cycle (hatchery-reared brood stock and larvae from this brood stock). Such issues have been explained in the second round of the Delphi study. For such discussions, high technical knowledge is demanded. A disadvantage of the Delphi study which turned up in the third round was 'strategic answering'. Showing the results of the second round the answers changed in the third round. The interpretation of results, mainly quantitative results become more difficult.

The method is considered adequate to evaluate the impacts and requirements by being constitutive. Through open questions in the first round, critical issues could be marked. Based on these issues a weighting was done in the second and third rounds.

10.2.2.3 Qualitative system dynamics approach

The aim of this step was to outline the requirements for better understanding of interactions between variables in a network. By defining central cycles with drivers and key factors the qualitative system dynamics approach was used as a didactical instrument to communicate the importance of interactions within the system. It was useful to make the participants aware that different thinking of an enterprise functionality exists. It was also important to include and illustrate soft factors (such as motivation of employees) in the cycles. These soft factors help to consider rather long-term feedback-loops. The interviews were a useful approach in building the network and the portfolio. The expected results have been provided with the approach of qualitative system dynamics. To debate the topic directly in an interactive form, with all interview partners together, would have been easier and probably more efficient. As this was

not possible, the knowledge and experiences of the Delphi study and of the literature analysis was summarized and introduced by the investigator.

10.2.3 Statistical methods of the data analysis in the case study

To analyze the key issues on a shrimp farm, the case study farm 'Camanor' was selected and data were analyzed. In addition to this analysis, the investigator had the opportunity to 'observe' the farms' situation on location for almost three years. The investigations about the history and reporting of changes in the case study have been used for the work on the question focus. The single case study has to be seen as a 'laboratory' investigator selects the topic of a new experiment. Experiences in the case study may be useful for further research projects and lessons may be learned by other farm managers, without conducting the same experiences.

Statistical methods were used to test various hypothesis, mainly within the production process (testing of the structure). It is an adequate method for a wide data set such as the data set of this case study. It is particularly adequate to test correlations, which are expected from a technical point of view. This indicates that good production know-how is required to be able to interpret statistical results. The data availability and quality is also very important. On the one hand data based on the daily production activity reflects the 'reality' of a shrimp farm, and on the other hand, the risk for measurement failures and failures in the data preparation is high. Inconsistency in the data collection exists due to changes in the production-process and non-standardized data collection. As a result of these difficulties, the secondary data record had to be limited to data which had been prepared by the investigator.

Interpretation of statistical results are basically valid for the circumstances of the investigated case. The possibility of generalizing the results to other farms is limited because of varying situation of circumstances (e.g. different environmental conditions). The utility of the case study for generalization is through the information provided of what can be measured and how it can be measured. Furthermore, conclusions of the interactions and the holistic/integrated consideration of a shrimp farm can also be drawn for other farms.

The trend analysis of socio-economic impacts is adequate for the purpose of the study. It focuses on the progress in the development towards sustainable management. Therefore time series analysis is important.

10.2.4 Monitoring and simulations

The balanced scorecard is an adequate instrument for the purpose of this study which is the monitoring of the activities of a shrimp farm towards sustainable management. First of all, it is a valuable instrument because it allows sustainability aspects to be included into its perspectives (see 9.1). It is an appropriate instrument, because it considers the firms' strategy and interactions (cause and effect chain, drivers and outcome measures) which can be deduced from the network of qualitative system dynamics approach. Furthermore, the concentration on a few outcome measures makes it efficient for monitoring and reporting. The difficulties of using a balanced scorecard in the case can be explained by the necessity of a continuous participating management to actualize the daily changing frame. This is costly and rather difficult for an enterprise which is highly expansive.

The financial simulation is an adequate method to simulate development of key figures, or management decisions over time and estimates the outcome measures. It also allows the sensitivity of various strategies to be measured. The model has to be adapted to the farms properties and updated with farm data. It can be used as an instrument to prepare information for strategic decisions of the management, such as investment activities, adaptations of the pro-

duction process or handling with uncertainties (for instance the price development of shrimps). It is a tool to improve the management awareness concerning changes.

10.2.5 Final conclusions and further research

The provided results are useful for the management of a shrimp farm which is committed to improvements towards sustainable practices. It also gives suggestions for possible actions, critical factors which should be observed, trials which could be done on the farm, data which could be analyzed, and ways of analyzing data. This illustrates the practical utility of the research. An overall picture ('big picture') of the challenges of a shrimp farm in achieving sustainable management is provided.

Based on this picture further research is called for. Extended investigations from societal and environmental points of view, would provide additional aspects to the business case-perspective, which was the main focus in this project. Such investigations would require interdisciplinary work, involving ecologists, and sociologists. A further project should broaden the question focusing on the value chain, including input suppliers, transport, trading-structure, distribution and consumption. The impact of technological improvements for the development towards more sustainable practices would be another interesting aspect to focus on. The implementation of a balanced scorecard on a shrimp farm, testing of its functionality, and defining the necessary adaptations may be part of further investigations.

Furthermore, many aspects that have been illustrated in the 'big picture' might be analyzed with more detail and a broader data base. For instance, the socio-economical impact of a shrimp farm, including multiplier-effects in the local community, would provide important insights for social measures of a shrimp farm. Such a detailed analysis could provide findings with which to compare different farming systems or enterprises in different phases of their lifecycle.

It can be concluded that the research for practices towards sustainable shrimp farming is in its infancy. Further investigations should emphasize the practical aspects to ensure the usefulness for single shrimp farmers.

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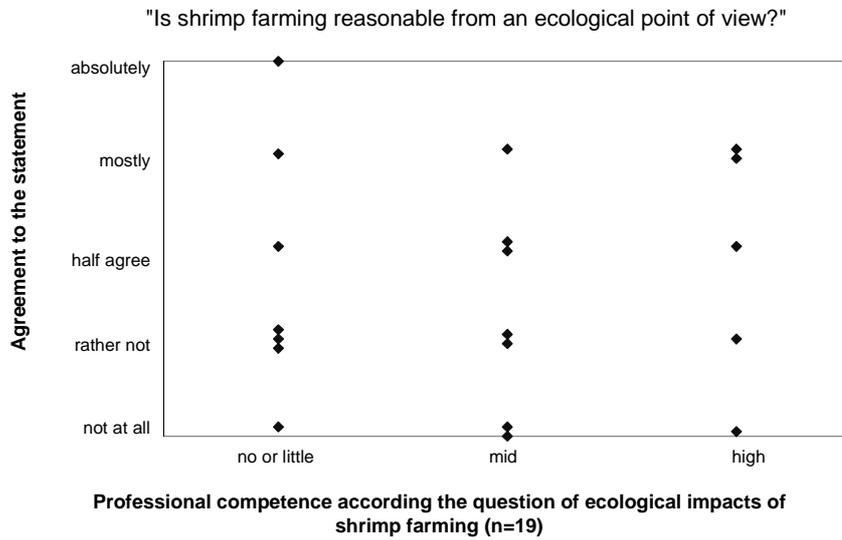
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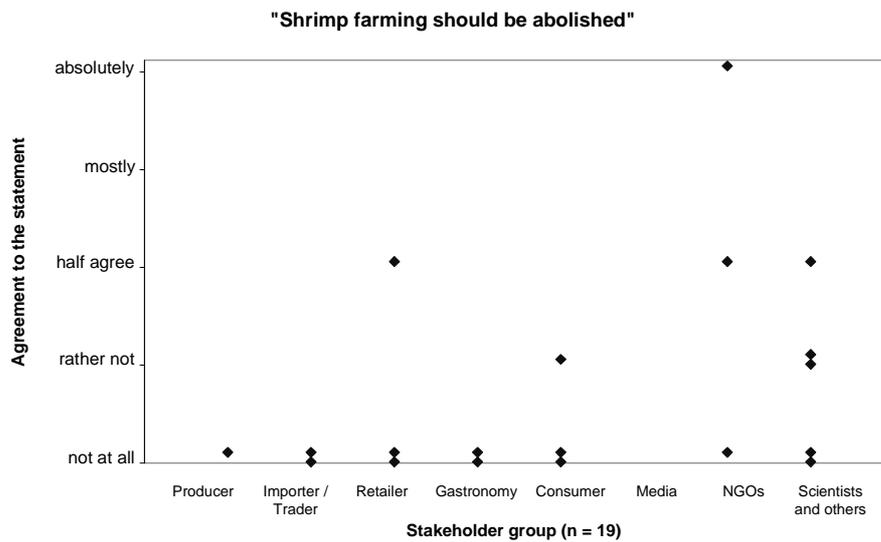
F APPENDIX

Figure 92: Agreement and professional competence



Source: Adapted from Lustenberger 2001a

Figure 93: Agreement to the statement and stakeholder group (control question)



Source: Adapted from Lustenberger 2001a

Table 49: Ranking of the importance of aspects

	Ranking of all expert opinions	Ranking group A	Ranking group B	Ranking group C
Environmental aspects	1	1	1	1
Social aspects	2	2	3	2
Production process	3	3	4	2
Economical aspects	4	3	2	5
Site evaluation	5	5	5	4

Figure 94: Weighting of criteria concerning site evaluation (third turn)

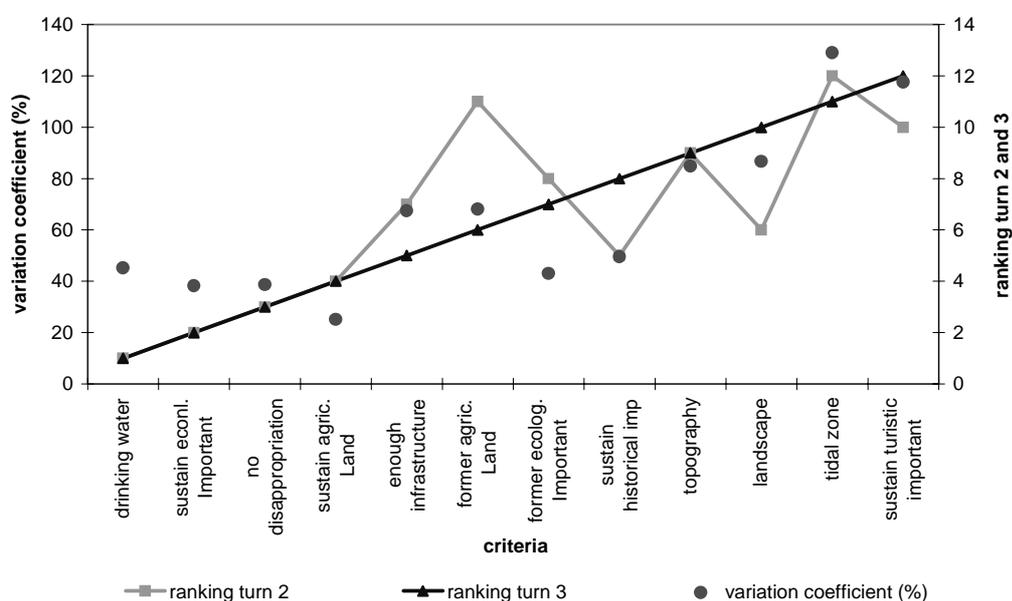


Table 50: Ranking of site evaluation criteria turn two and three

	Ranking turn 2	Ranking turn 3
Drinking water	1	1
Sustain ecological important area	2	2
No disappropriation	3	3
Sustain agricultural important area	4	4
Just where enough infrastructure	7	5
No certification for farms on former agricultural land	11	6
No certification for farms on former ecolog. Important land	8	7
Sustain historical important area	5	8
Topography	9	9
Landscape	6	10
Tidal zone	12	11
Sustain important land for tourism	10	12

Figure 95: Weighting of criteria concerning production process (third turn)

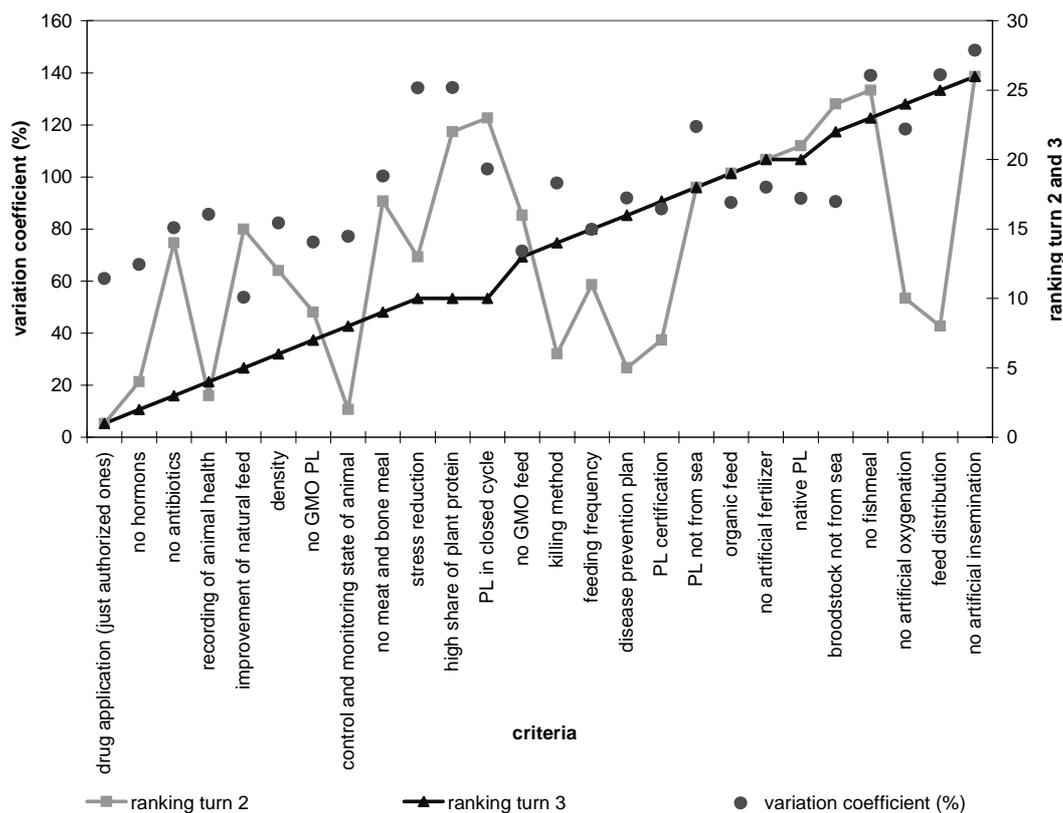


Figure 96: Weighting of criteria concerning environmental aspects (third turn)

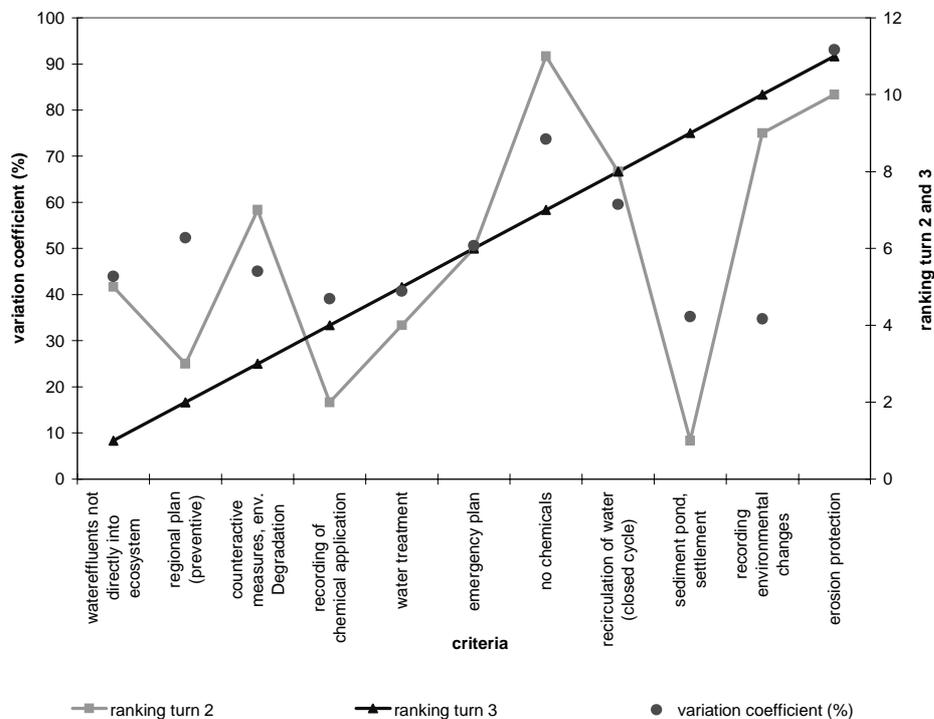


Figure 97: Weighting of criteria concerning social aspects (third turn)

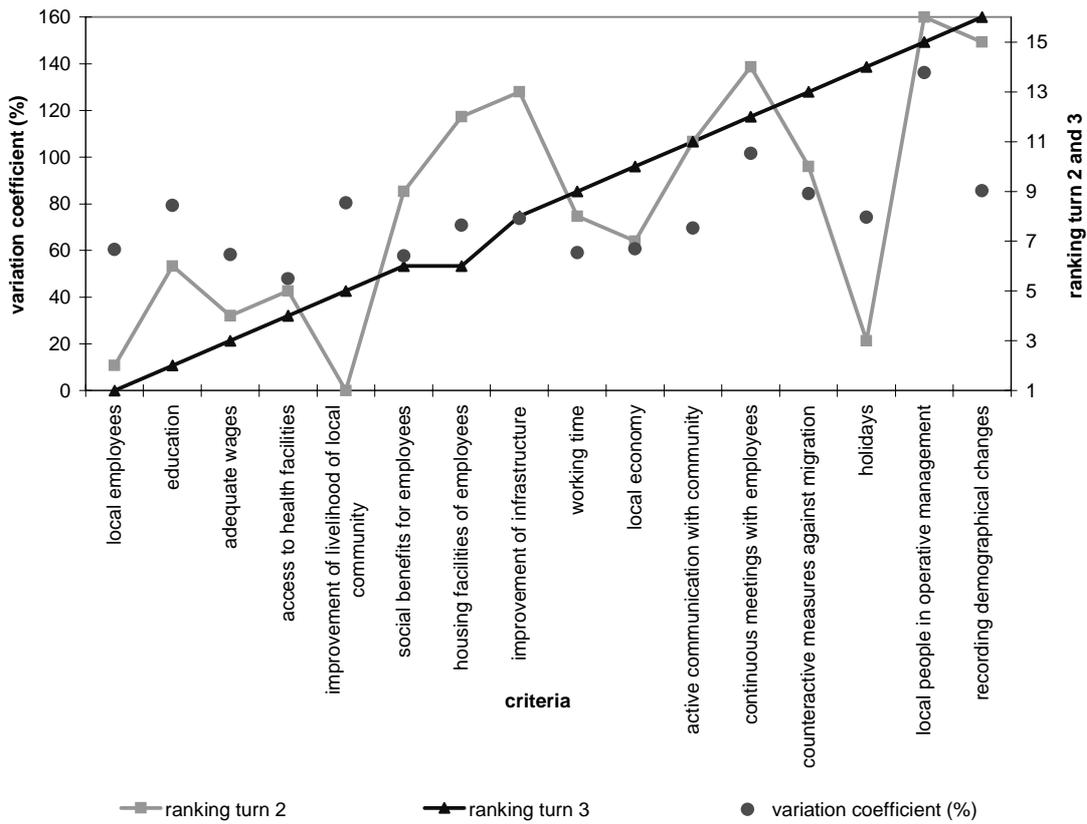


Figure 98: Central cycle No. 2

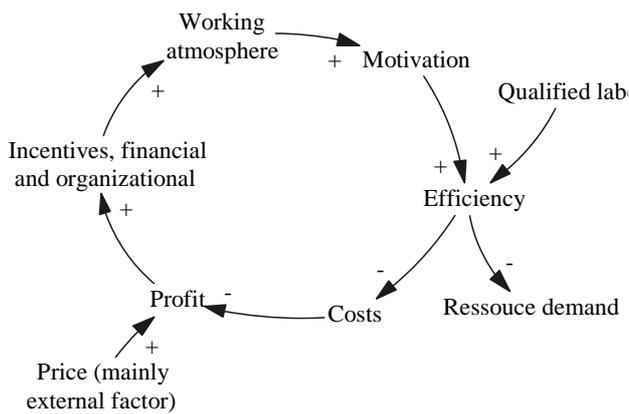


Figure 99: Central cycle No. 3

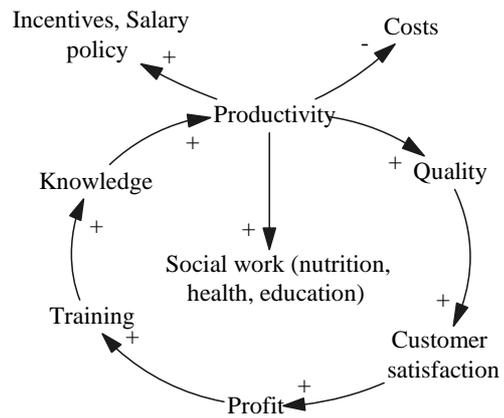


Figure 100: Central cycle No. 4

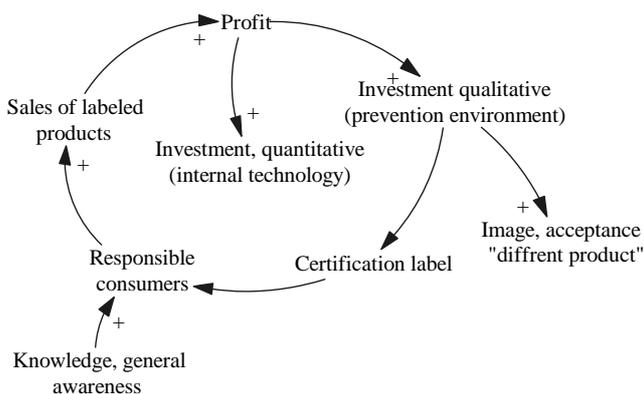
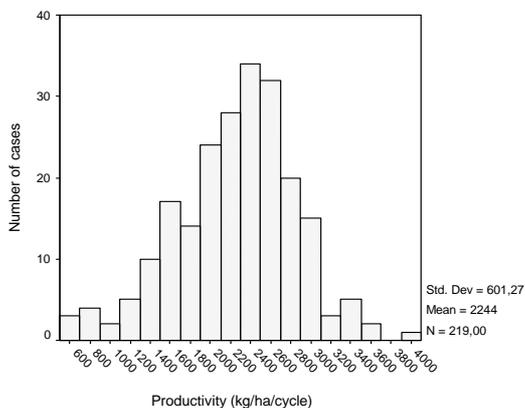


Figure 101: Productivity

a) in kg/ha/cycle



b) in kg/ha/day

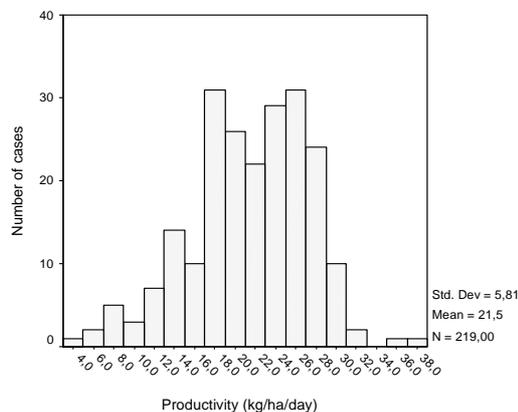


Table 51: Productivity correlations for scale measured data

Spearman's rho correlation coefficient (N=168)

	Productivity (kg/ha/day)	Stocking density (animals/m3)	Survival rate in %	Average weight (g/animal)	average temperature during the production cycle	Days of the production cycle
Productivity (kg/ha/day)	1.000		**	**	**	**
Stocking density (animals/m3)	.142	1.000		*		
Survival rate in %	.712**	.027	1.000	**		
Average weight (g/animal)	.438**	-.186*	.202**	1.000	**	
Average temperature	.387**	-.135	.128	.434**	1.000	**
Days of the production cycle	-.304**	.113	.025	.073	-.491**	1.000

** . Correlation is significant at the .01 level (2-tailed).

* . Correlation is significant at the .05 level (2-tailed).

Table 52: Productivity correlation for nominal measured variable 'farm location'

Pearson Correlation (N=219)

	Productivity (kg/ha/day)	Stocking density (animals/m3)	Survival rate in %	Average weight (g/animal)	Duration of production cycle	Farm
Productivity (kg/ha/day)		*	**	**	**	
Stocking density (animals/m3)	.147*			**		**
Survival rate in %	.720**				*	
Average weight (g/animal)	.308**	-.333**	.119		**	**
Duration of production cycle	-.287**	-.126	.139*	.317**		**
Farm	-.052	-.503**	.053	.411**	.332**	

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

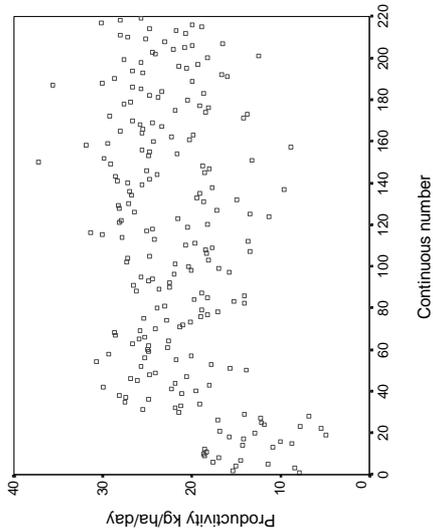
Table 53: Average productivity related to temperature averages (N=168)

No	Range average temperature (°C)	Average productivity (kg/ha/day)	Number of cycles
1	25.7 – 26.4°C	17.9	47
2	26.5 – 27.3°C	21.3	40
3	27.4 – 27.9°C	23.7	36
4	28.0 – 28.4°C	24.2	45

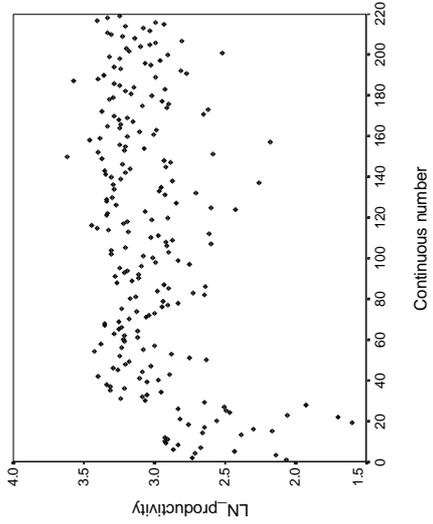
Figure 102: Data for the regression model

Data over time

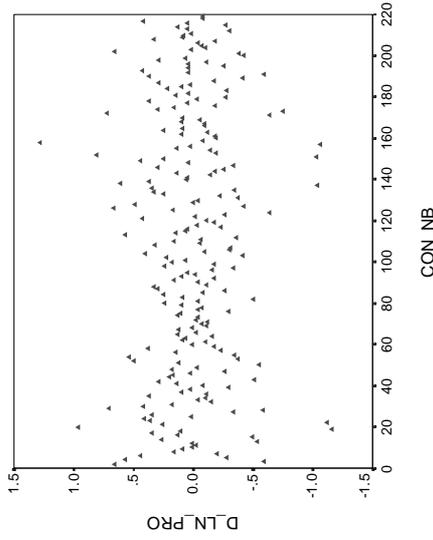
- Productivity over time



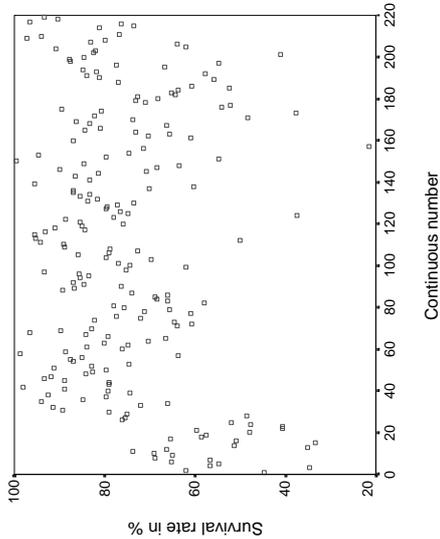
Log-linear data over time



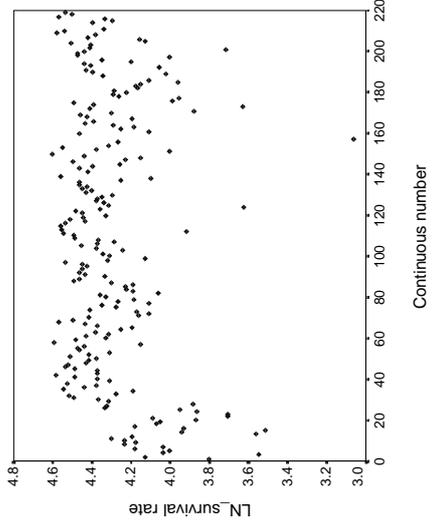
Data trend adjusted



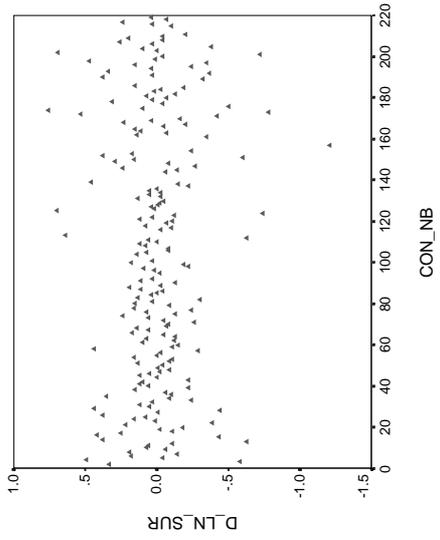
- Survival rate over time



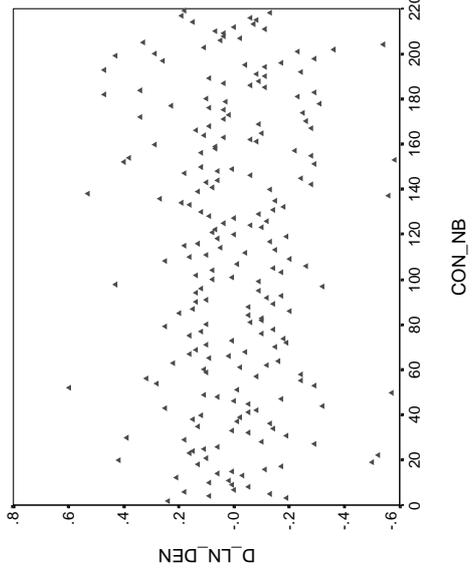
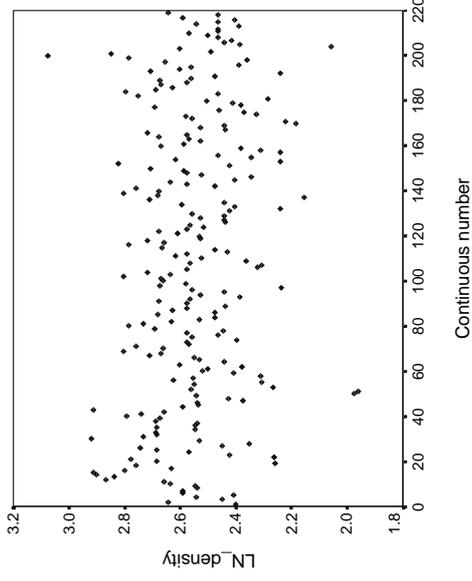
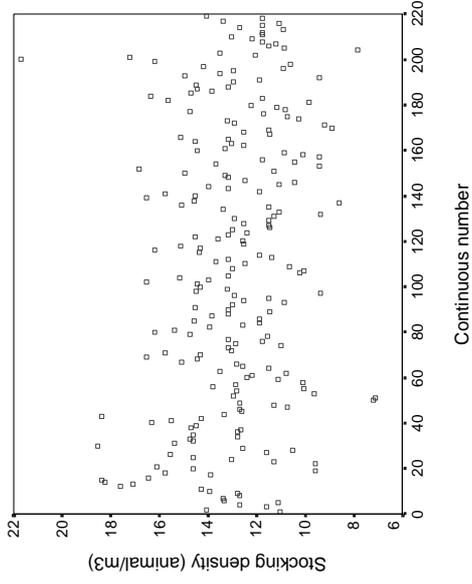
Log-linear data over time



Data trend adjusted



- **Stocking density over time**



- **Average weight over time**

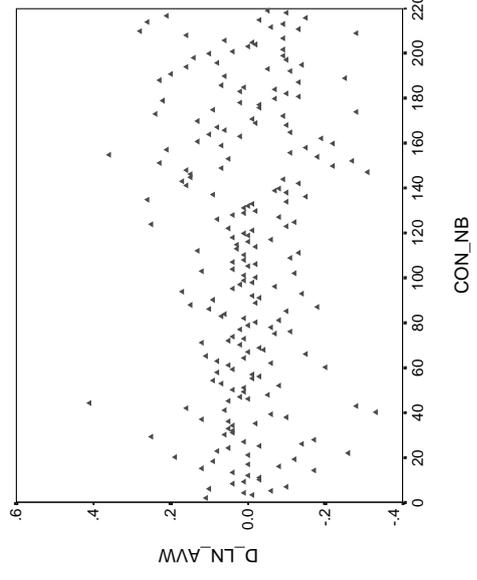
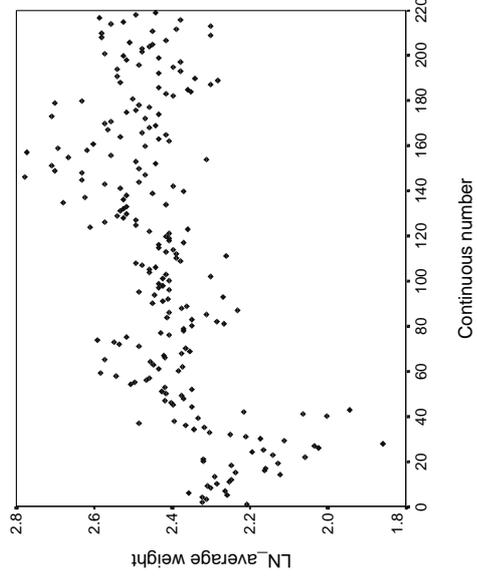
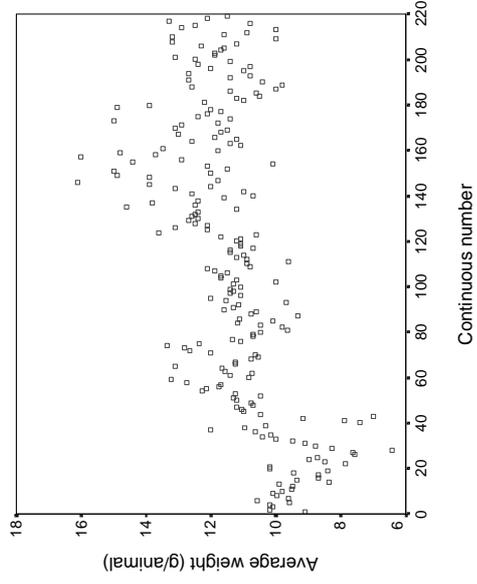


Table 54: Regression model with survival rate as an endogen variable

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	,911 ^a	,831	,827	,11551	,831	260,992	4	213	,000	2,917

a. Predictors: (Constant), D_LN_DAY, D_LN_DEN, D_LN_AVW, D_LN_PRO

b. Dependent Variable: D_LN_SUR

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics		
		B	Std. Error				Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF	
1	(Constant)	6,857E-04	,008		,088	,930	-,015	,016						
	D_LN_PRO	,806	,027	,996	30,289	,000	,754	,859	,670	,901	,854	,736	1,359	
	D_LN_DEN	-,545	,044	-,395	-12,350	,000	-,632	-,458	,029	-,646	-,348	,779	1,283	
	D_LN_AVW	-1,036	,072	-,449	-14,428	,000	-1,178	-,895	-,188	-,703	-,407	,820	1,220	
	D_LN_DAY	,845	,049	,555	17,322	,000	,749	,941	,163	,765	,489	,776	1,289	

a. Dependent Variable: D_LN_SUR

Figure 103: Crosstabulation Survival rate and Net margin

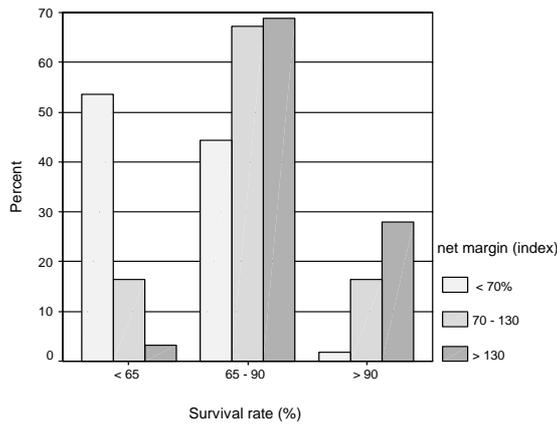


Figure 104: Crosstabulation Farm and Medical feed

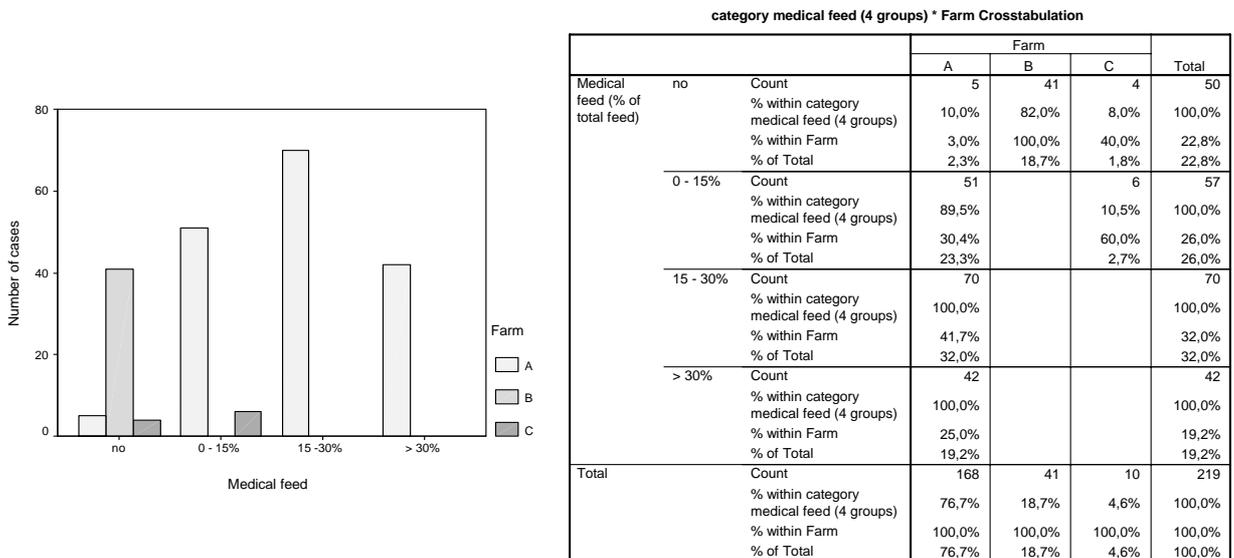


Table 55: Correlations medical feed

Spearman's rho Correlation Coefficient (N=168)

	% medical feed	Productivity (kg/ha/day)	Survival rate (%)	Stocking density (animals/m3)	Temperature during production cycle	Duration production	Days of preparation
% medical feed	1,000						*
Productivity (kg/ha/day)	-,055	1,000	**		**	**	**
Survival rate (%)	-,127	,712**	1,000				*
Stocking density (animals/m3)	-,030	,142	,027	1,000			
Temperature during production cycle	-,132	,387**	,128	-,135	1,000	**	
Duration production	,002	-,304**	,025	,113	-,491**	1,000	
Days of preparation	,159*	-,264**	-,169*	-,020	,071	-,141	1,000
Pond size (ha)	,252**	-,176*	-,203**	-,488**	,021	,096	,008

*. Correlation is significant at the .05 level (2-tailed).
 **. Correlation is significant at the .01 level (2-tailed).

Figure 105: Productivity over time

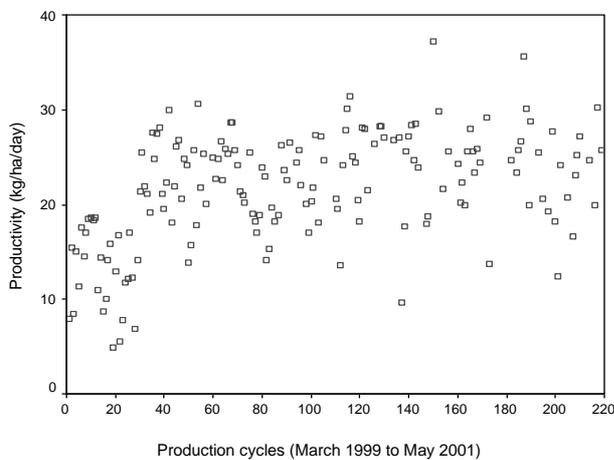


Table 56: Correlations FCR

Spearman's rho Correlation Coefficient (N=168)

	FCR	Feeding trays per ha	Survival rate in %	Productivity (kg/ha/day)	Stocking density (animals/m3)	Average weight (g/animal)	Temperature during production cycle	Duration production	Area of the pond (ha)	Days of preparation	% medical feed	Waste N (g/kg shrimp)
FCR	1,000			**				**				**
Feeding trays per ha	,127	1,000		**	**				**			
Survival rate in %	-,100	,065	1,000	**		**		**	**	*		
Productivity (kg/ha/day)	-,295**	,207**	,712**	1,000	**	**	**	**	*	**		**
Stocking density (animals/m3)	,088	,411**	,027	,142	1,000	*			**			
Average weight (g/animal)	-,117	,079	,201**	,438**	-,186*	1,000	**			**	*	*
Temperature during production cycle	-,114	-,006	,128	,387**	-,135	,434**	1,000	**				
Duration production	,327**	,036	,025	-,304**	,113	,073	-,491**	1,000				**
Area of the pond (ha)	-,039	-,331**	-,203**	-,176*	-,488**	,143	,021	,096	1,000		**	
Days of preparation	,065	-,064	-,169*	-,264**	-,020	-,413**	,071	-,141	,008	1,000	*	
% medical feed	,137	-,065	-,127	-,055	-,030	-,161*	-,132	,002	,252**	,159*	1,000	*
Waste N (g/kg shrimp)	,989**	,117	-,130	-,323**	,085	-,160*	-,124	,293**	-,039	,083	,166*	1,000
Waste P (g/kg shrimp)	1,000**	,127	-,100	-,295**	,088	-,117	-,115	,327**	-,040	,065	,138	,989**

** Correlation is significant at the .01 level (2-tailed).
 * Correlation is significant at the .05 level (2-tailed).

Figure 106: Waste N and medical feed (N=168)

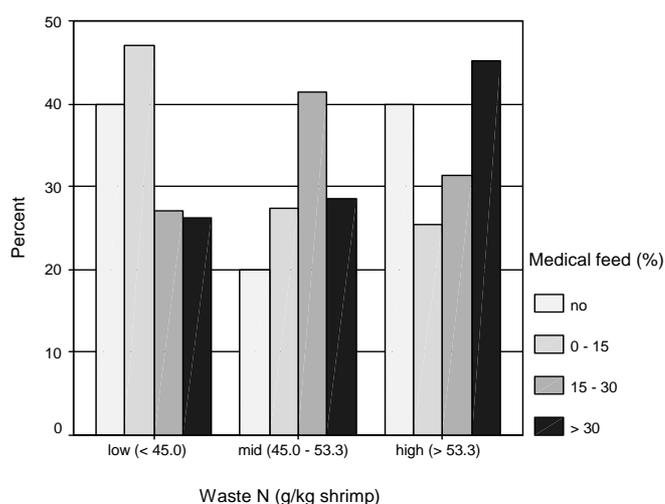


Table 57: Correlations net margin

Spearman's rho Correlation Coefficient (N=219)

	Net margin/ha/day	Net margin/kg	Productivity kg/ha/day	Survival rate (%)	Density (PL/m3)	Average weight (g/animal)	% medical feed	% PL costs of total costs	% feed costs of total costs
Net margin/ha/day	1.000	**	**	**		**		**	**
Net margin/kg	.887**	1.000	**	**		**		*	*
Productivity kg/ha/day	.812**	.502**	1.000	**	*	**		**	**
Survival rate (%)	.586**	.363**	.653**	1.000			*	**	**
Density (PL/m3)	.110	.106	.159*	-.058	1.000	**	**	**	**
Average weight (g/animal)	.292**	.181**	.293**	.131	-.347**	1.000	**	**	**
% medical feed	-.094	-.097	.016	-.154*	.333**	-.413**	1.000	**	**
% PL costs of total costs	-.337**	-.151*	-.391**	-.645**	.214**	-.534**	.288**	1.000	**
% feed costs of total costs	.343**	.144*	.420**	.668**	-.187**	.494**	-.213**	-.978**	1.000
% preparation costs of total	-.178**	-.016	-.342**	-.413**	-.109	-.028	-.287**	.328**	-.473**

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Table 58: Assumptions for the production costs per unit

	R\$/Unit		R\$/Unit
PL (per tsd)	6.10		
Feed costs per kg	1.31	Feed 1	1.51
Medical feed costs	1.80	Feed 2	1.99
Soy	0.48	Artêmia (kg)	2.00
Farelo de Trigo	0.25	Esterco	0.11
Uréia	0.34	Cal Virgem	0.13
Calcáreo	0.03	Fosfato MAP	0.37
Nutrilake	1.00	Cloro	7.20
Fix factor (R\$/ha/day)	25.00	Processing costs per kg	1.5

Source: Own calculation average costs, Data base Camanor

Figure 107: Assumptions for the selling price

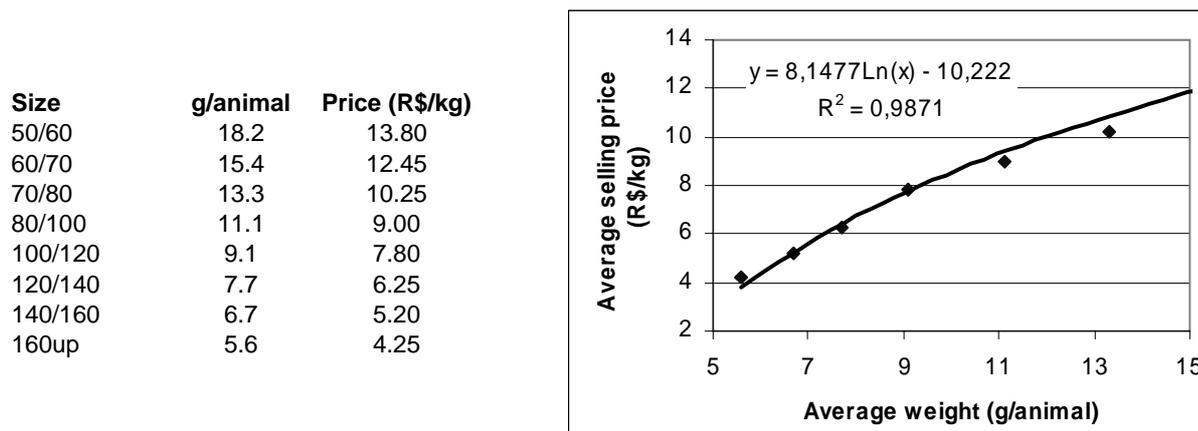
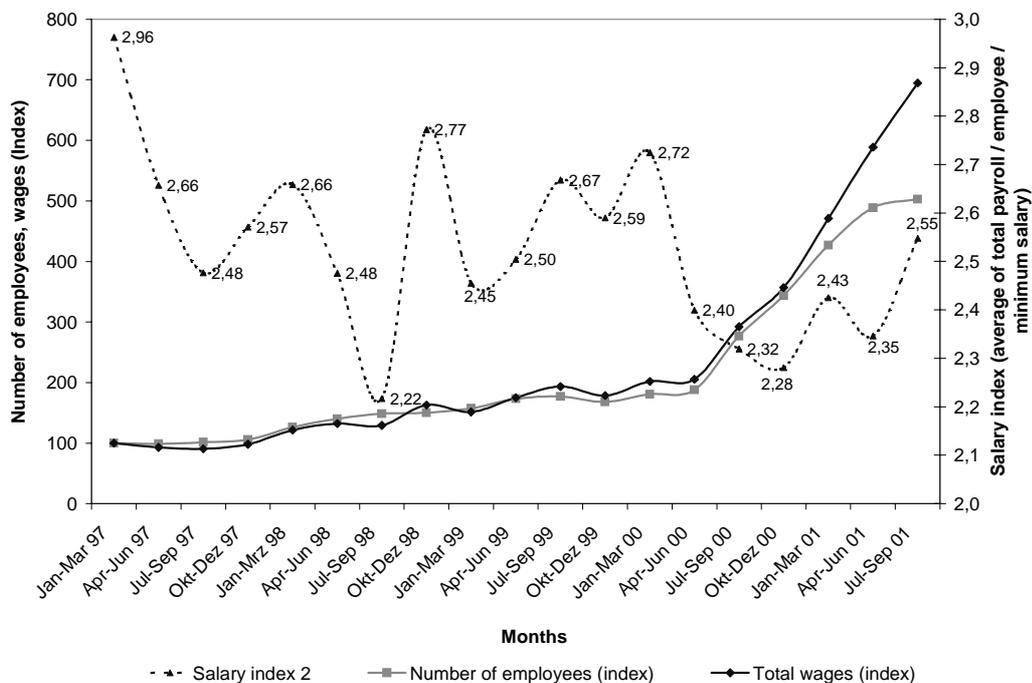


Figure 108: Number of employees, wages and Salary index 2 (Index: Jan-Mar 97 = 100)



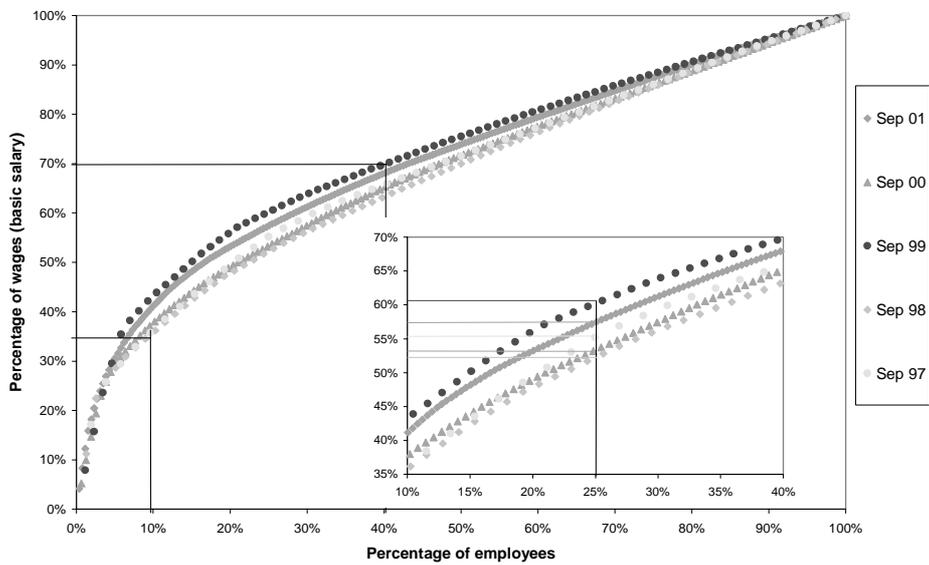
Source: Own calculation, Camanor 1997 - 2001

Figure 109: Salary index of basic salary and total salary



Source: Own calculation, Camanor 1997 - 2001

Figure 110: Distribution of base-salary: September 1997 - 2000



Source: Own calculation, Payroll Camanor

Table 59: Questionnaire for home visit




VISITA DOMICILIAR

Empresa: _____ Nº Reg. _____
I- Identificação
 Nome do Funcionário: _____
 Nome do Dependente: _____ Sexo: Masc. () Fem. ()
 Grau de parentesco: _____ Est. Civil: _____
 Data de Nascimento: _____ 2º Grau ()
 Escolaridade: Alfabetizado ()
 1º Grau Inc. ()
 3º Grau ()

II- Antecedentes Pessoais :

III- Antecedentes Familiares:**IV - Condições Sócio - Econômica**
Higiene Pessoal e Ambiental -

Iluminação adequada: Sim () Não () Ventilação adequada: Sim () Não ()

Obs. _____

V- Anamnese**1 - Condições Gerais**

2 - Pele e Mucosa

3 - Condições Músculo / Esquelética / Deambulação

4 - Cabeça e Pescoço (Higiene, Olho, Boca, Nariz e Ouvido)

5 - Tórax (Coração, Pulmão e Mamas)

6 - Abdome

7 - Aparelho Genital - Urinário

8 - Outros

Table 60: Questionnaire for interviews with employees




CONSULTA DE ENFERMAGEM

Empresa: _____ nº reg. _____
 Data: ____/____/____ Data Admissão: ____/____/____
I Identificação
 1- Nome _____
 2- Sexo: () Masc. () Fem. _____ 3- Data Nasc.: (a.) / / _____
 4- Cor: _____ 5- Est. Civil: _____ 6- N.º Dependente: _____
 7- Escolaridade: () Analf. () Alfab. () 1º Grau () 2º Grau () 3º Grau _____
 8- Ocupação: _____
 9- End. Res: _____
 10- Município: _____

II- CONDIÇÕES SÓCIO - ECONÔMICA

1- N.º Dependentes: _____ 2- Quantos moram na Casa? _____ 3- N.º Comodos: _____
 4- Tipo de Casa: _____ 5- Água: _____ 6- P/ Beber: _____
 7- Saneamento Básico _____ 8- Qual o destino dos dejetos? _____
 9- Energia Elétrica? _____ 10- Tem outro trabalho ? Qual? _____
 11- Mais alguém Trabalha ? Quem? _____ 12- Renda familiar: _____

III- CONDIÇÕES DE SAÚDE

1- Deformidades () Amputação () Cicatrizes () Cirurgias ()

Quais? _____

2 - Antecedentes Pessoais

Dermatites () Alergias () Anemia () Dores Articulares () Nefropatia ()

Dor na Coluna () Convulsões () Deficit Visua () D. Auditiva () Gastrite ()

Dist. Emocional () Hepatite () Cardiopatas () Infecção Respiratória ()

Obs. _____

3 - Antecedentes Familiares:

Hipertensão () Diabetes () Tuberculose () Neoplasias () Avc () Cardiopatas ()

Obs. _____

4 - Carteira Vacinal: Tétano () BCG () Hepatite () Influenza () Outras _____

5 - Queixas Atuais.

Cefaleia () Tortura () Edema () Obs.: _____

IV - ANAMNESE

1 - Sinais Vitais: Temp. _____ Pulso _____ Resp. _____ P. At. _____

Peso: _____ Altura: _____

2 - Condições de Higiene:

Boca/Dentes/Língua _____

Olhos _____

Nariz _____

Figure 111: Normal curve distribution

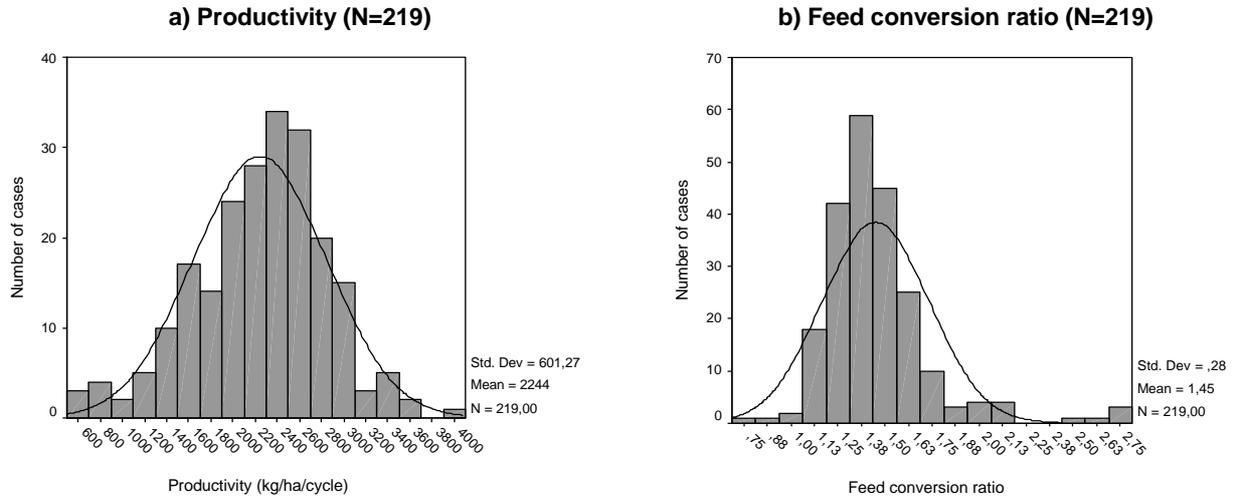
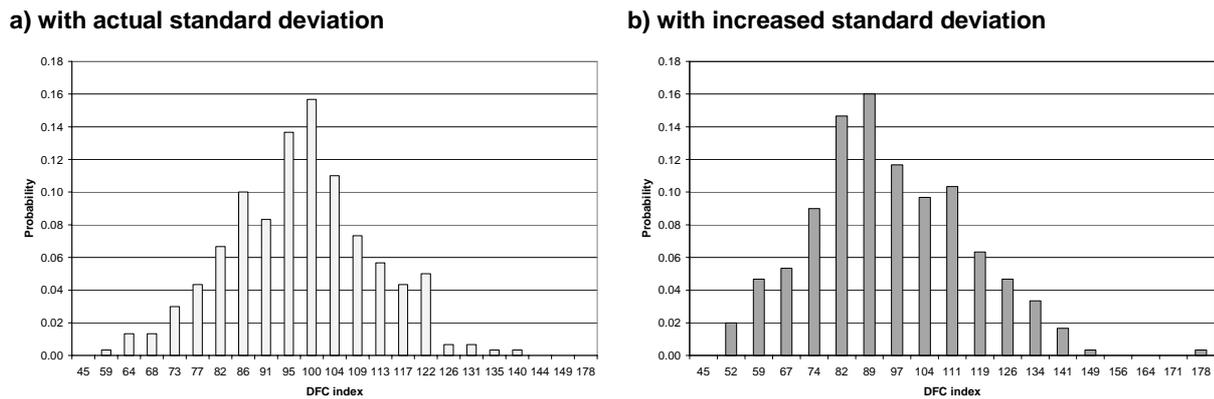


Figure 112: Variation of the enterprise value (index mean)



Curriculum Vitae

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Civil status: married

Education and professional experience

1980 - 1984 Elementary school, Walperswil, BE
1984 - 1988 Secondary school, Aarberg, BE
1988 - 1993 Gymnasium Bern Neufeld, BE (focus on law and economics, Matura Typus E)
1993 - 1998 Studies at the Department of Agriculture and Food Science, at the Swiss Federal Institute of Technology Zurich (ETH), Switzerland.
Graduation in:
⇒ Dipl. Ing.-Agr. ETH, Agricultural Economics
⇒ Lectureship
1999 - 2002 Assistant and Ph.D. student of Prof. Dr. B. Lehmann, at the Institute for Agricultural Economics, ETH Zurich
1999 - 2001 Field research on Camanor Produtos Marinhos Ltda. (shrimp farm in Northeast Brazil)