KNOWLEDGE EXCHANGE ON WATER RESOURCE MANAGEMENT FOR IMPROVED INTEGRATED AQUACULTURE FARMING SYSTEMS

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Report to the Water Research Commission

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EXECUTIVE SUMMARY

Motivation and background

Over the past four years the Project Team has been investigating and gathering information on aquaculture-agriculture systems, which are associated with farm/irrigation dams. Research methods in previous projects included conducting workshops and related information sessions. Limited attention was paid to the adoption of this information and its implementation. The study for this project focused on the process of knowledge exchange to improve existing water resource management principles and practices, as well as creating a better opportunity for sustainability to both aquaculture and agriculture. The project included both small- and large-scale producers, bearing in mind that large-scale producers in South Africa are considered small-scale in relation to other countries such as Chile, Denmark, Norway and Scotland. The definition of a small-scale fish farmer followed that of the Food and Agriculture Organization (FAO).

The output being considered included what quality of information is available locally as well as internationally; the level of accessibility, affordability and adoption levels; the different types of media or methods used to disseminate and access necessary information; what constraints farmers experience when gathering information; the farmer's ability to interpret and understand gathered information; the level of success of farming associated with the attained knowledge; benchmarking the success levels; and finally, considering the implicit transaction cost to fish farmers.

The expected impacts of this project were to get knowledgeable fish farmers on par with local and international developments; to improve accessibility to information systems for fish farmers; to promote the useful application of information and basic understanding; to improve communication between academia, fish farmers and the media; to create formalised research agendas based on the aquaculture sector requirements; and to contribute towards constructing an appropriate policy and strategy which can be used as management guidelines.

The primary aims of this project were:

- To investigate what information is available to fish farmers as local and captive knowledge.
- To evaluate the sources and accessibility of this information.
- To determine the level of interpretation that is associated with farming dynamics and context.
- To evaluate the impact of the applied transferred technology.
- To create a new set of instructions and learning material for academics and development practitioners.

This project is crucial to the development of the aquaculture sector in South Africa, but more in terms of promoting sustainable multi-utilisation of water resources. The project can present best management guidelines to ensure water resources are utilised and

managed to stringent regulations, both for aquaculture and agriculture. Ultimately, a holistic structure should be presented to the promotion and regulatory authorities whereby most concerns and challenges have been addressed through empirical and descriptive research and investigations. This knowledge exchange project is the third initiative with the WRC towards reaching the goal of sustainable water resource management by the aquaculture in conjunction with the agriculture sector in South Africa.

The following research questions were structured around the project:

a. What information is available to aquaculture and agriculture and how is it disseminated?

A considerable amount of information is available at different sources and formats. The quality and quantity of the available information was investigated.

b. *What media/modes are used by the fish farmers and alike to access information?*

It is difficult to promote any form of knowledge exchange if one does not understand which modes are used and the challenges associated with it. It was imperative to determine if more traditional or technological advance modes were considered.

c. In what ways are accessed information utilised?

Knowledge exchange can only be deemed successful if fish farmers adopt and implement it. Therefore, it is incumbent to understand the way information is channelled.

d. What are the constraints to information routes at farmer/producer level?

Fish farmers experience a myriad of problems and most of these problems can be ascribed to the fact that they do not have the desired information at hand. Major constraints leading to blockages in information flow were explored. The organisational arrangement that could assist was also evaluated.

e. What thinking/rationale processes drives information priorities?

Choices of what to use and where to apply are driven by many divergent factors. The Project investigated the dynamics surrounding demand and supply of knowledge exchange.

f. How many successful farming practices is based on existing and new knowledge?

Integrated agriculture-aquaculture in irrigation dams can only be successful if sufficient knowledge is present in both sectors. Historically, information was passed on from generation to generation and established a wealth of local and existing knowledge. The project interrogated to what extent existing (local) and new knowledge were complementing fish farming operations.

g. What are the cost implications of information dissemination?

Knowledge exchange needs to be presented as an acceptable value proposition to fish farmers. Cost-benefit scenarios, prevalent among farmers, were probed to ascertain what farmers are willing to spend to attain information.

h. What benchmark is being set by smaller and larger successful farmers?

The development of both small- and large-scale fish farming operations is driven within the confinement imposed by the physical, chemical and biological environment, as well as the socio-economic considerations. The benchmarks set by both were discussed.

i. How do South African fish farmers rate/compare i.e. to European and American producers?

It is of interest to rank South African fish farmers to farmers in Europe and America where aquaculture is well-developed. This was addressed by evaluating the existing practices and principles incorporated to improve management of the natural resources in South Africa.

j. How are South African farmers managing the influx of information related to the production and marketing?

Introducing strategies and guidelines to improve knowledge acquisition and dissemination is important to the production and marketing. Fish farmers will be able to grow their operations once the appropriate information is utilised.

Method of knowledge exchange

The scope of the study covered fish farming operations in three provinces of South Africa, *inter alia*, Western Cape, (WC), KwaZulu-Natal (KZN) and Limpopo. The goal was to have in-depth discussions with fish farmers in order to gain an insight into the dynamics surrounding knowledge access, exchange, and the adoption thereof. The common criteria considered for selecting the participants were: fish farmers with farms where the operation sites and the water sources are used for agricultural irrigation and aquaculture (i.e. fish farming) practices. The current practices and principles were investigated and evaluated to improve the overall management of water.

A total of 38 fish farms were visited in WC (9), KZN (9) and Limpopo (20) for the duration of the project. Semi-structured questionnaires (Appendices 1-3), as well as informal person-to-person discussions were used to collate information. Farmers were also contacted by email and telephone to request additional information. For each farm, maps were provided to indicate their location. A detailed profile was compiled and the knowledge dissemination route was described.

Although each province presents distinct geographical and climatic conditions, the common water usage is primarily for irrigation and secondary for fish farming. The WC has a Mediterranean climate with warm dry summers and wet cold winters. Most WC fish farmers are in the Strand/Somerset West, Stellenbosch/Paarl and Worcester/Ceres areas. The fish farms in KZN are mainly situated in the Midlands in the Maluti/Drakensberg area. The Maluti/Drakensberg area has a subtropical climate with summer rainfall. Limpopo has moderate winters and summers, but is generally a drier region with a prevalent water scarcity. The province is mostly reliant on underground water sources. The fish farms in Limpopo are scattered across five districts in the province.

The WC fish farmers mainly farm with rainbow trout. The farming systems include floating cages on farm dams, earthen ponds and gravitational-fed raceways. The fish

species predominantly farmed with in KZN are rainbow trout and Mozambique tilapia. In Limpopo, Mozambique tilapia and African catfish are mostly used. In the WC and KZN intensive operations are predominantly used, whilst in Limpopo fish are mostly farmed semi-intensively. In all instances fish are fed artificial diets with varying protein inclusion levels. Produce from the farms are sold through farm-gate sales as well as the retail, catering and hospitality sectors.

Results and conclusions on:

1. Investigating what information is available to farmers as local and captive knowledge

The **first objective** of fish farmer profiling included information on farmer demographics, and the availability of local and captive knowledge. In the WC, farmers are generally more organised with organisational support from a farmers' organisation and regular intervention from the public sector. The KZN farmers are largely functioning independently and leverage support from prominent electronic media and one-on-one consultation with prominent aquaculture experts in the industry. A large number of KZN fish farmers are set in their ways and not very susceptible to outside views and perspectives. However, once they realise that the cost-benefit is positive and that it has the potential to improve turnovers and profits, farmers exhibited keen interest. The farmers in north-eastern Limpopo were mostly isolated and indicated a desperate need for assistance with training and intervention to improve and expand their ventures. Emerging farmers were the ones marginalised. Limpopo indicated a lack of support, especially once the farm is operational. The challenge with the local knowledge systems is not the abundance of resources, but more the comprehension and application thereof to improve operations. Although there is a myriad of information available on the internet, farmers are still sceptical about it and, in most instances, overwhelmed by the different way of doing things. In these cases, it was found that farmers opted for practices and systems which were demonstrated to them and shown to work. Although the efficiency level was not clear, farmers would rather follow the latter as they would be assured that the system will function. Generally, fish farmers also expressed that the mere interaction with the project provided information on different aspects which they did not have before. Hence, the project has improved their knowledge base.

A re-thinking on research output is required to facilitate a process of successful dissemination and adoption. This strategy coupled with demonstration stations and complying farmers will enhance knowledge exchange and use. Farmers should lead the way in setting the agenda for knowledge creation as well as successful exchange and implementation. The discussions with the farmers have provided greater insight into what is deemed to be important to achieve improved management of South African water resources. It can be encapsulated as "talk to fish farmers first to provide fish farmer perspective on issues"

2. Evaluating the sources and accessibility of information

The **second objective** of the project included the evaluation of sources and the accessibility of this information. It covered many related aspects which were considered during the investigation. Fish farmers are using a range of technology modes to access information that are relevant for their operations and do not use modes that are

considered not to add value. The technology exchange techniques selected and implemented by the project provided valuable insight to the efficacy of such modes. This is the first step towards improving delivery and dissemination of much needed information at farm level. However, the application should be seen in context with the constraints to technology exchange as experienced by the fish farmers. These include a range of factors, *inter alia*, those associated with lack of access to information and communication technologies (ICT) to that of comprehending basic practices and principles pertaining the importance of regular monitoring and evaluating the water quality on the farm. Furthermore, it also included other tasks such as conducting frequent sub-sampling of the fish populations to calculate the feed conversion ratios (FCR's). Fish farmers are also encouraged to feed fish appropriate diets to minimise wastage that can lead to water quality deterioration. However, fish farmers do not always realise the extent of the consequences of their actions and how it can compromise the long-term sustainability of their fish farming operations.

During the engagement with fish farmers, most of them raised specific concerns and problems they experience on the farm, such as low dissolved oxygen levels, sick fish, and the prevalence of predators. Although these problems were *ad hoc,* farmers usually want a rapid response in terms of receiving the relevant information and advice for them to act swiftly. They also realise that they are dealing with live animals, which require immediate attention, and need to act to minimise losses. Therefore, irrespective of which technology exchange source is available or in use, fish farmers are calling for information on appropriate management to the current situation. The general input received is that the farmers would like to work with the authorities to improve communication.

There is a lot of information available pertaining to technology exchange techniques, as well as a multitude of others to be considered such as, formal qualifications at different educational levels, cellular phone-based short messaging services, demonstration stations, seasoned fish farmers in the area, and different forms of social media. Fish farmers are already at a loss trying to navigate through mass literature on aquaculture. Therefore, the demand and needs to receive and interpret takes priority over continued supply of information. Fish farmers expressed several times that they require information from reliable and trusted sources. Farmers tend to value the information provided by older or seasoned farmers more than the information available on the internet. This farmer-to-farmer exchange is still greatly valued by farmers. They appreciate "old hands" that have been active for many years and revised the ways and means of dealing with problems through workable solutions at local level.

The internet is certainly the dominant technology mode used in the WC and KZN provinces but less than one third of fish farmers in Limpopo had access to or used it. A significant amount of information pertaining to aquaculture is available on South Africa's national departments' websites. However, only a few of the fish farmers were aware of the information or have accessed it.

Farmer-to-farmer interaction continues to be a critical information source in the WC and KZN and to a lesser extent in the Limpopo province. A growing reality, that may become

a future constraint to farmer-to-farmer exchange as identified in the WC, is the intellectual property rights which prohibits certain farmers from sharing information and may require creative private public sector collaboration on non-competitive areas of value for the sector.

Fish farmers continue to hold learning organisations in high regard albeit with criticism of not focussing on practical hands-on teaching. It was suggested that hands-on teaching methods could incorporate relevant case studies presented to the participants. Given this experience and particularly the volatile situation in the Limpopo province, regarding poor relations between farmers and government extension officers, learning organisations such as Stellenbosch University may potentially have a critical role to play in facilitating and be a leading agent as a higher learning organisation and thus a technology mode to provide knowledge.

A key learning from this study is the lack of regular visibility of government extension officers providing information or extension at farm level in all three provinces. In some instances, as in the Limpopo province it has created animosity between fish farmers and extension officers with no apparent solution in the short term. However, it does present an opportunity to focus on technology modes that farmers currently value, while learning organisations are also granted the chance to play a role in capacity building if this technology mode is found to continue in the future. In the Limpopo province, there is an urgent need for technology exchange skills. The most cost-effective short-term way to achieve this may be through the placement of post-graduate interns with farmers, the training of farmers in terms of financial management and market requirements, as well as support to encourage more contact sessions between farmers. Given that most fish farmers have internet access it might be of value to consider the option of exploring a voice or Short Message Service (SMS) as a technology mode.

The interaction with fish farmers has highlighted the need to work with farmers to understand their needs at farm level. Also, the interaction must be led by organisations and or individual (s) that farmers trust and recognise as having relevant skills and experience. Given the small numbers of farmers in the three provinces, solutions need to be tailor-made for specific needs and they should also be cost-effective. The four key technology modes, recommended to assess in more detail, is the Stellenbosch University website platform for alumni of short course graduates, the postgraduate student blog initiated by the University of KwaZulu-Natal for aquaculture, a student placed as intern in-field and lastly a workshop with small-scale farmers.

3. Determining the level of interpretation associated with farming dynamics and context

The **third objective** of the project was to determine the level of interpretation that is associated with farming dynamics and context. Herewith the constraints to technology exchange, as experienced by the fish farmers, include a range of factors from those associated with lack of ICT (i.e. access to internet) to that of understanding the importance of regular monitoring and evaluation of the water quality on the farm to ensure the long-term sustainability of their fish farming operations. Most of the farmers have trouble managing predation. Predators such as fish eagles, cormorants, frogs and

otters hunt fish, resulting in great losses and damages to the systems. The farmers requested information sessions on the appropriate management and prevention of predation as some of these species are either threatened or protected by law. Generally, the fish farmers would like to work with the authorities and refrain from destroying or bewildering the predators indiscriminately. However, predation leads to great financial losses when fish are captured or wounded during hunts.

There is a considerable amount of information available, but fish farmers find it difficult to make sense of it. They are unsure whether it is outdated or relevant to their production systems. The farmers also struggle to distinguish if the information is reliable and whether the sources can be trusted. Farmers tend to value the information provided by experienced fish farmers more than that which is available on the internet. They believe that farmers who have been active for many years have encountered problems and managed to find workable solutions for it. A large portion of the fish farmers did not conduct any water quality tests as they assumed that the water which is provided by springs and streams are of good quality. In fact, farmers were dependent on the Department of Water Affairs to perform regular water testing in the area. Furthermore, in some cases, farmers were monitoring the basic water parameters such as dissolved oxygen and temperature on the farm, whilst other did not even bother to monitor these basic ones. The farmers rather indicated that they observed the fish regularly and could tell when something was wrong. They would also apply reactive treatment such as salt dosing as a standard procedure to treat ill-appearing fish.

All the fish farmers requested market intelligence to expand their operations. They were not informed about potential markets, product development and trading incentives as provided by the government, i.e. Department of Trade and Industry. The farmers conduct a large portion of market exploration and development by themselves. However, they iterated that such initiatives could be far-reaching if the applied expertise and experiences were improved. In addition, farmers also indicated that there is a lack of development finance and sponsorship, as well as limited access to loans from commercial banks. Furthermore, no real investment is ploughed into the sector. The farmers indicated that it was difficult for them to maintain good feeding practices as they were unable to find suppliers or stores selling fish feed. This is considered as one of the reasons for underperforming or unsuccessful projects.

In Limpopo, fish farmers felt that they were unable to apply the knowledge that they obtained at workshops irrespective of what they were made to believe during their training sessions. Consequently, this leads to insecurity in the management of their fish farming operations, and is further exacerbated by the minimum support from extension officers. In many instances, fish farmers were given starter packs and had to sort operations on their own. Therefore, they were unable to tell whether they were doing things correctly or determine how well the fish were performing in the production system. Other mentioned aspects which constraint their aquaculture developments include a lack of specialised equipment, theft and disease outbreaks. The farmers requested an independent body or person to conduct regular water testing and disease monitoring on their farms. In effect, they realised the value of early detection for the prevention of mass mortalities.

Fish farmers also felt that the sustainability of the operations are threatened by climate change, the unpredictability in water supply from streams and boreholes, strong winds that can destroy the cage culture infrastructure as well as the occurrence of algae blooms which affects product quality and dissolved oxygen concentrations in the water column. Farmers with cold freshwater fish species were very concerned about the onset of warm water temperatures earlier in the season. This would shorten their production timeframe and increase the risks associated with farming into the warm water period. Farmers would appreciate some sort of prediction charting to consult and anticipate inclement weather patterns.

4. Evaluating the impact of applied exchange technology

The **fourth objective** of the project was to determine the level of interpretation that is associated with farming dynamics and context. Most small-scale fish farmers in the Limpopo have limited access to reliable information regarding the use of improved technology and farming methods. None of the farmers were informed about the importance of monitoring the water quality in their ponds. They also did not know how to determine it or owned any equipment to test their water. It can be argued that the sampling equipment is expensive. Yet, it is expected that at least fish farmers need to take responsibility for the basic understanding of the important practices and principles. However, the situation is much more complicated and is influenced by various external factors, thereby rendering it difficult to access these fundamentals. These fish farmers are subsistence-based operators who earn a meagre or no income at all from their fish. Therefore, they are unable to turn their fish farming into profitable businesses due to a lack of funds, infrastructure, training, mentorship and other required inputs. In general, it is also evident that fish farmers have received no continued and meaningful support from local government officials to monitor and evaluate their progress for the farming of fish. Although a few of the farmers have received cursory visits in the past, others have never been contacted by any officials. The motivation for fish farming is low and the future thereof remains bleak in the region. To date there is also no tangible evidence of a goal-directed plan from local or national government to drive this process.

However, the WC presents a much better picture of the current status and future expectations. There is a larger fish farming commercial base and most of the farmers are aware of the essential farming methods required to achieve success. Their technology requirements hinge on market intelligence to diversify products and procurements as well as source funding and investment to expand operations to meet critical economies of scale. The organisational support is also well structured and although there is a shortage in capacity at government organisations, there is a farmer support unit where emerging fish farmers can leverage information and assistance. The success of rainbow trout farming is also exacerbated by several larger commercial farms, thus providing critical production volumes to maintain market delivery. The aquaculture strategic development plan is also comprehendible through a functional producer association. The association acts as a forum where issues can be discussed pertaining to emerging farmer development as well as research requirements. The provincial government has also attained funding models. Thus, start-up projects have a greater chance of successful

procuring capital provided that their business plans are in order. However, these type of funding models are absent or not delivering in the other two provinces.

KZN is struggling with farmer-official dynamics as there is a high level of mistrust on what the government promotes as unlocking the potential of aquaculture. Many fish farmers are disillusioned about the lack of support and opportunities to implement projects. It presents a stale mate as government officials blame the limited delivery on lack of human resources, technical skills, the organisational plan and basic funding. Furthermore, fish farmers are viewing it as incompetency and the failure to list aquaculture as a priority sector for socio-economic development in the province.

The technology development agenda is clear and it is believed that action can be driven once "all the links in the chain are achieved". However, the associated bureaucratic process to realise this goal, is hampering the evident plight of the fish farmers as well as the ambition of potential ones. Although everyone realise that it is by mandate the role of government to drive the policy for enhanced delivery, fish farmers on the ground are eager to receive or access information from any other source or organisation. Unfortunately, it is a vicious circle where everyone is refraining from accountability. Numerous other African countries are moving ahead with swift deliveries on aquaculture developments. For example, Uganda is exploring several novel technology exchange modes in using mobile phones, while Nigeria is implementing social media, radio and television (TV) advertising to achieve a wider outreach. Kenya has an aquaculture stimulus programme and has launched a campaign on "eat fish today for a healthy living" to promote aquaculture research and development. The success of various other African countries is imbedded in excellent strategic plans backed by government policy and timeous execution. In contrast, South Africa fails to deliver action plans, amidst excellent infrastructure and organisations. Therefore, it is of great importance to galvanise and consolidate the efforts made through the project.

5. Creating a new set of instruction and learning material for academic and development practitioners

The **fifth objective** of the project included areas to create a new set of instructions and learning material for academics and development practitioners. The organisational arrangement to support fish farmers *viz*, extension services, remains the first port of call. However, there is a disjunction as to the responsibility for technology exchange. Government is expected to deliver this service according to the legislative framework for aquaculture research and development. Fish farmers believe that the aquaculture sector is unduly bureaucratic and "over-regulated", thus not creating an enabling the environment for the sector to grow. They express a need to communicate regularly with government officials to receive the latest policy development supporting growth and hold officials accountable for delivery or lack thereof. Furthermore, fish farmers not only highlighted the lack of communication from the government, but also pointed out the alarming absence of communication between different governmental departments. In addition, academics generally believe that they are not obligated to facilitate technology exchange. Academic organisations are there to generate information and provide or package it in formats conducive for availability and dissemination.

Workshops, as modes of knowledge exchange, were not always successfully applied. Some fish farmers felt that they were unable to apply the knowledge that they obtained at workshops irrespective of what they were made to believe during their training sessions, or they found it was mostly impractical at farm level. Thus, the exchange mode cannot be regarded as insufficient, but rather the type of information which was presented at this forum. This could lead to workshops being dispelled as ineffective if the facilitation thereof is not well-prepared and fail to articulate appropriate information. Hence, it is crucial that once-off workshops are followed up with a mentorship programme or "after service support" to provide a continuum of theory in practice backed by knowledgeable intervention when required.

A component of the knowledge exchange project is to sensitise the fish farmers regarding sustainability and their important role in achieving it. Surprisingly, farmers expressed a good understanding of sustainability, as defined by their own interpretation, and exclaimed that their fish farming operations are threatened by fluctuating temperatures due to climate change, the unpredictability in water supply from streams and boreholes, strong winds destroying cage culture infrastructure and the occurrence of algae blooms affecting product quality and dissolved oxygen concentrations in the water column. Fish farmers with cold freshwater species were very concerned about the onset of warm water temperatures earlier in the season which could shorten their production cycle and increase the risks associated with farming into the warm water period. Fish farmers are farming for the long run and generally appreciate any efforts which are made towards achieving that goal.

The above-mentioned instructions and learning materials were proposed based on almost three years of working with fish farmers in the respective provinces. The farmers were brought in from the onset of the project as the Project Team realised early that knowledge exchange can only be accomplished when there is full participation. The farmers are regularly briefed and kept up to date about progress and developments. Resultantly, they are incentivised to be part of identifying appropriate knowledge exchange modes and techniques as well as relevant information to be disseminated and suggesting solutions for fish farming problems. The focus remains on how farmers can access and use available information on water resource management.

Research questions which were structured around the study, and answered.

a. What information is available to aquaculture and agriculture and how is it disseminated?

Information is available from various sources including popular and scientific publications, public sector technical reports, producer association, local and international experts and from generic aquaculture or agriculture keyword-search (via search engines) on the internet. However, the dissemination processes are not reaching target groups due to the fish farmer's lack of knowledge of where and what is available. Furthermore, numerous fish farmers do not have connection to the internet, rendering the wealth of internet knowledge inaccessible.

b. *What media/modes are used by the fish farmers and alike to access information?*

A great number of fish farmers across the three provinces (i.e. WC, KZN and Limpopo) use the internet as their main source of information. Fish farmers are also very reliant

on farmer-to-farmer knowledge exchange, especially when addressing problem scenarios which have been encountered by other fish farmers. The extension services rendered by government farmer support programmes are less entrusted as it is believed that the extension officer does not have the required knowledge to assist. In another scenario where trust has been lost in possible assistance, rendered by extension officers, is due to lack of regular farm visits and interactions with the emerging and operational fish farmers. Other sources such as multi-media (television and radio, cellular phone SMS) and social media (Facebook, Twitter, WhatsApp) are yet to be explored for mass-media broadcasting and for reaching farmers in remote areas.

c. In what ways are accessed information utilised?

Accessed information are usually utilised to address challenges and problems at farm level. Emerging fish farmers, especially in Limpopo, are using any relevant information to get their operations off the ground and include basic information in the value chain such as site selection, pond construction, feed and disease management and marketing off-sets. Fish farmers in the WC would otherwise use information to improve their economies of scale, investigate value-adding options and improve management efficiencies. The different status of farmers greatly influences their knowledge application.

d. What are the constraints to information routes at farmer/producer level?

The main constraint is lack of providing appropriate knowledge. Fish farmers measure provision of knowledge as to the cost-benefit of acquiring it and the value proposition it presents. A large number of people attended information session at workshop and farmers' days, but were not satisfied with the potential practical application. A considerable amount of the existing publications are too complicated and provided problems with comprehension. Fish farmers also felt that information should be available in local languages as their literacy levels were not on par with what was expected. Extension services, or the lack thereof, were also singled out as a major constraint to aquaculture development and a strong call was presented to improve communication and interaction.

e. What thinking/rationale processes drives information priorities?

The general driving forces to acquire knowledge on aquaculture in the WC are to improve farming systems and diversify operations. KZN felt that their operations were environmentally sound as they are farming in a region with high water quality. However, they welcomed information on value-adding and the improvement of market shares. Aquaculture has been proven to provide real benefits to rural and peri-urban communities. The co-existence of integrated aquaculture-agriculture will only prosper when both primary and secondary users of irrigation dams apply practices to sustain high water quality.

f. How many successful farming practices is based on existing and new knowledge?

All the fish farming practices are based on existing knowledge either provided by seasoned farmers in the area or through extension officers initially. A large amount of experience is still gained from trial-and-error strategies. Farmers are slow in adopting new knowledge, especially where specialised equipment needs to be purchased.

However, most fish farmers in the project were positive about any kind of intervention as they felt better off and more informed after such visits. They welcomed the interest shown and encouraged regular interaction.

g. What are implicit transactions costs associated with information dissemination?

The implicit transaction cost of knowledge acquisition was evident among all the fish farmers. Management of fish farming operation were always voicing what would the associated costs be such as to attend workshops, implement water quality monitoring and the training for workers. Numerous farmers felt that knowledge exchange should be led by the public sector that is at the forefront of decision-making and policy formulation.

h. What benchmark is being set by smaller and larger successful farmers?

Small-scale aquaculture is limited through the use technology and the physical environmental such as available freshwater resources and land tenures. Thus, the benchmark is set to what economy of scale is required to farm successfully within the local confinement. Furthermore, they are characterised by lower yield and market share. Large-scale fish farmers are continuously exploring ways of improving their efficiencies and setting benchmarks through low feed conversion ratios (FCR's) and higher profits.

i. How do South African farmers rate/compare i.e. to European and American producers?

The quality of local production can compete at the same level as their overseas counterparts. However, the South African water resource management requires improvement given that their accountability is considerably lower. Overseas, farmers are subjected to stringent compliance and audits whereas South African policing is poor relating to the compliance of environmental regulations by local fish farmers. Furthermore, overseas farmers are linked to markets through certifications programmes which provide a self-regulatory environment and the potential to grow their market share.

j. How are South African fish farmers managing the influx of information related to production and marketing?

Although knowledge is power, fish farmers would generally source relevant information to specific farming requirements or scenarios. The irony amidst all the available information is expressed by the farmers saying that "they did not know it exists!".

<u>Recommendations and future studies</u>

The study concluded that knowledge exchange as encountered in WC, KZN and Limpopo is motivated and driven by several factors involving service delivery through government extension services, accessibility and affordability of ICT (specifically in rural Limpopo) and eventually the cost-benefit of using available information or purchasing specialised equipment to incorporate technical knowledge. Although the scope of the study was limited to WC, KZN and Limpopo, keen interest was expressed by fish farmers in Mpumalanga and the Eastern Cape provinces to participate in similar studies. Hence,

future work could engage these farmers to provide a more comprehensive overview of South Africa's footprint in freshwater aquaculture. Therefore, the improvement of water resource management in agriculture-aquaculture farming systems is enhanced. It is recommended to focus on:

- The promotion of platforms which provide information for improved water resource management. This can be achieved by optimising the website and extension services to facilitate effective knowledge exchange.
- Monitoring and evaluation of the operational procedures at different farming levels by accounting the continuum of external factors affecting the use-and-loss of aquaculture principles and practices. This can be achieved by qualifying the usage and presenting guidelines to maintain and improve its usage.
- The policy environment surrounding fish farmer support and assistance needs to be understood by fish farmers. This can be achieved through the incorporation of regular focus group discussions and smaller group workshops to improve communication and accountability to the farmers.

This project was the last in the series of studies with the aim of investigating the interaction of floating net cage fish farming and irrigation farm dams. It is proposed to consolidate the outputs and further the impact of existing sources for advancements at the fish farmer level. Other suggestions related to the study were highlighted and included to monitor the distribution of manuals in all three formats: ask readers to provide feedback**;** update contact details in manuals in print or electronic format; provide reference to resources for more advanced level to cater for the diverse range of farmers; provide web links to manuals to download on learning organisation and farmer association websites; the products developed are made available in the home language of fish farmers with improved ease of read and the use may be improved by including more graphics and photographs. Opportunities for future research or technology exchange, identified with farmers in Limpopo, can be achieved by placing dedicated postgraduate interns (from Stellenbosch University) with selected farmers, provide information, investigate the technology demonstration centre (either on farm or to create one at one of the government owned facilities) and lastly to test SMS or voice message services (given the lack of internet facilities) which is focused on feed and market information (including finance).

Opportunities for future research or technology exchange identified with farmers in WC are: public private sector collaboration on feed research; structured mentoring programmes for farmers and postgraduate students; international and local (with other provinces) learning exchanges. Opportunities of interest are:

- Functional dedicated website on integrated agriculture-aquaculture farming systems listing all WRC related publications.
- Improve existing publications which were identified to be complicated or less comprehendible due to the language it was written in.
- Link fish farmers to other structures such as producer associations, academia and research organisations to improve the efficiency of local facilities.

However, expectancy cannot be placed solely on fish farmers to be innovative in exploring the possibilities and opportunities, irrespective whether they are

entrepreneurial-driven or labour-orientated. The challenge is to adopt the technology development agenda and combine it with the future expectations of fish farmers to provide the full package which is needed to prosper. The added value of such an initiative could provide the required fact-based agenda for fish farmers to elevate the status of their operations and grow the aquaculture sector in South Africa.

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Dr GR Backeberg	Water Research Commission (Chairperson)
Mr HM du Plessis	Independent advisor
Mr PJ Botes	Department of Water Affairs and Sanitation
Prof K Dzama	Stellenbosch University
Mr F Endemann	Department of Agriculture: Western Cape
Mr T Sefike	Department of Agriculture: Western Cape
Mr D Horstman	Department of Agriculture, Forestry and Fisheries
Mr J Theron	University of Limpopo
Dr CLW Jones	Rhodes University
Dr JP Nell	ARC–Institute for Soil, Climate and Water

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LIST OF SYMBOLS, ACRONYMS AND ABBREVIATIONS

AASA – Aquaculture Association of Southern Africa

AVI – Avi-Products Pty Ltd

CD – Compact Disc

CITES – Convention on International Trade in Endangered Species of Wild Fauna and Flora

CPPP – Community Public Private Partnership

DAFF – Department of Agriculture Forestry and Fisheries

DVD – Digital Versatile Disc

FAO – Food and Agriculture Organisation of the United Nations

FCR – Feed Conversion Ratio

FFS – Farmer Field Schools

HTML - Hypertext Mark-up Language

ICT – Information and Communication Technologies

KZN – KwaZulu-Natal

LDEAT – Limpopo Department of Environment and Tourism

SADC – Southern Africa Development Community

SARNISSA - Sustainable Aquaculture Research Networks in Sub Saharan Africa

SASSI – South African Sustainable Seafood Initiative

SSA – Small-scale Aquaculture

SU – Stellenbosch University

TSS – Three Streams Smokehouse

TST – Three Streams Trout

WC – Western Cape

WCTA – Western Cape Trout Association

WFC – WorldFish Center

CHAPTER 1: Introduction

1.1 Background and rationale

Over the past four years the Project Team has been investigating and gathering information on aquaculture-agriculture systems which are associated with farm/irrigation dams. The project builds on documents and academic publications that were produced during this time (Du Plessis, 2007; Maleri *et al*., 2008, Salie *et al*., 2008; Lansdell, 2010; Maleri, 2011). Research methods included the conducting of workshops and related information sessions, however, limited attention was paid to the adoption of this information and its implementation. Thus, the project focused on the process of technology exchange to improve existing principles and practices. It also aimed to create a better opportunity for sustainability for both aquaculture and agriculture. The study included small- and large-scale producers, keeping in mind that large-scale producers in South Africa are considered small-scale in relation to other international countries such as Chile, Denmark, Norway and Scotland. The concept of small-scale fish farming followed the definition presented by Edwards (2013) at the FAO's Fisheries and Aquaculture meeting held in Rome in 2013.

The outputs being considered include: the quality of information that is available locally as well as internationally; the level of accessibility, affordability and adoption levels; the different types of media or methods used to disseminate and access necessary information; what constraints farmers experience when gathering information; the farmer's ability to interpret and understand gathered information; the level of success of farming associated with the attained knowledge; benchmarking the success levels; and finally, considering the cost-benefit and transaction cost to farmers.

The expected impacts of this project are: to get knowledgeable farmers on par with local and international developments; to improve accessibility to information systems for farmers; to promote the useful application of information and basic understanding thereof; to improve communication between academia, farmers and media; to create formalised research agendas based on sector requirements; and to construct an appropriate policy and strategy which can be structured as management guidelines. The primary aims of this project were: to investigate the type of information available to farmers as local and captive knowledge; to evaluate the sources and accessibility of this information; to determine the level of interpretation that is associated with farming dynamics and context; to evaluate the impact of the applied exchanged technology; and also, to create a new set of instructions and learning material for academics and development practitioners.

The involvement of the WRC has provided the organisational and financial support to the programme and enabled the Project Team to complement the Department's (Aquaculture) work on water resource management. The study is crucial for the promotion of the aquacultural industry, but more so, to promote sustainable multi-purpose utilisation of water resources. The research can present best management guidelines to ensure that water resources are utilised and managed to stringent regulations for both aquaculture and agriculture. Ultimately, a holistic structure should

be presented to the promotion and regulatory authorities addressing a large portion of the concerns and challenges through empirical and descriptive research and investigations. This knowledge exchange project is the third initiative towards reaching the goal of sustainable water resource management by the aquaculture sector in South Africa.

1.2 Project scope and extent

The research scope covers fish farming operations in three provinces, *inter alia*, Western Cape (WC), KwaZulu-Natal (KZN) and Limpopo. The goal was to have in-depth discussions with fish farmers to gain an insight into the dynamics surrounding knowledge access, exchange and adoption thereof. The common criteria considered for selecting participants were: fish farmers with farms where the operation sites and the water sources are used for agricultural irrigation and aquaculture (i.e. fish farming) practices. The current practices and principles were investigated and evaluated to improve the overall management of water.

A total of 38 farms were visited in WC (9), Limpopo (20) and KZN (9) for the duration of the project. Standard questionnaires (Appendices 1-4) and person-to-person visits were used to collate information. Farmers were also contacted via email and phone to request additional information. For each farm maps were provided indicating their location as well as picturing the lay-out of their farms. A detailed profile was compiled and the knowledge dissemination route was described.

Although each province presents distinct geographical and climatic conditions, the common water usage is primarily for fish farming and secondary for irrigation. The fish farms in KZN are mainly situated in the Midlands within the Maluti/Drakensberg area. The area has a subtropical climate with summer rainfall. Limpopo has moderate winters and summers, but is generally a drier region with a prevalent water scarcity. The province is reliant on underground water sources. The fish farms are scattered across five districts. The WC has a Mediterranean climate with warm dry summers and wet cold winters. A large quantity of fish farmers are in the Strand/Somerset West, Stellenbosch/Paarl and Worcester/Ceres areas. A Köppen Classification was also completed for each study area.

The fish species mainly farmed in KZN is rainbow trout and in Limpopo, Mozambique tilapia. The WC also farms with rainbow trout. The farming systems included floating cages on farm dams, earthen ponds and gravitational-fed raceways. Fish are mostly farmed semi-intensively in Limpopo, whereas intensive operations are followed in WC and KZN. In all instances fish are fed artificial diets with varying protein inclusion levels. Produce from the farms are sold through farm-gate sales as well as the retail, catering and hospitality sectors.

Location of sites

The fish farmers were in three provinces, across 10 regions. The regions were as follow: WC (Boland, Overberg, Cape Winelands and Koue Bokkeveld), KZN (Underberg Drakensberg and Midlands) and Limpopo (Vhembe, Capricorn, Mopani, Sekhukhune and Waterberg).

Suitability of sites

Desktop studies were conducted to locate sites and farmers were contacted to appraise the suitability of the proposed projects for the investigation. The owners of the qualifying projects were consulted for cooperation. The Project Team decided to visit all the complying sites in the different provinces. This enabled the Project Team to identify trends and describe processes prevalent in a bigger sample of projects. Information was also obtained from fish farming operations which did not comply, but provided valuable input regarding their approach to knowledge.

1.3 Project Team composition

The Project Team consisted of the following individuals:

Leading organization:	Department of Animal Sciences, Stellenbosch University
Project leader:	Dr Khalid Salie
Key advisor:	Prof Kennedy Dzama
Co-workers:	Ms Samantha Joao, Ms Nanje Olivier, Mr Kobus Groenewald, Ms Wendy Engel, Mr Ashley Patience, Mr Robert Andrews and Ms Anneleen Swanepoel
Administrator:	Ms Samantha Joao
Financial management:	Stellenbosch University

Salaried staff on the WRC budget included: Ms Samantha Joao, Ms Nanje Olivier and Ms Anneleen Swanepoel (research assistants). Bursary holders included Mr Ashley Patience and Mr Sipho Mafuyeka.

1.4 Collaborating organisations

- Department of Agriculture (WC): Mr Ferdie Endemann and Mr Thabo Sefike
- Auburn University: Prof Claude Boyd
- Ghent University: Ms Laurien de Hovre and Ms Nathalie Willemot
- Stellenbosch University: Dr Shayne Jacobs, Mrs Anneline Molotsi, Prof Kennedy Dzama and Ms Emma Vink
- Stellenbosch University Water Institute: Ms Engela Duvenage
- St Andrews University & SU: Prof Krishen Rana
- University of the Western Cape: Prof Mafa Hara
- Agriculture Economist Consultant: Ms Wendy Engel
- Website Engineer: Mr Kobus Groenewald

1.5 Structure of the report

The overall objective of this report is to present the main outcomes and expected impact produced by the Water Resource task team during this Project. The report is structured into chapters. **Chapter 1** includes the general introduction explaining the background and rationale for the study, and **Chapter 2** provides a literature overview. **Chapter 3** deals with the prevailing local knowledge of the fish farmers in the respective provinces, thus providing baseline profiles including the skills and knowledge base. **Chapter 4** presents issues pertaining technology profiles including constraints, techniques, as well as adoption and implementation. **Chapter 5** reports on the knowledge dissemination and finally the technology development agenda as articulated by the respondents. The

report culminates in **Chapter 6** where an overall summary is provided and recommendations and future studies are proposed.

CHAPTER 2: Literature review

2.1 Introduction

In this literature review, an evaluation is presented on local and international work executed on knowledge exchange to farmers. By analysing several publications, five important aspects on knowledge exchange were identified. Firstly, related (international) research is presented. Secondly, the importance of knowledge exchange in aquaculture and thirdly the information sources, used by farmers, are described. Fourthly, the study presents some constraints to knowledge exchange, such as accessibility and unreliability of the information. The fifth aspect concerns a discussion on the relationship between knowledge exchange and the demographic characteristics of farmers. The review concludes with several recommendations for future research.

2.2 Knowledge transfer and exchange in aquaculture

Knowledge and information are indispensable ingredients for sustaining and improving an agricultural enterprise. These elements are vital for increasing production and improving marketing and distribution strategies (Oladele, 2006). For farmers, access to relevant and useful information is essential for increased productivity. They need information on technologies, construction and management, breeds and spawning, processing, storage and marketing and financing (Ofuoku *et al*., 2008). Although nowadays mass media and information technologies provide a wide range of information, constraints to the access of information is still a real experience for fish farmers (Oladele, 2006). Therefore, the degree to which projects are feasible, and whether it could be successfully implemented in South Africa and elsewhere on the continent, needs to be explored (Academy of Science, 2006). It is not only important to understand farmers' information needs, but also the information sources which are available and accessible to them. In addition, it should be examined which information channels they use and why. Only by obtaining these data, appropriate policies, programs, trainings and organizational innovations can be designed.

Definition of knowledge transfer

Argote and Ingram (2000) define knowledge transfer as "the process through which one unit (i.e. group, department, or division) is affected by the experience of another".

Definition of knowledge exchange

Knowledge exchange is a process which brings together academic staff, users of research and wider groups and communities to exchange ideas, evidence and expertise (Contandriopoulos *et al*., 2010; CAHSS, 2017). Knowledge exchange is a process that generates, shares and/or uses knowledge through various methods appropriate to the context, purpose, and participants involved. Knowledge exchange includes concepts such as sharing, generation, co-production, co-management, and brokerage of knowledge (Fazey *et al*., 2013).

Definition of agricultural information

Agricultural information, as suggested by Agbamu (2006), is defined as all published or unpublished knowledge in all aspects of agriculture. He classified agricultural information into four categories namely, technical-, commercial-, socio-cultural- and legal information. Fish farming information can be considered as all published or unpublished knowledge in all aspects in the life cycle of fish production (Agbamu, 2006).

2.3 Methodology

The study serves as a foundation for continued update and evaluation. Through the analysis of numerous scientific research articles and explicit analysis dimensions, common facets were detected. The result of the analysis of the different research publications can be found in Table 2.1 and will be discussed in the next section (i.e. 2.4 Analysis and synthesis of the literature). Some of the publications do not concern aquaculture specifically, but the common focus on knowledge exchange has been identified in related sectors like agriculture. A few general publications on the topic were also consulted.

Additionally, another analysis was conducted on an important part of knowledge exchange namely, the information sources of the fish farmers. A variety of information sources are mentioned in many of the analysed literature. The frequency of usage and the effectiveness of the sources were questioned during these studies with farmers, fish farmers, goat farmers etc. The data are represented in a framework that can be found in Table 2.2.

Table 2.1. An analysis of the different research publications.

	Agriculture	Fish farmers	Small-scale/ holder farmers	Information sources	Knowledge exchange interventions	Framework for exchange	Innovation adaptation	Knowledge gap	Problems in knowledge exchange	Quality of information	Information accessibility	Information more comprehensible	Demographic characteristics	Relationship demogr. charact. & info source./util.	Knowledge/ adoption index	Preference for interpersonal/expert sources	Preference for radio	Preference for extension agents	Preference for other farmers	Questionnaire	Survey	Interview	Observation method
Agricultural Information Sources Used by Farmers in Imo State, Nigeria. (U. N. Opara, 2008)	x			x												x				x			
Information Utilisation among Rural Fish Farmers in Central Agricultural Zone of Delta State, Nigeria. (A.U. Ofuoku, G.N. Emah & B.E. Itedjere, 2008)		x		x						x	x		x	x								x	
Access to Agricultural Information by Fish Farmers in Niger Delta Region of Nigeria. (M. U. Ogboma, 2010)	x	x		x							x		x							x	x	x	x
Information Sources and Risk Attitudes of Large-Scale Farmers, Farm Managers, and Agricultural Bankers. (G. F. Patrick & S. Ullerich, 1996)	x			x												x					x		

Agricultural Knowledge and Information Systems in Kenya – Implications for Technology Dissemination and Development. (D. Rees *et al*., 2000)	x			x												x						x	
Farmers' Information Needs and Search Behaviours. (S.C. Babu *et a*l., 2012)	x			x							x		x	x		x					x		
Sources of Farm Information among Nigerian Cocoa Farmers. (E.D. Monu & M.M. Omole, 1982)	x			x									x	x			x	x	x		x		
A Study of Women Farmers' Agricultural Information Needs and Accessibility: A Case Study of Apa Local Government Area of Benue State, Nigeria. (O. J. Okwu & B. I. Umoru, 2009)	x			x							x		x	x					x	x			
Role of Mass Media in the Dissemination of Agricultural Technologies Among Farmers. (M. Irfan *et a*l., 2006)	x			x															x			x	
Role of Print Media in the Dissemination of Agricultural Information among Farmers (S. Farooq *et al*., 2007)	x			x															x			x	
A Cluster Randomised Controlled Trial to Compare the Effectiveness of Different Knowledge Exchange Interventions for Rural Working Equid Users in Ethiopia. (A.P. Stringer, E.C. Bell *et al*., 2011)					x									x									
A Framework for the Exchange of Animal Health Knowledge to Rural Goat Owners. (A.F. Vatta, J.F. de Villiers *et al*., 2011)			x			x																	
Developing Farmer Focus Groups as a Knowledge Exchange Mechanism: A Practical Experience. (K. Barribal, S. Byles *et a*l., 2005)					x																		
Knowledge and Information Exchange in Agriculture using Hypermedia: a System Review. (M.J. Carrascal, L.F. Pau & L. Reiner, 1995)	x				x						x	x									x		
Learning from Six Reasons Why Farmers Do Not Adopt Innovations Intended to Improve	x						x															x	

Sustainability of Upland Agriculture. (S. Fujisaka, 1993)																							
The Effects of Different Knowledge Dissemination Interventions on the Mastitis Knowledge of Tanzanian Small-scale Dairy Farmers. (C.E. Bell, N.P. French *et al*., 2005)			x	x	x															x			
Exchange of Farm Technology to Small Farmers: a Study of Organisational Problems in India. (N.K. Jaiswal & K.B. Srivastava, 1976)	x		x		x																		
Farmer-to-farmer Exchange of New Crop Varieties: An Empirical Analysis on Small Farms in Uganda. (W. Grisley, 1993)	x		x		x								x								x		
Understanding the Process of Knowledge Exchange to Achieve Successful Technological Innovation. (M. Gilbert & M. Cordey-Hayes, 1996)				x		x																	
Knowledge and Adoption Gap Among the Fish Farmers regarding Composite Fish Culture Technology. (S. Sasmal , H.K. Patra & J.D. Sarkar, 2006)		x	x					x							x							x	

Table 2.2. Frequency of usage and the effectiveness of the information sources.

	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**	**11.**	**12.**	**13.**	**14.**	**15.**	**16.**
Extension agents	X	X	X	X	X	X	X	X	X	X						
Mobile extension firm	X															
Age grades	X															
Contact farmers	X	X		X			X									X
Fellow farmers	X	X		X			X	X	X	X						
Radio	X		X	X		X	X	X	X	X	X					
Television	X		X	X		X	X	X	X	X						
Community leaders	X		X													
More experienced farmers	X	X		X		X	X									

Extension leaflets	X															
Bank	X			X	X											
Community/village meetings	X		X								X				X	
Friends and relatives	X				X	X		X	X	X						
Farm demonstrations and agricultural shows	X											X				
Farmers cooperatives	X	X			X	X										
NGOs		X	X		X					X						
Research institutes and universities		X		X		X										
Personal experience			X		X											
Workshop/seminar			X									X				
Ministry of Agriculture			X		X	X										
Magazines			X	X		X		X	X							
News publications			X	X		X	X	X	X	X						
Local government offices			X													
Internet			X	X												
Journals			X		X		X		X	X						
Libraries			X		X				X	X						
Posters			X		X				X	X						
Field days/conference				X												
Sales/supplier personnel				X	X		X									
Veterinarian				X	X											
Farmer training centres/trainings					X						X					
Handouts											X				X	
Farmer focus groups													X			
Hypermedia														X		
Video															X	

2.4 Analysis and synthesis of the literature review

After discussing and analysing the literature, a review was developed which examines knowledge exchange in aqua- and agricultural systems. This review will discuss several analysis dimensions that occur in the literature and are of importance for a better understanding of the subject. These dimensions have been carefully selected to give an overview of the current situation. The dimensions include: related research on knowledge, the importance of knowledge exchange, information sources, constraints to knowledge exchange and demographic characteristics. The dimensions are indicated in Fig 2.1.

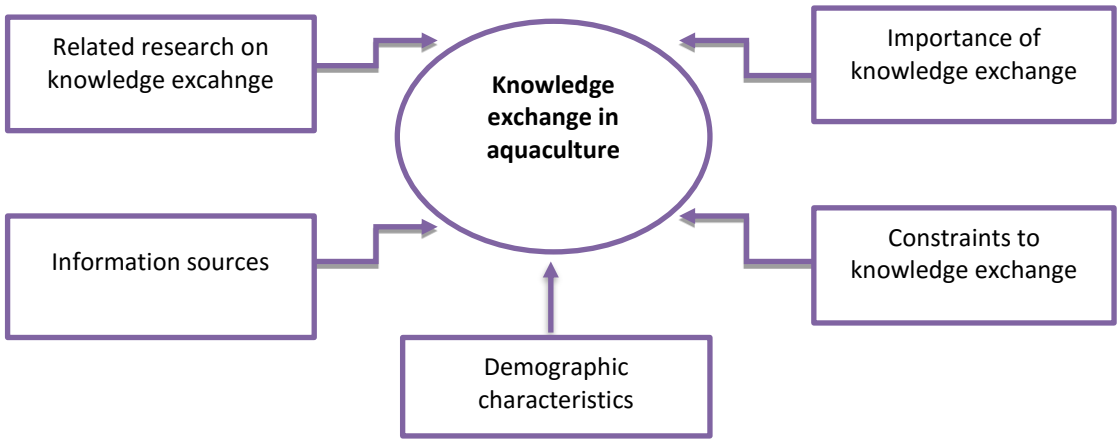

Fig. 2.1. Analysis dimensions for knowledge exchange.

Scientific research on knowledge exchange in aquaculture is limited. Internationally, there is only a few similar studies. For example, the research from Nigeria by Ofuoku *et al*. (2008). This research, specifically, concerns fish farmers. Research has also been done on knowledge exchange by other farmers e.g., cacao farmers, goat farmers and dairy farmers. The above-mentioned research in Nigeria indicated that the available knowledge and information on fish farming techniques were not adequately used by the fish farmers. These findings encouraged extension officers to adapt their approach for disseminating fish farming information to achieve better understanding and efficient utilisation by the fish farmers. Ofuoku *et al*. (2008) recommended that the extension agents should increase their efforts to teach the fish farmers how to use complex information. Literature from India (Felsing & Haylor, 1999) clearly describes the situation of the Indian fish farmers and their problematic access to knowledge and information about new fish farming techniques and technologies. Farmer information sources and associated needs have been analysed in Africa (Kaniki, 1991; Stefane *et al*., 2005; Aina, 2006), and several studies have examined the factors that influence farmer search strategies (Adolwa *et al*., 2010; Opara 2010; Okwu & Dauda, 2011). It is important to understand the information needs of the farmers, their search methodology as well as the different sources they depend on for accessing information in order to assist design effective extension programs and advising services in developing countries. Furthermore, it should also be understood what motivated farmers use certain abstracts of information.

2.5 The importance of knowledge exchange in aquaculture

All the analysed publications in this literature review state that knowledge exchange is essential within aquaculture. They confirm that knowledge and information are necessary for increased production and productivity. Oladele (2006) also mentions the importance of

knowledge exchange for improving marketing and distribution strategies. Knowledge acquisition is believed to be one of the four main components of instigation of actual behavioural change. This is in conjunction with skills development, attitudes development, and motivational support (Mitchell *et al*., 2001). For the management and operation of an agricultural enterprise, fish farmers requires access to adequate information. The implementation and utilisation of this information on fish farming technologies will translate into efficiency in fish production. Ofuoku *et al*. (2008) states that when the information is acquired and effectively utilised by the fish farmers, culture fish production will increase. This will translate into income, improved farmers' standard of living, improvement in rural and by extension, the nation's economy.

Information also opens windows of sharing experiences, best practices, sources of financial aids and new markets (Ogboma, 2010). According to Opara (2008), access to the right information at the right time in the right format and from the right source may shift the balance between success and failure of the farmer. This is because agriculture systems become more complex and farmers' access to reliable, timely and relevant information sources becomes more critical to their competitiveness. Diekmann *et al*. (2009) also noted that information must be relevant and meaningful to farmers, in addition to being packaged and delivered in their preferred way.

Research on the information sources and services used by farmers is important to identify the relevance of these sources and the farmers' preference for the different types of sources and services. Research on information sources and search behaviour can help technology developers and extension agents to decide how information on new farming technologies can be adequately exchange. Farooq *et al*. (2007) indicate that effective dissemination of the latest technology among the end users-farmers is indispensable for farmers to develop skills, acquire knowledge and attain good standards in respect of quality and productivity as per demand from the end users for internal consumption and for export. However, Swanson and Rajalahti (2010) reported that the provision and targeted delivery of agricultural information to small and marginal farmers remains a challenge in extension programs. Literature indicates that there are several constraints to knowledge exchange. These are discussed below:

2.6 Describing a range of information sources

A wide range of knowledge exchange methods are available for educating farmers. Some examples of these information sources are: radio, extension agents, television, workshops, demonstrations, news publications, hand-outs, personal contacts, internet, contact with other farmers and a myriad of other to be considered. Many organizations and actors are involved in developing and exchanging knowledge deemed to be required by farmers. Because of this wide range of sources, it is important to choose an appropriate medium with the best effects on knowledge acquisition. Ample research has been done to investigate the impact of some of these knowledge exchange methods. One research study compared the effectiveness of a village meeting, a radio program and hand-outs (Stringer *et al*., 2011). The study showed that direct contact with an extension agent is helpful for farmers, especially when it is combined with a demonstration and/or presentation as well as giving farmers the opportunity to ask questions (Stringer *et al*., 2011). These findings are confirmed by other studies. Although there are only a few female farmers, it is valuable to mention that male

farmers have more access to information through extension agents than female farmers (Matanmi, 1991; Osuman, 1997).

Group discussions, print media, television and radio are also mentioned as information sources by farmers. Television is very popular as a source for agricultural information. Interventions based on visual images were also successful information sources, especially to younger aged farmers. Mosher (1976) concluded that changes in the behaviour of farmers can be made through the reading of materials for knowledge exchange such as posters, pamphlets and newsletters. The sources of knowledge for small-scale famers are local (Rees *et al*., 2000). They prefer obtaining information by interpersonal contacts. Their information sources consist of interactions with neighbours, family, community based organisations, NGO's and extension agents. Information generated by research organisations and universities is not often used by farmers as an information source. Studies indicate that these organisations must put more effort to deliver information to farmers. With the advent of technology some new knowledge exchange methods are introduced, for example hypermedia. However, this method is only useful when farmers have portable computers with hypermedia applications.

Social capital is an important aspect in the context of the farmers' information search and acquisition and in the manner it is being used. A better understanding of the factors which influences social capital could be helpful to comprehend the information-seeking behaviour of farmers. An important factor to consider is the investment of farmers in developing relationships or individual characteristics.

By analysing different studies on information sources the conclusion is reached that the main sources which farmers prefer are personal contacts and interactions with other farmers and extension agents. Furthermore, television, radio and news publications are popular media as knowledge exchange methods. However, it should be kept in mind that none of these media is the best. Better medium depends on the socio-economic environment and the information that must be exchange to the farmers. Djojomartono & Pertini (1998) recommend to use a combination of channels and to use a range of methods (and not just one) to exchange knowledge. This is necessary as farmers indicated in previous studies that they use more than one source to meet their needs to gain knowledge. Information needs to be accessible, comprehensible, affordable and relevant to farmers. This aim can only be achieved with effective knowledge exchange methods.

Godtland *et al*. (2004) investigated the effectiveness of farmer field schools (FFS) in Peru as a potential effective approach to disseminate knowledge to farmers. This knowledge exchange method was used for the first time in Asia to diffuse knowledge about pest management to rice farmers. The importance about FFS is that the training program uses participatory methods. The goal is "to help farmers develop their analytical skills, critical thinking, and creativity and help them learn to make better decisions" (Kenmore, 2002). It also makes farmers able to adapt the technologies to their own needs (Vasquez-Caicedo *et al*., 2000). Interactive learning and field experimentation are central aspects of the FFS. The need for external support will be reduced because farmers are trained to teach courses and they must share their knowledge with colleagues. A few studies have been done on the impact of FFS on the knowledge of farmers. In general, they conclude that FFS participants have higher

scores on knowledge relative to non-participants in the program. However, the diffusion of knowledge to other farmers is still minimal.

By comparing FFS and a conventional exchange of technology agricultural extension program, FFS participants have higher scores on knowledge acquisition. Both programs indicate higher scores than non-participants. The study indicates that if control over land- and household assets is related to wealth, FFS is better for richer and younger farmers, compared to the conventional exchange of technology agricultural extension program. Another important conclusion is that the impact of FFS on knowledge increases by demographic factors such as land ownership, the number of family members and the value of household assets. However, knowledge decreases with the age of the household head. These findings are only valid for the FFS. Godtland *et al*. (2004) conclude that knowledge is not influenced by the level of education of the household head. The relationship between knowledge search, use and acquisition by farmers and demographic characteristics are described in section 2.8.

In a review by Felsing and Haylor (1999) several sources and media that are used by farmers for information dissemination are discussed. They recommend to use a variety of media as different media will be accessible to different target groups. They argue that to reach farmers, farmer-to-farmer extension is very effective. Some of these dissemination channels will be clarified and discussed below:

2.6.1 The researcher

Traditionally, the role of a formal researcher is to produce finished, non-adjustable recommendations to extension agents. The extension agents are then expected to be able to interpret and teach these recommendations to the farmers. To provide simple all-inclusive solutions and recommendations, research and extension organisations often centralise and standardise information. The capacity of researchers also needs to be improved in terms of communicating their research in ways that resonate best with their intended communities. This requires careful consideration of the local language and platforms to be used (Sitas *et al*., 2014).

2.6.2 The extension officer

The task of the extension agent is to demonstrate acceptable improvements and look for ways to make their adoption reach the farmers. The extent to which information is disseminated is often highly dependent on the efforts and dedication of the extension agents. The creation of a platform is imperative where industry and government can come together to solve issues in the sector and share valuable knowledge and know-how.

2.6.3 The fish farmer

In the development and research field the role of farmers is generally limited. They are viewed as passive recipients of packaged solutions and are expected to adopt new information and technologies developed by formal researchers. Felsing and Haylor (1999) suggest that for ensuring efficient dissemination of relevant information, extension should involve the collaboration of all organisations involved as well as the target farmers. Mostly the end-users will know best what is relevant to them, and therefore there is a strong argument for involving farmers in the production of extension materials. Byram and Garforth (1980) noted that this will also ensure that the produced material will be comprehensible for the target audience.

2.6.4 The knowledge 'toolbox"

As previously mentioned (see section 2.6 Describing a range of information sources), farmers draw on a wide range of information sources, ranging from friends and relatives, radio and television, to extension agents. Wealthier farmers are known to have more contact with extension agents than the poorer farmers (Norrish & Lawrence, 1997). The most resource-poor farmers (and women) are often illiterate and commonly use more pictorial materials such as posters or cartoons.

2.6.5 The farmer-to-farmer situation

Roling *et al*. (1998) have shown that people most frequently and effectively communicate with those who are most like themselves. That is the reason farmers often depend on other farmers and are more likely to obtain information from colleagues than from extension professionals (Deppert *et al.*, 1990). Such farmer-to-farmer knowledge exchange should be recommended and encouraged for reaching the highest number of farmers in an area, and towards understanding of advisories and appreciation of services in their specific fields (Zuma-Netshiukhwi *et al*., 2013).

2.7 Constraints to knowledge exchange

Oladele (2006) notes that constraints of access to information are still a real experience for many farmers. Most small-scale fish farmers in Africa have limited access to reliable information about improved farming methods (Matuha *et al*., 2016). Other studies also mention the problem of access to agricultural information of many farmers, although the advent of information technologies succeeded in eliminating bottlenecks in information dissemination. Agricultural research in India (Babu *et al*., 2012) has shown that the major constraints to information access are poor availability and unreliability of information. The Indian farmers also mentioned a lack of awareness of information sources available and that the available information was not timely. Information from universities and research stations was described as 'locked' and difficult to access. Follow-up and field visits were also lacking. Lack of credit and interest in agriculture reduced the incentive to search for information. The researchers of this study recommend that extension programs should tailor the delivery of agricultural information to the different information search behaviour of farmers.

Previous research from India (Felsing & Haylor, 1999) found that the accessibility of extension media differs between different target groups. Generally, farmers have access to radio and some have access to television and video, but most farmers have low literacy levels and limited knowledge of the technical language used in manuals. On the other hand, aquaculture extension agents can generally access television, video and radio, while some have access to computers and the internet. Likewise, the authors of this study recommend the tailoring of material to specific target audiences, the promotion of a range of flexible technology options or practices, and also, extensive farmer participation in the development of extension materials. In addition, Sammadar (2006) found that for marginal and small agricultural landholders, context-specific information could have a greater impact on the adoption of technologies and increase farm productivity. Although, it is more resource intensive to make information context-specific Garforth *et al*. (2003) emphasised the importance of the availability of information at farm level. They further explained that this information could vary spatially and temporally and with different degrees of specificity. Akinsola (2014) further

postulated that dynamic knowledge support platforms possess potential resources that may be applied to improve South Africans' emerging farmers' transformation into a sustainable market–oriented farming enterprise. However, Grisley (1994) stated that, in developing countries, formal markets for information on new technologies often do not exist or if available, are ineffective and beyond the financial means of many small-scale farmers.

Box 1: FAO's definition of small-scale aquaculture.

"Rural aquaculture is still widely used but the term 'small-scale' aquaculture (SSA) has come into vogue. A definition of SSA was agreed at the FAO workshop indicating that SSA comprises a spectrum:
1) systems involving limited investment in assets, some small investment in operational costs, including largely family labour and in which aquaculture is just one of several enterprises (known in earlier classifications as Type 1 or rural aquaculture); and 2) systems in which aquaculture is the principal source of livelihood, in which the operator has invested substantial livelihood assets in terms of time, labour, infrastructure and capital (this was labelled as Type II SSA system). Common elements characterising this SSA definition are ownership of, or access to, an aquatic resource; ownership by family or community; and relatively small size of landholding. However, if aquaculture becomes the primary livelihood activity, there is likely to be greater investment and hire of labour with an indistinguishable overlap between small and medium or even large scale-aquaculture" (Edwards, 2013)

Traditionally farmers in these countries have relied upon other farmers for access to new technologies, ideas and production methods. It is known that male farmers in Nigeria have more access to agricultural extension services than women. Agricultural extension services are mostly staffed by men and are inclined to helping men folk, as observed by Osuman (1997). A previous study of Morna (1989) in Malawi, shows that when agricultural extension workers visit rural areas to explain improved technologies or other access to inputs, they usually interact with men and not women.

Carrascal *et al*. (1995) identify several problems of information and knowledge exchange in agriculture. First they mention user variety. The information gained through research must be exchanged in a comprehensible way, so that it reaches not only other scientists but also the end agricultural user i.e. the farmer. The language through which the knowledge is exchanged must be comprehensible and must include different levels of explanation according to the user specialisation (farmers, students, advisers, companies and scientists who possess various degrees of computer skills and specialisation). McRoberts *et al*. (1991) indicates that there is a need to choose tools which are easy to use and efficient in their functions for information exchange. Another problem is the linkage of disciplines, the information structure. It is important to combine and link information/knowledge of different disciplines, avoiding unnecessary redundancies, to give adequate solutions to all agricultural problems of a farm. That is why, according to Rauscher (1987), sound knowledge/information organisation is essential for the exchange. Carrascal *et al*. (1994) also confirms the problem of information access. They suggest that the methods to access information/knowledge should be made more flexible and that farmers must consider and support multiple ways to analyse a problem.

2.8 Demographic characteristics

Research indicates that several factors can influence a farmers' use and search for information, especially personal characteristics. Age (Carter & Batte, 1993), education (Waller *et al*., 1998) and income level have a significant relationship to the access of information of female farmers. This means that women have more access to information if they are older,

more educated and rich or have a higher standard of living. These findings were also found by Gill (1987), Olowu and Igodan (1989) and Matanmi (1991). In addition, factors such as farm size (Solano *et al*., 2003; Alvarez & Nuthall, 2006; Llewellyn, 2007), type of farm enterprise (Carter & Batte, 1993), experience in farming (Schnitkey *et al*., 1992), ownership of farm (Ngathou *et al*., 2002) and debt level (Tucker & Napier, 2002) have an influence on the use of information by farmers. Geographical characteristics such as distance to the technological adopter (Llewellyn, 2007) or to market centres (Solano *et al*., 2003) can also be factors. Research has shown a strong positive relationship between participation in organisations and the education level of farmers. Fish farmers' demographic characteristics are related to information utilisation and influence their adoption of fish farming technologies in the same way that that information sources on improved fish farming technologies influence the usage of this information (Ofuoku *et al*., 2008). In general, studies indicate that adults are more receptive to information when it is applicable to their situation and when there is a need for them to know (Bessoff, 1995).

On the base of these findings one can conclude that there is a relationship between demographic characteristics and the information search and use by farmers. If the focus is on personal characteristics of farmers, studies indicate that low information users and searchers have a lower standard of living and education level as well as smaller holding size (land). Thus, the level of education and the state in which farmers reside are related to the choice of useful information sources. That is also the reason why not all farmers use the same source of information or regard them as the most useful.

2.9 Conclusions

To understand the information needs of the farmers, their search behaviour and which sources they depend on for accessing information, it is important to design effective extension programs and advising services in developing countries. Research on farmers' information sources and information needs has been executed in Africa (Kaniki 1991; Stefane *et al*., 2005; Aina, 2006), and a few other studies have examined the factors that influence farmer search strategies (Adolwa *et al*. 2010; Opara 2010; Okwu & Dauda, 2011). Knowledge exchange within aquaculture is essential. It is necessary for increased production and productivity of farmers' activities. To decide how information on new fish farming technologies can be adequately exchanged, technology developers and extension agents must be aware of the information sources and search behaviour of farmers. Mahieu (2015) suggested the importance of creating a platform where industry and government can come together to solve issues in the sector and share valuable knowledge and know-how.

For farmers, there is a wide range of knowledge exchange methods available. These include the radio, extension agents, television, workshops, demonstrations, news publications, hand-outs, personal contacts, internet, contact with other farmers and a myriad of other potential media. Research has shown that for small-scale famers the sources of knowledge are local (Rees *et al*., 2000). Their information sources consist of interactions with neighbours, family, community based organisations, NGO`s and extension agents. However, there are still many constraints to access information (Oladele, 2006). Several studies mention the problems farmers experience in accessing agricultural information, although the advent of information technologies succeeded in eliminating bottlenecks in information dissemination. For example, in developing countries the formal markets for information on new technologies

often do not exist or if they are available, they are ineffective and beyond the financial means of many small-scale farmers (Grisley, 1994).

The information utilisation and the information sources of farmers are influenced by their demographic characteristics. The demographic characteristics of the farmers influence their adoption of fish farming technologies in the same way that information sources on improved fish farming technologies influence the usage of this information (Ofuoku *et al*., 2008). Furthermore, traditional and modern information and communication technologies could play a key role in bridging the two knowledge systems and disseminating knowledge to farmers (Munyua & Stilwell, 2013).

2.10 Recommendations

Research on knowledge exchange for water resource management for improved integrated aquaculture and agricultural is necessary for better information dissemination and information flow to farmers. While a few nations have already examined this study field (i.e. Nigeria and India), a greater understanding of the differences in farmer information strategies across other countries (i.e. South Africa) is needed. There seems to be a lack of quantitative and qualitative research in this regard. To evaluate behavioural changes in search strategies and the implementation of new technologies by farmers, long-term research is recommended. Although there are numerous information sources available for farmers, extra research on the effectiveness of these information sources can be conducted.

Another gap in the literature is specific studies on aquaculture knowledge exchange systems. Most of the analysed publications in this literature review focussed on agricultural systems. Although many core issues are crosscutting, further reviews on knowledge exchange among emerging small-scale fish farmers would be desirable.

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CHAPTER 3: Local knowledge systems of fish farmers: A baseline on the profiles, knowledge base and skills level of fish farmers in the Western Cape, KwaZulu-Natal and Limpopo provinces

3.1 Introduction

The study entailed visiting fish farming operations in three provinces, *inter alia*, Western Cape (WC), KwaZulu-Natal (KZN) and Limpopo. The focus of the discussion with the farmers was to gain an understanding of the dynamics around information flow to and from the farm.

A total of 38 farms were visited: nine in WC, nine in KZN and 20 in Limpopo. A semi-structured questionnaire was used to collate data. For each farm maps were provided indicating their location as well as picturing the lay-out of their farms. A detailed profile was compiled and the knowledge dissemination route was described. Lastly, charts were provided on farmers' use of information sources depicting the dominant ones.

Although each province presents distinct geographical and climatic conditions, the common water usage is primarily for irrigation and secondary for fish farming. The WC has a Mediterranean climate with warm dry summers and wet cold winters. Most fish farmers are in the Strand/Somerset West, Stellenbosch/Paarl and Worcester/Ceres areas. The fish farms in KZN are mainly situated in the Midlands in the Maluti/Drakensberg area. The area has a subtropical climate with summer rainfall. Limpopo has moderate winters and summers, but is generally a drier region with a prevalent water scarcity. The province is reliant on underground water sources. The fish farms are scattered across five districts in the province.

The WC farms with rainbow trout. The farming systems included floating cages on farm dams, earthen ponds and gravitational-fed raceways. The fish species mainly farmed in KZN is rainbow trout and in Limpopo it is Mozambique tilapia. The WC and KZN have intensive operations and in Limpopo fish farms are mostly semi-intensively run. In all instances, fish are fed artificial diets with varying protein inclusion levels. Produce from the farms are sold through farm-gate sales and to the retail, catering and hospitality sectors.

Many of the farm management staff had completed a tertiary education and were proficient in ITC applications. A great amount of the information flow was received through the internet, although regular coverage and reception was constraint in some areas. Newly operational farmers were highly dependent on single resource persons who exhibits a wide-spread know-how of specific species farmed and had a track record and experience of farming themselves. Farmers who had been operational for some time were fastidious to their practices and exhibited a high level of resistance to new ideas or alternative ways of practising.

The general trend was that fish farmers require a more efficient way of acquiring and managing knowledge and information. They expressed that they look favourably towards applications that can improve their business. Most of the farmers would like to grow their ventures and realised the importance of communication with the extended supply chain. A few suggestions received by the farmers on knowledge exchanges included a dedicated website/chatroom to which the farmers can subscribe and use the forum to share and consult. Furthermore, some farmers exclaimed that a demonstration centre for learning and teaching could be an asset in an area. The centre could be used to train new workers on site and serve as a resource station. Other farmers were just enquiring about local experts they

can consult on the type of species and farming system they are operating. They felt confident enough to explore and assimilate knowledge and apply themselves. In all instances the case for knowledge exchange to grow the sector together was always accentuated.

The report provides a summary for each province and presents detail on basic knowledge acquisition and exchanges. It explains the case for better communication among researchers, officers and farmers. It further explores modes/methods of potential knowledge dissemination and exacerbates the importance of improved management for better water resource management. Further anecdotal stories and relevant information as conveyed by the fish farmers were captured in Appendix 4.

3.2 Baseline water quality summary for main water resources used by the fish farmers in the respective provinces

Data was obtained from the DWA (2017) on water quality recorded over time for selected rivers providing water to the fish farms in the three provinces. The data sets included 16 standard parameters for water quality. However, parameters which are important for fish farming, such as dissolved oxygen and temperature, were not included. The baseline data can be used for future comparison of the impact of fish farming on water quality.

3.2.1 Western Cape

Table 3.1. Water quality data for Berg River sources used by the fish farmers [summary data from 1995 to 2016, DWA (2017)].

Parameter	Median reading for river water quality
TDS (mg/L)	35.7
EC (mS/m)	5.87
pH	7.2
Na^+ (mg/L)	5.83
K^+ (mg/L)	1.02
Ca^{++} (mg/L)	2.98
Mg^{++} (mg/L)	075
CL^- (mg/L)	8.11
SO_4^{2-} (mg/L)	3.00
TAL (mg/L)	9.35
F^+ (mg/L)	0.139
PO_4^{3-} (mg/L)	0.016
NO_2^-+NO_3^- (mg/L)	0.113
NH_4^+(N) (mg/L)	0.02
Kjel_N(N) (mg/L)	n.a.
SiO_2 (mg/L)	4.68

3.2.2 KwaZulu-Natal

Table 3.2. Water quality data for Umzimkulu River used by the fish farmers [summary data from 1971 to 2016, DWA (2017)].

Parameter	Median reading for river water quality
TDS (mg/L)	44.5
EC (mS/m)	5.6
pH	7.48
Na^{+} (mg/L)	2.6
K^{+} (mg/L)	0.48
Ca^{++} (mg/L)	4.9
Mg^{++} (mg/L)	1.95
CL^{-} (mg/L)	2.6
SO_4^{2-} (mg/L)	2.00
TAL (mg/L)	22.6
F^{+} (mg/L)	0.05
PO_4^{3-} (mg/L)	0.012
NO_2^{-}+NO_3^{-} (mg/L)	0.06
NH_4^{+}(N) (mg/L)	0.02
Kjel_N(N) (mg/L)	0.104
SiO_2 (mg/L)	5.48

3.2.3 Limpopo

Table 3.3. Water quality data for Mutshindudi River sources used by the fish farmers [summary data from 1971 to 2014, DWA (2017)].

Parameter	Median reading for river water quality
TDS (mg/L)	82
EC (mS/m)	11.4
pH	7.78
Na^{+} (mg/L)	5.1
K^{+} (mg/L)	0.39
Ca^{++} (mg/L)	7.9
Mg^{++} (mg/L)	4.8
CL^{-} (mg/L)	5.9
SO_4^{2-} (mg/L)	2.00
TAL (mg/L)	42.7
F^{+} (mg/L)	0.106
PO_4^{3-} (mg/L)	0.018
NO_2^{-}+NO_3^{-} (mg/L)	0.188
NH_4^{+}(N) (mg/L)	0.02
SiO_2 (mg/L)	8.01

3.3 Köppen climate classification

3.3.1 Western Cape

Table 3.4. Köppen climate classification for fish farms in the WC (Classification, Climate classification, [s.a.]).

Farm name	Location	Köppen classification
Unlimited Olive People's Trust	Buffet Olives Farm, Paarl	Csa (Hot-summer Mediterranean climate)
Three Streams Trout	Franschhoek	Csb (Warm-summer Mediterranean climate)
Lourensford Trout	Lourensford Wine Estate, Somerset West	Csb (Warm-summer Mediterranean climate)
Nuwejaarsrivier Forelboerdery	Of the R43 toward Bot River and Kleinmond	Csb (Warm-summer Mediterranean climate)
Thambo Lentlanzi	Jonkershoek Nature Reserve, Stellenbosch	Csb (Warm-summer Mediterranean climate)
Fizantakraal Trout	Du Toitskloof Mountains, Paarl	Csa (Hot-summer Mediterranean climate)
Soetfontein	Close to Prince Alfred Hamlet and Ceres	Csb (Warm-summer Mediterranean climate)
Langekloof Trout	Stanford, Gansbaai	Csb (Warm-summer Mediterranean climate)
Nuwedam and Lomond	Stanford, Gansbaai	Csb (Warm-summer Mediterranean climate)

3.3.2 KwaZulu-Natal

Table 3.5. Köppen climate classification for fish farms in KZN (Classification, Climate classification, [s.a.]).

Farm name	Location	Köppen classification
Amatikulu Ornamentals	29º4'15.989''S and 31º38'56.76''E (Mtunzini)	Cfa (Humid subtropical climate)
Kel Mark Trading	29º28'12.331''S and 30º28'51.146''E (Wartburg)	Cwb (Subtropical highland oceanic climate)
Giant's Cup Hatchery	29º43'52.972''S and 29º22'23.699''E (Underberg)	Cwb (Subtropical highland oceanic climate
Crystal Waters	29º43'52.972''S and 29º22'23.699''E (Underberg)	Cwb (Subtropical highland oceanic climate
Splashy Fen Trout Farm	29º48'5.396''S and 29º20'24.648''E (Underberg)	Cwb (Subtropical highland oceanic climate
Wayfarer Trout	29º32'18.006''S and 30º00'25.084''E (Howick)	Cfb (Oceanic climate)
Bushman's River Trout	29º12'59.951''S and 29º33'33.685''E (Cathedral Peak)	Cwb (Subtropical highland oceanic climate
Peak Trout	28º56'43.858''S and 29º11'46.024''E (Bergville or Umhlanga)	Cwa (Humid subtropical climate) or Cfa (Humid subtropical climate)
Milestone	29º28'2.842''S and 30º29'34.533''E (Wartburg)	Cwb (Subtropical highland oceanic climate

3.3.3 Limpopo

Table 3.6. Köppen climate classification for fish farms in Limpopo (Classification, Climate classification, [s.a.]).

Farm or farmer's name	Location	Köppen classification
Muanalot	Dopeni	BSh (Hot semi-arid climates)
Mphaphati	Dopeni	BSh (Hot semi-arid climates)
Shavhani	Shanzha	BSh (Hot semi-arid climates)
Mukwevho	Mandala	BSh (Hot semi-arid climates)
Nemutamba	Makwarela	BSh (Hot semi-arid climates)
Tshivhuyahuvhi	Tshikonelo	BSh (Hot semi-arid climates)
Mudau	Lwamondo-Matatani	BSh (Hot semi-arid climates)
Mafukasaga	Lwamondo-Tshifulanani	BSh (Hot semi-arid climates)
Ndou	Muledane	BSh (Hot semi-arid climates)
Mahwasane	Mutshenzeni	BSh (Hot semi-arid climates)
Tshivhase	Phiphidi	BSh (Hot semi-arid climates)
Nemaranzhe	Maranzhe-Vondo	BSh (Hot semi-arid climates)
Mamatsharanga	Mbahela	BSh (Hot semi-arid climates)
Mulaudzi	Mbahela	BSh (Hot semi-arid climates)
Makwathana	Tshivhulani	BSh (Hot semi-arid climates)
Mphaphudi	Mubvumoni	BSh (Hot semi-arid climates)
	Thohoyandou (Closest to most fish farms)	BSh (Hot semi-arid climates)

Köppen climate classification system description

A - Tropical Moist Climates:

- All months have average temperatures above 18° Celsius.
- Annual precipitation is more than 1500 mm.
- There are three minor Köppen climate types in the A-group and designation is based on seasonal distribution and rainfall.
    - **Af (*tropical wet)*** – tropical climate with precipitation occurring all year long, intense surface heating (daily highs of 32°C and 22°C is the average temperature at night) and high humidity.
    - **Am (*tropical monsoon)*** – annual rainfall is equal to or greater than **Af** but precipitation occurs mostly in the 7 to 9 hottest months.
    - **Aw (*tropical wet and dry*)** – an extended dry season during the winter and less than 1000 mm in the summer.

B - Dry Climates:

- Deficient precipitation during most of the year.
- Potential evaporation and transpiration exceeds precipitation.
    - **BW (*dry arid*)** – true desert climate and **h** and **k** may further be used to distinguish if the dry arid climate is found in the subtropics or the mid-latitudes.
    - **BS (*dry semiarid*)** – a grassland climate that receives more precipitation than **BW** and the letters **h** and **k** is also used for distinction between dry semiarid climate found on the subtropics or in the mid-latitudes.

C - Moist Mid-latitude Climates with Mild Winters:

- Warm and humid summers with mild winters.
- Main weather feature in winter is mid-latitude cyclone.
- Summer months are dominated by convective thunderstorms.
    - **Cfa (*humid subtropical*)** – hot muggy summers and frequent thunder storms with mild winters.
    - **Cs (*Mediterranean*)** – humid climate with short dry summers and heavy precipitation occurs in the mild winters.
    - **Cfb (*marine*)** – receive rain mainly during the winter season and extreme summer aridity.

D - Moist Mid-Latitude Climates with Cold Winters:

- Warm to cool summers and cold winters.
- Average temperature of the warmest month is 10°C and the coldest month is less than -3°C.
- Winters are severe with snowstorms and strong winds.
    - **Dw (*dry winters*)**
    - **Ds (*dry summers*)**
    - **Df (*wet all seasons*)**

E - Polar Climates: with extremely cold winters and summers:

- Year-round cold temperatures with the warmest month less than 10°C.
    - **ET (*polar tundra*)** – soil is permanently frozen to depths of hundreds of meters.
    - **EF (*polar ice caps*)** – surface permanently covered in snow and ice.

3.4 Western Cape – Baseline information

3.4.1 Locations of fish farms

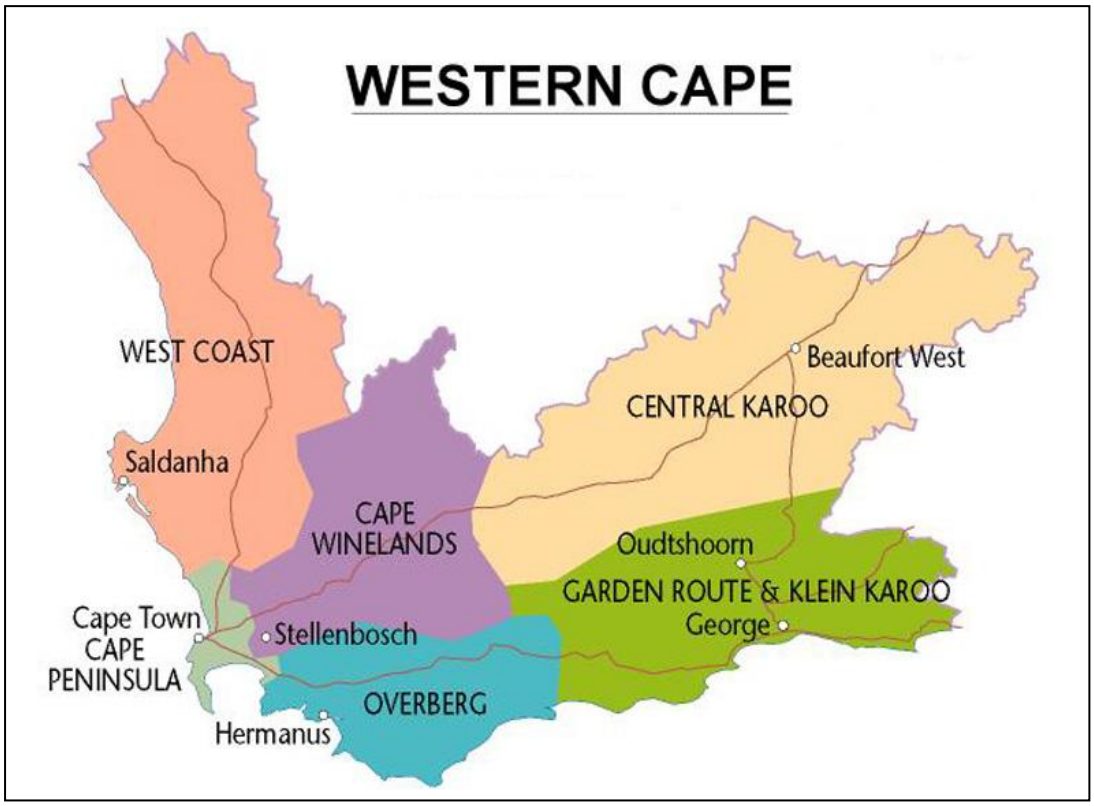

Fig. 3.1. General location of the fish farmers in and around Stellenbosch in the south-western corner of the Western Cape.

3.4.2 Description of fish farms

1. Unlimited Olive People's Trust
2. Three Streams Trout
3. Lourensford Trout
4. Nuwejaarsrivier Forelboedery
5. Thambo Lentlanzi
6. Fizantakraal Trout
7. Soetfontein
8. Langekloof Trout
9. Nuwedam & Lomond

(see Appendix 4: Captured stories shared by the fish farmers in the three provinces)

Table 3.7. Summary of fish farmers' profiles for the Western Cape.

Fish farm	Farm manager	Age	Children	Language*	Education	Housing	Years of experience	Production per year in tons	Farming system
Unlimited Olive People's Trust (Paarl)	Male	42	2	A & E	High school level	On the farm	12	12	Cages
Three Streams Trout (Franschhoek)	Male	37	1	A & E	Masters in Aquaculture	Stellenbosch	12	900 000 live fish & 12-16 tons of plate size	Porta-pools
Lourensford Trout (Somerset West)	Male	38	2	A & E	Degree in Aquaculture	On the farm	15	80 (30 tons in the cages and 50 tons in raceways)	Cages & raceways
Nuwejaarsrivier Forelboedery (Kleinmond)	Male	40	2	A & E	Degree in Tourism	On the farm	5	7.5	Cages
Thambo Lentlanzi (Jonkershoek)	Male	35	2	A & E	Certificate of aquaculture	Jonkershoek	13	40	Cages
Fizantakraal Trout (Du Toitskloof)	Male	32	1	E & A	Languages	On the farm	10	75	Ponds
Soetfontein (Ceres)	Male	44	2	A & E	Grade 12 & 2 years diploma agriculture	On the farm	8	Winter: 18-20 tons & summer: 12 tons	Ponds
Langekloof Trout (Stanford)	Male	65	2	A & E	Electronics	On the farm	8	5	Pools (juveniles) & portapools
Nuwedam & Lomond (Stanford)	Male	29	1	A & E	1 year aquaculture	Gansbaai town (not on the farm)	9	80	Cages

*A= Afrikaans; E= English

Table 3.8. Knowledge and information accessed by the Western Cape fish farmers.

Fish Farm	Knowledge and information access
Unlimited Olive People's Trust (Paarl)	- Other fish farmers - Information from Stellenbosch University - Courses and training at the University - Internet
Three Streams Trout (Franschhoek)	- Masters in Aquaculture at Stellenbosch University - Working experience with catfish and tilapia - Working experience in Scotland (six years) - Internet - Other fish farmers (South Africa, Scotland and Denmark)
Lourensford Trout (Somerset West)	- Fly fishing as hobby - Degree in aquaculture - Working experience in England - Trial-and-error - Other fish farmers
Nuwejaarsrivier Forelboedery (Kleinmond)	- Fly fishing as hobby - Training at Jonkershoek - Trial-and-error - Father - Other fish farmers
Thambo Lentlanzi (Jonkershoek)	- Courses in fish diseases and management - Trial-and-error - Stellenbosch University
Fizantakraal Trout (Du Toitskloof)	- Trainings and workshops from Stellenbosch University - The Western Cape Trout Association - Partnership with Aquasearch and Coppens - Internet and Other fish farmers
Soetfontein (Ceres)	- Trainings from the University - Course material - Internet - Other fish farmers
Langekloof Trout (Stanford)	- The Western Cape Trout Association - Internet - Other fish farmers
Nuwedam + Lomond (Stanford)	- Western Cape Trout Association - Internet - Other fish farmers

In Table 3.8 it is clearly stated which knowledge and information access points were important to the fish farmers in the WC. The organisational support rendered by the producer associations and the recreational angling fraternities is further acknowledged. The role of ICT is also highlighted through the usage of the internet. However, the local knowledge is explained through the passing on of information from previous generations. Furthermore, trial-and-error practices are still evident and explain fish farmers' strategies in the absence of ready-available information. Many fish farmers felt that the best learning school was through self-teach and experience (i.e. learning through mistakes). Local and international higher education organisations were also listed as learning instruments for many of the fish farmers.

3.4.3 Bar chart illustration of different information sources used by the fish farmers.

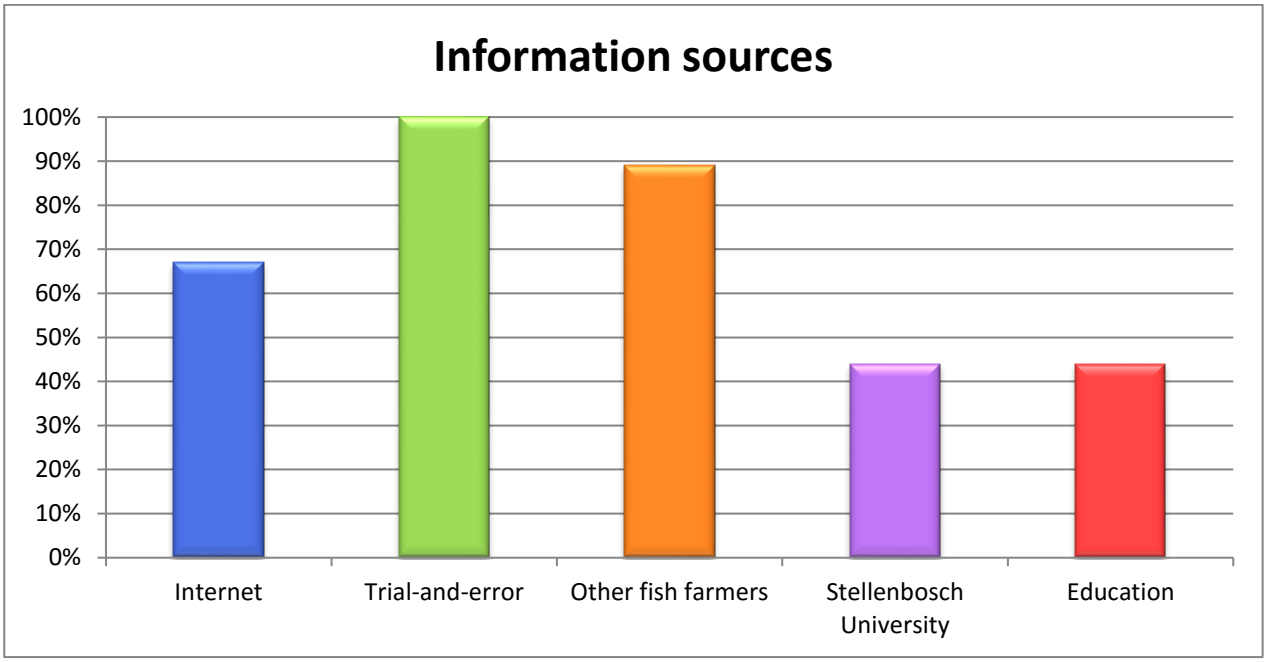

Fig.3.2. Bar graph summary of the information sources used by the Western Cape fish farmers.

3.5 KwaZulu-Natal – Baseline information

3.5.1 Location of fish farms

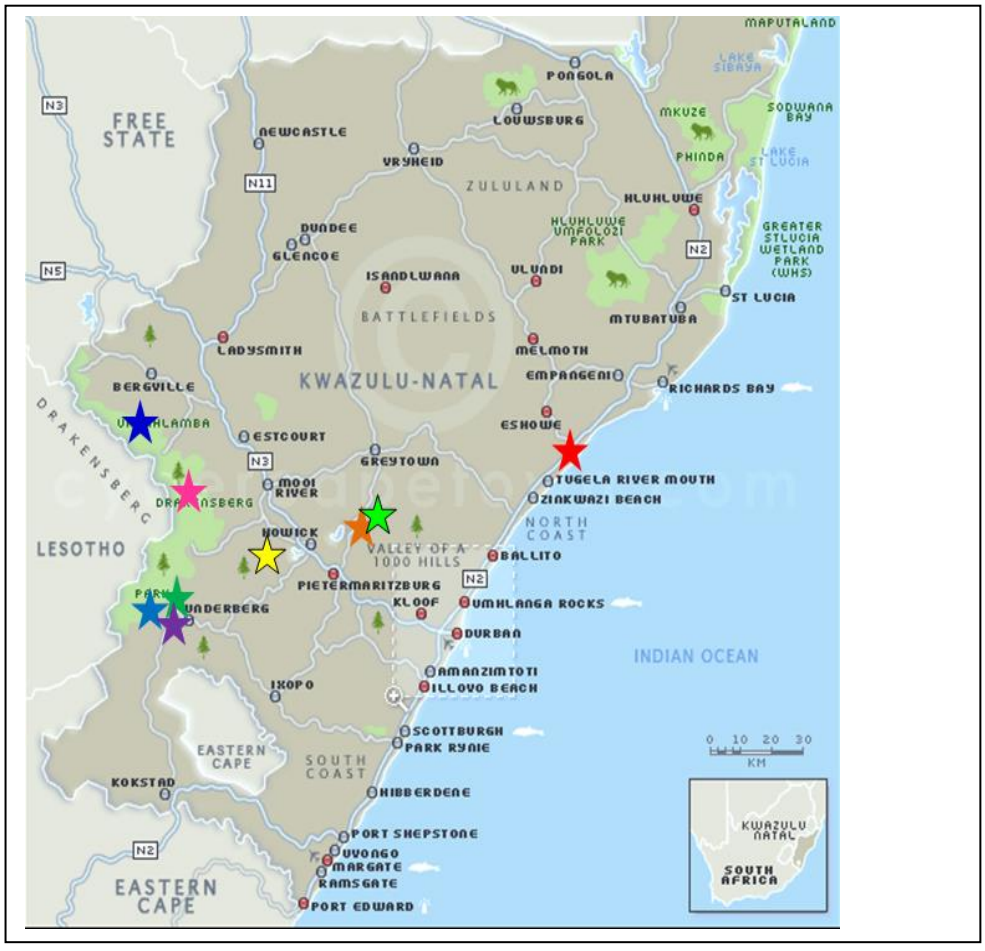

Fig. 3.3. The geographical location of the fish farms for KZN (indicated by stars).

3.5.2 Description of fish farms

1. Amatikulu Ornamentals
2. Kel Mark Trading
3. Giant's Cup
4. Crystal Waters
5. Splashy Fen
6. Wayfarer Trout
7. Bushman's River Trout
8. Peak Trout
9. Milestone

(see Appendix 4: Captured stories shared by the fish farmers in the three provinces)

Table 3.9. Summary of fish farmers' profiles for KZN.

	Farmer	Age	Children	Languages	Education	Years of experience	Access to internet
Amatikulu Ornamentals	Male	40	2	English, Afrikaans	Studied Horticulture	7 in ornamentals	Yes
Kel Mark Trading	Male	49	3	English, Afrikaans	Agricultural College	33 years with crocodiles	Yes
Giant's Cup	Male	64	4	English, Afrikaans, Hebrew, Dutch, German, Xhosa	Grade 10	28	Yes
Crystal Waters	Male	75	5	English, Afrikaans, Zulu, Xhosa	BSc Agriculture	6	Yes
Splashy Fen	Female	52	2	English, Afrikaans, Zulu, Xhosa	Diploma in Agriculture	5	Yes
Wayfarer Trout	Male Male	60 29	2 -	English, Afrikaans English, Afrikaans	BSc Building Tertiary education	8 8	Yes Yes
Bushman's River Trout	Male	59	1	English, Afrikaans, Zulu	Diploma in Nature Conservation	3	Yes
Peak Trout	Male	33	2	English, Slovenian	N/A	9	Yes
Milestone	Male	53	3	English, Afrikaans	Degree in Agricultural Management and Honours in Commerce	0	Yes

Table 3.10. Summary of fish farmers' contact details and farm location coordinates in KZN.

	Farmer	Farm co-ordinates	Contact number/s	Website
Amatikulu Ornamentals	Male	29º4'15.989''S and 31º38'56.76''E	082 333 3996	-
Kel Mark Trading	Male	29º28'12.331''S and 30º28'51.146''E	082 372 0919	-
Giant's Cup	Male	29º43'52.972''S and 29º22'23.699''E	033 701 1511	www.giantscup.co.za
Crystal Waters	Male	29º43'52.972''S and 29º22'23.699''E	033 701 1751	www.crystalwatersunderberg.co.za
Splashy Fen	Female	29º48'5.396''S and 29º20'24.648''E	082 860 0370	-
	Male	29º48'5.396''S and 29º20'24.648''E	082 441 1310	-
Wayfarer Trout	Male	29º32'18.006''S and 30º00'25.084''E	031 940 1303	-
	Male	29º32'18.006''S and 30º00'25.084''E	082 415 3780	
Bushman's River trout	Male	29º12'59.951''S and 29º33'33.685''E	079 527 3878	www.bushmansrivertrout.co.za
Peak Trout	Male	28º56'43.858''S and 29º11'46.024''E	083 375 5571	-
Milestone	Male	29º28'2.842''S and 30º29'34.533''E	082 894 8946	-

Table 3.11. Summary of the fish farms' detail located in KZN.

	Species farmed	Other activities on farm	Purpose of system	Water source	Water outflow	Number of staff	Farming system
Amatikulu Ornamentals	Tropical & cold water ornamentals	Water plants	Live sales	Ground water	Onto surrounding land	9	Concrete ponds in tunnels, glass tanks in hatchery
Kel Mark Trading	Crocodiles	Experimented with tilapia	Skins and meat	Umgeni River	Settling dams, irrigation dams, or back to river	20	Earthen ponds, Fiberglass circular tanks, concrete ponds
Giant's Cup	Rainbow trout	Sheep, guest cottages for fly fishers	Full range (Live sale to value added products)	Lake on Umzimkulwana River	Settling ponds, then back to the river	7	Earthen ponds, plastic circular ponds, hatchery
Crystal Waters	Rainbow & Brown Trout	Cattle, horses, game, guest cottages	Stocking of own dams, surplus live sales	Umzimude River	Irrigation dams or back to the river	1	Concrete ponds, metal ponds & hatchery
Splashy Fen	Rainbow & Brown Trout	Some heifers	Live sales	Mountain stream	Back into stream, to Mzimude River	3	Concrete ponds & hatchery
Wayfarer Trout	Rainbow trout	Small-scale hay crops	Sold for consumption, fillets, cold smoked fillets	River	Back into the river which joins up with the Umgeni River	3	Hatchery (trays and 3 small concrete ponds), earthen ponds
Bushman's River trout	Rainbow trout	Game farm	Sold for consumption (fresh, vacuum packed, frozen; hot smoking; fillets), sold for stocking	Bushman's River	Back into the river which joins up with the Bushman's River	2 managers, 9 permanents workers	Hatchery, round tanks, rectangular raceways
Peak Trout	Rainbow & Brown trout	None	Live sale & processed products	From the stream	Back into the Mlambonja River	6 permanent and 3 casual	Hatchery, growing ponds & raceways
Milestone	Mozambique tilapia	Vegetables & herbs (Aquaponic system), Nguni cows	Produce fish (gutted and gilled), vegetables & herbs for consumption	Dam (on Nhlambamasoka River) & borehole	Re-circulating system – small amounts for irrigation	2	Tunnels containing circular fibre glass tanks for fish & rectangular trays for plants

Table 3.12. Knowledge and information accessed by fish farmers in KZN.

	Knowledge and information access
Amatikulu Ornamentals	- Practical experience, self-taught, trial and error - Internet - Other farmers
Kel Mark Trading	- Internet - Other farmers
Giant's Cup	- Practical experience, self-taught, trial and error - Internet
Crystal Waters	- Practical experience, self-taught, trial and error - Books - Other farmers
Splashy Fen	- Practical experience, self-taught, trial and error - Other farmers - Internet
Wayfarer Trout	- Practical experience, self-taught, trial and error - Other farmers - Internet - Books
Bushman's River trout	- Practical experience, self-taught, trial and error - Other farmers - Internet
Peak Trout	- Practical experience, self-taught, trial and error - Other farmers - Internet - Books
Milestone	- Internet - Other farmers

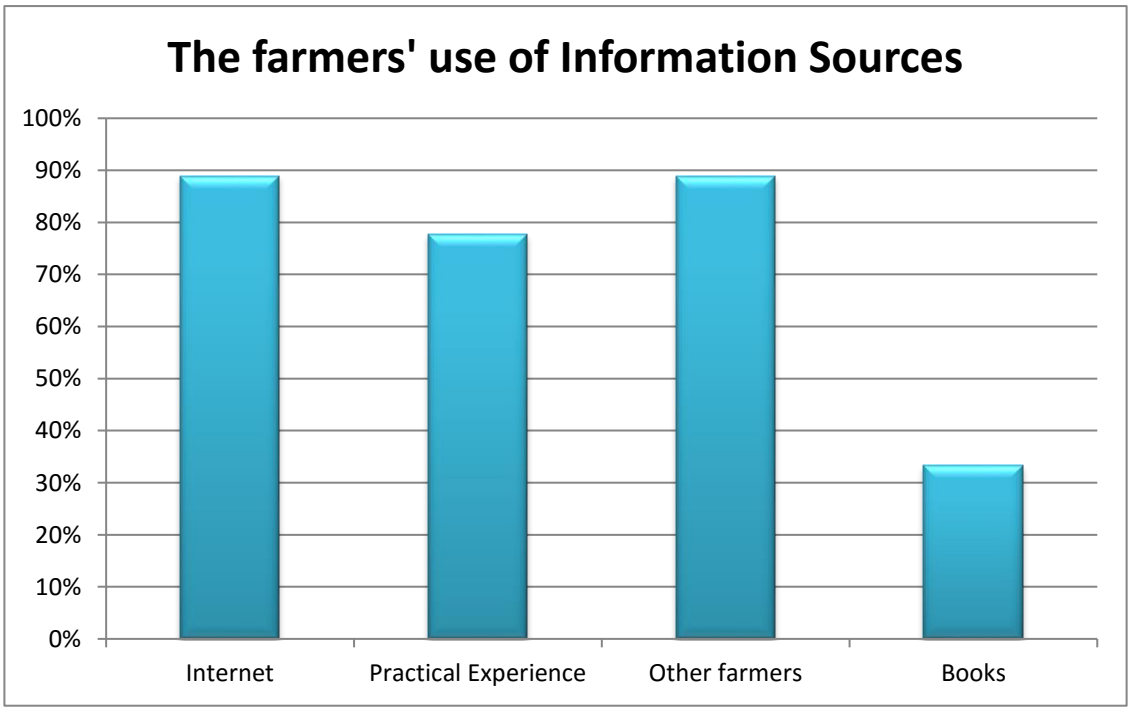

Fig. 3.4. Bar graph indicating the main sources of information used by fish farmers in KZN.

3.6 Limpopo – Baseline information

3.6.1 Location of fish farms

Fig. 3.5. The geographical location of the fish farms (mostly around the stars) in Vhembe District in Limpopo.

3.6.2 Description of fish farms

1. Nemubvumoni
2. Nemaguvhuni
3. Mudau
4. Tshivhase
5. Ndou
6. Tshikonelo
7. Mandala 1
8. Mandala 2
9. Tshivhulani
10. Dopeni

(see Appendix 4: Captured stories shared by the fish farmers in the three provinces)

Table 3.13. Summary of knowledge sources for fish farmers in Limpopo.

Fish farmer	Workshop	Extension agents	TELEVISION	Radio	Internet	Books
1.	√	√	√	√		
2.	√	√				√
3.	√	√			√	
4.	√	√				
5.	√	√				
6.	√	√				
7.	√	√			√	√
8.	√				√	
9.	√	√			√	
10.	√	√				

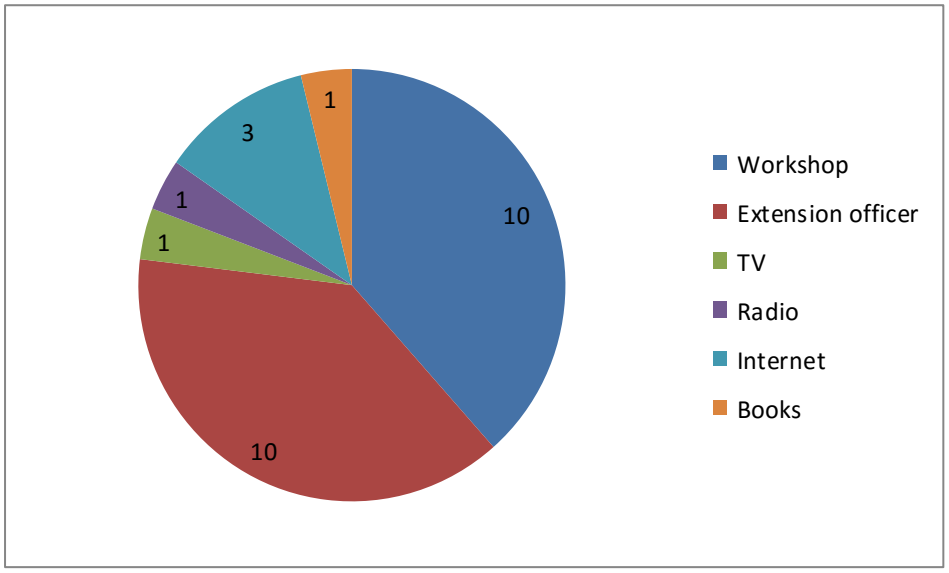

Fig.3.6. Pie chart summarising sources of knowledge for randomly selected fish farmers in Limpopo.

3.7 Conclusion

The study provided an overview of the local knowledge systems of selected fish farmers in the three provinces in South Africa. The common criteria considered for selection were: fish farmers with operation sites where the water source is primarily used for agriculture irrigation and secondary for aquaculture (fish farming) practices. To improve overall management of water, the current practices and principles applied were investigated and evaluated.

In the WC, farmers were more organised with organisational support from a farmers' organisation and regular intervention from the public sector. The KZN farmers were mostly functioning independently and leverage support from prominent electronic media and one-on-one consultation with recognised persons in the industry. Many of these farmers are set in their ways and unsusceptible to outside views and perspectives. However, once they realised that the cost-benefit was positive and has the potential to improve turnovers and profits, farmers exhibited keen interest. The farmers in north-western Limpopo indicated a desperate need for assistance in training and intervention for them to improve and expand their ventures. Limpopo indicated a lack of support, especially once the farm was operational.

The challenge with the local knowledge systems was not the abundance of resources, but more the comprehension and application of resources to improve operations. Although there is a myriad of information available on the internet, farmers were still sceptical about it and, in most instances, overwhelmed by the different way of doing things. In these cases, it was found that farmers opted for practices and systems which were demonstrated to them and shown to work. Although the efficiency level was not clear, farmers would rather follow the latter as they were assured that the system will at least function.

A re-evaluation of the research output was required to facilitate a process of successful adoption. This strategy coupled with demonstration stations and complying farmers will enhance knowledge exchange and use. Farmers should lead the way in setting the agenda for knowledge creation as well as successful exchange and implementation. Overall, the discussions with the

farmers have provided greater insight to what is deemed to be important to achieve improved management of South African water resources.

3.8 References

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CHAPTER 4: Technology exchange: Constraints, techniques and adoption and implementation

4.1 Introduction

The first phase of the project was to collect as much information as possible on each farm and compile a profile including demographical and technical information. The objective was for the Project Team to firstly, orientate them on ground level information that the farmer deems to be important, and secondly to begin to understand the dynamics of information flow and the different aspects associated with it. These included accessibility, relevance of application, constraints of technology exchange and the level of successful adoption.

This chapter describes the constraints associated with technology exchange as indicated by the farmers. A great amount of the information pertaining to this chapter was extracted from a comprehensive report on *"Local knowledge systems of farmers"* (captured in Appendix 4).

All three provinces were quite diverse in the nature of their fish farming operations and the political and socio-economic driving forces were subsequently different. The priority listing was also different, i.e. knowledge on feed quality and reliability of supplies was the most important aspect for the WC farmers, whereas the Limpopo farmers listed their priority needs on acquiring adequate training and provision of extension servicers.

The documentation of these constraints (underlined in the text) was the first approximation of the analyses of factors limiting the growth and development of the aquaculture sector in South Africa. Additional follow-up visits were conducted whereby the results of the first phase were re-confirmed and engage farmers were further engaged and the Project Team could list additional constraints and communicate it to the respondents. At many farm visits the Project Team identified production aspects that required attention. These aspects were interrogated and discussed with the farmers and assisted their understandings of what measures have been tried or put in place to address it.

An informed farmer is a successful farmer. Therefore, the challenge remains as to what extent farmers can be supported through successful exchange of technology to enable them to achieve optimal production output with minimum environmental degradation. The approach was not to research and provide acquired results, but rather to investigate and assess how available information is utilised, and if not, what facilities could be provided to assist.

The chapter presents a discussion on each farm and a description of key findings pertaining constraints to technology exchange. However, the constraints were not only confined to technology exchange, but were documented in general as experienced by the farmer. The Project Team opted to describe constraints holistically as all these aspects contribute to optimising production efficiency, and ultimately sustainability in water resource management.

The project was approached in three phases. These include, *inter alia*, a basic scoping and profiling of fish farmers in the three respective provinces, the investigation of current knowledge exchange systems including access and application, and thirdly, adoption and implementation and with reference to technology exchange techniques, especially in areas where accessibility is challenging. The technology exchange and diffusion process was simplified and indicated (see section 4.3.1). The Project Team explored techniques associated with internet-based, social

media, participatory and formal teaching. The Project Team decided on four key technology exchange techniques to be assessed:

- Stellenbosch University's website forum for *alumni* of aquaculture training via short courses, graduate and postgraduate programmes.
- Social media, i.e. Student aquaculture blog at University of KwaZulu-Natal.
- Graduate internship placement as resource mode at farm level.
- Workshop and seminars presented as participatory platforms for small-scale fish farmers.

The approach of fish farmers in the assessment is quite diverse in the manner they apply principles and practices to their operations. The situation is exacerbated by the prevailing political and socio-economic driving forces in the different regions. The priority listing was also different i.e. knowledge on feed quality and reliability of supplies is very important for the WC farmers, whilst the Limpopo farmers listed their priority needs on training and extension visits.

The value of the knowledge exchange project was in talking to fish farmers and gauging their management for analyses of factors limiting or enhancing the growth and development of the aquaculture sector in South Africa. Regular visits and continuous communication with fish farmers were important components of the protocol and served to keep farmers engaged from the onset and through the process. Fish farmers' buy-in improved the output by providing quality information. The Project Team could list new ideas, additional constraints and communicate it to the respondents. At many farm visits the Project Team could identify production aspects that required attention. By way of taking cognisance on how and when to apply appropriate engagement and discussions, the Project Team were successful in exchanging the information to farmers and share their understanding and thereby determining and proposing mitigation measures to address it. Therefore, the challenge remained as to what extent farmers can be supported through successful exchange of technology to enable them to achieve optimal production output with minimum environmental degradation.

The report presents a discussion on potential technology exchange modes that can be considered for improving the flow of information to the fish farmers. Furthermore, strategies are presented on ways of implementing it as well as assessment procedures to monitor and evaluate the impact.

4.2. Area-specific constraints in different provinces

4.2.1 Western Cape province

Unlimited Olive People's Trust

This farm produces about twelve tons of trout per year using four cages in an irrigation dam on the olive farm.

The farmer does not perform any water quality tests, as he feels that the water quality is good enough as is and he has had no issues in the past.

The farmer considers predation (birds etc.) and water temperatures as constraints to his system. Otters are especially clever at getting through and making holes in the cage nets.

Three Streams Trout

This farm produce about 900 000 live trout (for live sale) and 12-16 tons of plate size tout per year in tanks. They make use of 1.5 to 3 tons of feed per month, using less in summer.

Sometimes they experience parasite problems in summer due to the increased water temperatures. They also experience predation by birds and otters, but use nets to protect the fish.

They monitor temperature and oxygen daily.

Lourensford Trout

The farm can produce 30 tons of trout in the cages and 50 tons in the raceways. The farmer uses roughly 120 tons of feed per season.

Water quality tests are performed at least four times a year and, if necessary, more tests are done. Predators include birds and otters. The farmer placed nets around his system. However, he pointed out that the kingfishers are clever and finds a way in.

The farmer has previously lost 10 tons of fish (in one instance) due to a bacterial disease in the second week of October. The chance of bacterial diseases increases with rising water temperatures. Thus, warm water temperatures are a major constraint to this system.

Nuwejaarsrivier Forelboerdery

The farmer currently has two cages in his dam which can each hold 3000 trout. He harvests around 7.5 tons per season.

Previously, the farmer had his cages in another dam, but had to move them due to the high sediment content. The farmer would like to expand his system. However, this depends on the amount of available water.

The water quality in the new dam is decent. However, sometimes algae problems occur in summer. The farmer tests the water quality at a lab before he stocks the cages and a veterinarian also checks the pH-, oxygen-, nitrites- and nitrates levels of the water. Predators include cormorants.

Thambo Lentlanzi

There are four big and four small cages in the dam which produce about 40 tons of trout per season.

The water quality is tested by a student once every two months. Predators include otters, fish eagles and cormorants. Theft is a major problem at this site. The nets are cut by the thieves and this also results in many escapees.

Fizantakraal Trout

There are twelve raceway ponds that produce about 75 tons of trout per year. They make use of about eight tons of feed per month.

The water quality of the farm is tested weekly on Fridays in the dead spots of the ponds. Electric fences around the farm keep most predators out, but occasionally otters do get into the system.

Soetfontein Trout Hatchery

There are ten hexagonal ponds (hexagons) in use on the farm (the porta-pools are not being used). Molopong took over the system in 2014.

Trout are produced all year due to the cold-water temperatures. In winter they produce around 18-20 tons and in summer 12 tons of trout. Water quality is tested on a regular basis with Molopong running the system.

Langekloof Trout

There are ten smaller pools for the fingerlings and six porta-pools for grow-out. They produce 5 tons of trout per year and use a bag of feed per day.

The quality of the water has been tested several times and the farmer experienced that the pH and the water temperature are especially important to control. The farmer also feels that water from the porta-pools are very good for irrigation.

The farmer has no predation problems as his fish are housed in tanks surrounded by netting. However, the fish do suffer from *Trichodina* species infection almost every summer due to their increased susceptibility in higher water temperatures.

Nuwedam & Lomond Trout Farmers

The farmer has cages in two dams and produces about 80 tons of trout per season. Water quality is tested twice a year. Predators include birds and otters. Strong winds have been an issue for the farmer – causing damage to the cages.

4.2.2 KwaZulu-Natal province

Amatikulu Ornamentals

Amatikulu Ornamentals is a large-scale ornamental producing system making use of 300-500 kg of feed per month (3.6-6.0 tons per year) in over 20 concrete ponds (8 X 30 m each).

Constraints experienced by this farmer include predators and transport issues. Frogs and birds are a major issue as they prey on the smaller fish. Once frogs get into the ponds, they are very difficult to remove. Ponds need to be drained and completely cleaned; otherwise the frogs may consume all the fish over time, which can have devastating effects on profits. The Malachite Kingfisher is another predator that preys on the fish. The farmer has made use of nets to try and prevent predator entry. However, as the system is quite large and is also old in certain areas, predators still manage to get in.

Another constraint involves transportation of the fish as they need to be transported alive. During transportation of the fish to their respective customers, the oxygen and temperatures of the water must be carefully monitored to prevent mass mortalities.

In terms of water quality, the pH is mostly checked, as (according to the farmer) little can be done about the oxygen and temperature. If something goes wrong, it is generally due to a pH

change or due to new fish coming in. They use ground water in their system which flows back out onto the land once it has passed through the system.

According to the farmer, the main expenses are feed, transport, land and electricity with transport being the biggest expense; especially when importing and re-selling. A cheaper, alternative feed source would also improve feasibility.

Kel Mark Trading

This crocodile farm harvests around 100 to 500 crocodiles per month; making use of 40 earthen ponds (30 X 15 m) and indoor ponds which hold roughly 300 000 litres of water. There are about 10 000 crocodiles on the farm at a time and they consume roughly 500 tons of meat per year.

The farmer farms with crocodiles which require a warm environment and feels that the biggest constraint to his system is cold water with water temperature being constantly monitored in the crocodile system. Hence, the farmer makes use of some indoor systems to keep water temperatures high. The farmer attempted to grow Mozambique tilapia in co-culture with the crocodiles in these systems. However, Parks Board stopped it as it was apparently illegal to keep predators with prey. The farmer was planning to set up a system where tilapia can use the heated outlet water separately from the crocodiles. The farmer feels that a constraint to this development was that he will require help to get a fish system in place and running as he has little knowledge about fish. He also feels that the information for fish farming that he found was not specific enough i.e. to start out.

The water flows from the Umgeni River (± 8 km downstream of the Albert Falls Dam) through the crocodile system and into settling dams, irrigation dams or back into the river. The farmer admitted that the water was high in nutrients but he did not recently test the quality of this water.

In terms of the crocodile meat products, constraints are experienced with regards to export. The farmer used to export meat, but the government has certain regulations to meet with regards to sampling, which can only be done in Onderstepoort Veterinary Institute, Pretoria. However, they are unable to get samples there in one day, as sampling needs to be done daily. Sampling would thus need to be done privately, which was not feasible at that stage, consequently they prefer to sell locally.

Giants Cup hatchery

This trout farm uses roughly 2-3 tons of feed per year and has an on-going harvest depending on the demand.

The farmer regards water supply, the market, bureaucracy and legal frameworks as constraints to his aquaculture system. In terms of water supply, the water levels in the dam drop very low during the dry season restricting water supply. During storms supply pipes may become blocked with debris which prevents water from reaching certain ponds which may lead to mass mortalities. The market is unpredictable and swings between over- and under-demands. Thus, there has been an occasion when the farmer was left with products for months, while other times everything was sold out within weeks.

Water is obtained from the dam (± 10 km from the furthest stream origin), flows through this system, and then flows back into the river which is used for irrigation purposes further downstream. There is a SAS bio-monitoring station at the top of the farm, as well as below the hatchery. The Department of Water Affairs used to come regularly to check water quality, but have since stopped.

Crystal Waters

This is a small-scale trout farm. The farmer claims to have sold about 10 000 fish of 80/100 g in the past year; mostly for the stocking of local dams.

Predators to the system include otters and the Malachite Kingfisher. The farmer tries to keep them out with netting.

The farmer does not use any methods to test water quality as the water is fresh and clean from the river. To date there has been no problems with water quality as his farm is set far up the river in the mountains. Issues have only arisen when the water supplies have been cut off due to storms, hail etc. The water flows from the river (± 11 km from the furthest stream origin), through the aquaculture system and then back into the river or into irrigation dams.

The farmer does not have internet on his farm as the reception is poor. He also does not have a computer.

If the farmer sees that the fish are not doing well he generally adds some salt to the water. He is not completely sure of what it does, but it seems to help the fish recover each time.

The biggest issue he has had with his system is problems with water flow (due to blockages from storms etc.).

Splashy Fen

This trout farm started off with 50 000 eggs and then later stocked about 5 000 fish per pond. Therefore, they could hold a maximum of 60 000 fish in the concrete tanks in total for the season.

Otters and birds proved to be a problem in the farmer's system. Consequently, thick and high concrete pond walls were built, while netting and chicken mesh was used to keep these predators out. However, after time the mesh rusted and the netting acquired holes. It was later discovered that electric wires, just above the ground around the perimeter, were very successful in keeping otters out. However, there is a cost associated with running anti-predation devices.

They never used to check water quality, as the water from the stream was very clean. Their system is situated high up the river close to the starting point (± 2 km from the furthest stream origin). If anything, temperature was the problem; they would measure temperatures and stop feeding once it reached 19°C. The fish behaviour would generally tell them if there were any issues. Water flows through the system and back into the stream which later joins a bigger river which farmers use for irrigation.

The farmer feels that the main constraint to her system was the minimal water flow during the dry period (end of July to beginning of October) if there hadn't been any snow and rain. The base flow in the river is not enough to maintain reasonable production levels.

Wayfarer Trout

This trout farm has about 150 m^2 of ponds with roughly 230 m^3 of water. They use about 120 kg of feed monthly (1.44 tons a year). They produce about one and a half tons of trout per year.

They say that otters are their primary predators and they use nets covering their ponds to keep them out.

In terms of water quality, they measure the temperatures but otherwise do not do any forms of water quality testing. The water flows from the river (± 6 km from the furthest stream origin), through the system and then back into the river which is then used for irrigation purposes further downstream.

They feel that constraints to their system are their water volumes and the climate. They also feel that the market is rather small in their area and thus have no further plans for expansion.

Bushmans River trout

This trout farm is currently producing about 50 tons a year; however they are now increasing the size of the system and are aiming to produce around 100 tons by next year. They use roughly 130 kg of feed per day (± 47.5 tons per year) depending on the size of the fish in the system at any particular time.

Problematic predators include otters, grey herons, stalks and iguanas. They have used electric fencing and netting to try to keep these animals out. They are also considering scaring devices to combat omni-present predators.

In terms of water quality, the Department of Water Affairs usually checks their water every now and then, with the last visit being about a year ago. Otherwise they just monitor the water temperatures and the dissolved oxygen levels. The water flows from the Bushman's River (± 18 km from the furthest stream origin), through the system and then back into the river which is used for irrigation purposes further downstream.

The manager feels that constraints or issues that may negatively impact the system include high temperatures and low dissolved oxygen levels which can quickly result in large scale mortalities. He has also experienced overstocking problems in the system. Storms have also proven to be an issue as they affect water quality and may also create electrical cuts whereby standby generators need to be used. The supply of electricity is also not reliable and he predicts that power-cuts occur at least once a month.

Peak Trout

This trout farm uses roughly 40 to 50 tons of feed per year. In the first year of production (April 2012 to April 2013) they produced 42 tons live weight of trout, and aimed for 60 tons the following year.

The water flows from the stream (± 8 km from the furthest stream origin), through the system and then back into the Mlambonja River which is used for irrigation purposes further downstream. Umgeni Water Affairs comes to test water quality.

The farmer feels that the major constraints to his system are climate change and lack of government support and intervention. He feels that current issues that face the fish farmer industry are drastic and there is almost no re-investment.

Milestone

This farmer is starting an Aquaponic system with tilapia and vegetables/herbs. He will have roughly 660 fish per round tank and his tanks will hold roughly 5000 L which means that best case scenario; he could harvest about 2 tons per cycle.

He will make use of a re-circulating system with small amounts of water being used for irrigation. He says he will monitor temperature closely once his system is up and running.

The farmer feels that issues or constraints to his system could include electricity costs, feed costs, strong winds, very hot days (which will be fine for the fish, but may cause the plants to wilt) and his lack of knowledge on the ratios of plants to fish.

4.2.3 Limpopo province

Nemubvumoni/Mafukasaga

The farm is a small-scale tilapia farm consisting of eight grow-out ponds and two ponds for juveniles. Fish are sold locally and they harvest their fish twice a year.

Theft is a major constraint to the farmer's system. People come in at night to steal fish as there is no fence. A security or electric fence would need to be erected to help prevent this, however this may be costly. Birds are also a predator problem, which may be combatted by covering ponds with nets.

The other challenge is lack of equipment. She has no scale to weigh the fish and thus sets the price using the arbitrary method (hand size tilapia cost approximately R10).The farmer also harvests using a parachute net, which creates noise and scares away the fish when harvesting. This prevents her from being able to harvest all fish in the pond. The net is also in poor condition.

The stream that is the only source of water is seasonal and the farmer feels that there is a need for the construction of a borehole that could act as a back-up when the stream runs dry. The water is also used to grow vegetables. The farmer uses no methods whatsoever to test water quality.

The farmer feels that another major constraint is the lack of finance or sponsors. She wishes to expand her farm and introduce different species, as well as make it a place where students can come to learn how to fish farm, since it's a new and undeveloped sector in the province.

Another issue is that there are currently no stores/retailers that sell fish feed in the local area. Extension officers organise and deliver fish feed to the farmer. The farmer has no access to internet or to the local library.

Nemaguvhuni

This farm is a small-scale tilapia farm that uses four earthen ponds to produce fish for household consumption. Water is obtained from a spring and flows back into the stream once it leaves the ponds.

The farmer had a major theft problem (especially as he does not live close to the ponds) where people would come and remove fish from his ponds. However he reported this to the police and the suspects were arrested. Since then theft has been minimal.

The farmer also reported that predators have been an issue in his ponds. He says that snakes have been feeding on the fish and has thus had the reeds around the ponds removed where it is suspected that the snakes may hide. Birds are also possible predators; the solution being to cover the ponds with nets.

Access to fish feed is another major challenge for the farm.

The farmer has no access to internet.

Mudau

This farmer farms tilapia in two earthen ponds for household consumption with the hopes to be able to sell fish soon. The farmer hopes to extend his pond, which is currently under construction, to the river and also then introduce cage production to ultimately increase his overall yield per year.

This farmer also faces theft issues (also not living at this location), especially at night due to lack of a security barrier. Finances however prevent him from establishing one, and he struggles to safeguard his fish.

Predation from birds and frogs has also been noticed and this would also require nets to help prevent the issue.

The farmer also feels that there is lack of finance or sponsors in the aquaculture sector.

This farmer does however have access to internet.

Tshivhase

This farmer farms tilapia in two earthen ponds for household consumption only, although he can see the demand for fish in the area.

He is currently feeding his fish with fresh chicken waste. He has no access to internet.

The challenge that the farmer is facing is lack of support and financial assistance. This has prevented him from expanding his fish ponds and applying the knowledge that he had learned from a workshop and would very much appreciate similar intervention to improve his know-how of fish farming.

Ndou

This farmer currently farms with tilapia in two earthen ponds for household consumption, but wishes to expand his fish farming to increase productivity, due to the high demand for fish in the area.

The farmer experiences theft issues due to the lack of fencing. His poor pond structure also makes the harvesting of fish difficult. He feels that he lacks knowledge in the aquaculture field and he feels that there is no financial support and sponsors in the sector.

4.3 Technology exchange techniques

4.3.1 Preface

"Technology exchange, also called exchange of technology, is the process of exchanging skills, knowledge, technologies, methods of farming, examples of farming and associate facilities among governments or universities and other organisations of learning to ensure that scientific and technological developments are accessible to a wider range of users who can then further develop and exploit the technology into new products, processes, applications, materials or services. It is closely related to (and may arguably be considered a subset of) knowledge exchange. Horizontal exchange is the movement of technologies from one area to another. Currently exchange of technology is primarily horizontal. Vertical exchange occurs when technologies are moved from applied research centres to research and development departments, to facilitate the availability to the primary production sector (Fig. 4.1.). This type of exchange is also explored (Adapted from Wikipedia).

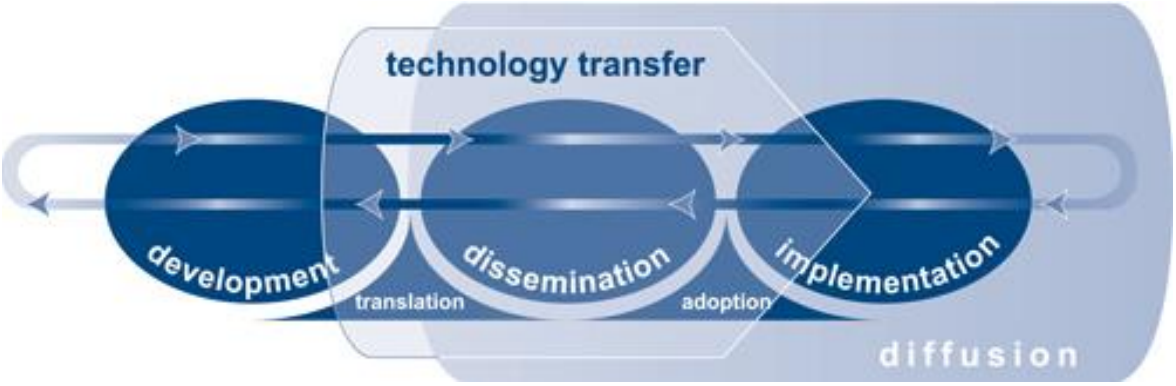

Fig. 4.1. Technology exchange and diffusion (adapted from www.nattc.org).

The rationale is that it is basically known what is working and what not, together with reasons for each phenomenon. Furthermore, technology exchange techniques were identified as ways of making information available, and the onus is on implementation to enhance access and availability. Emphasis was placed on the impact of two related WRC publications*, inter alia*, Training Manual for Small-scale Rainbow Trout Farmers in Net Cages on Irrigation Dams (Salie *et al*., 2008) and the Manual for Rural Freshwater Aquaculture (WRC, 2010) as well as the electronically availability thereof. The dissemination process is subject specific and is focussing on "Water Resource Management". The flow diagram in Fig.4.2 indicates how the target group (fish farmers) are linked to the extension officers and the continuous involvement of university staff in knowledge exchange at different levels. Diverse platforms such as a dedicated website, use of social media and the involvement of study groups are incorporated in the cycle.

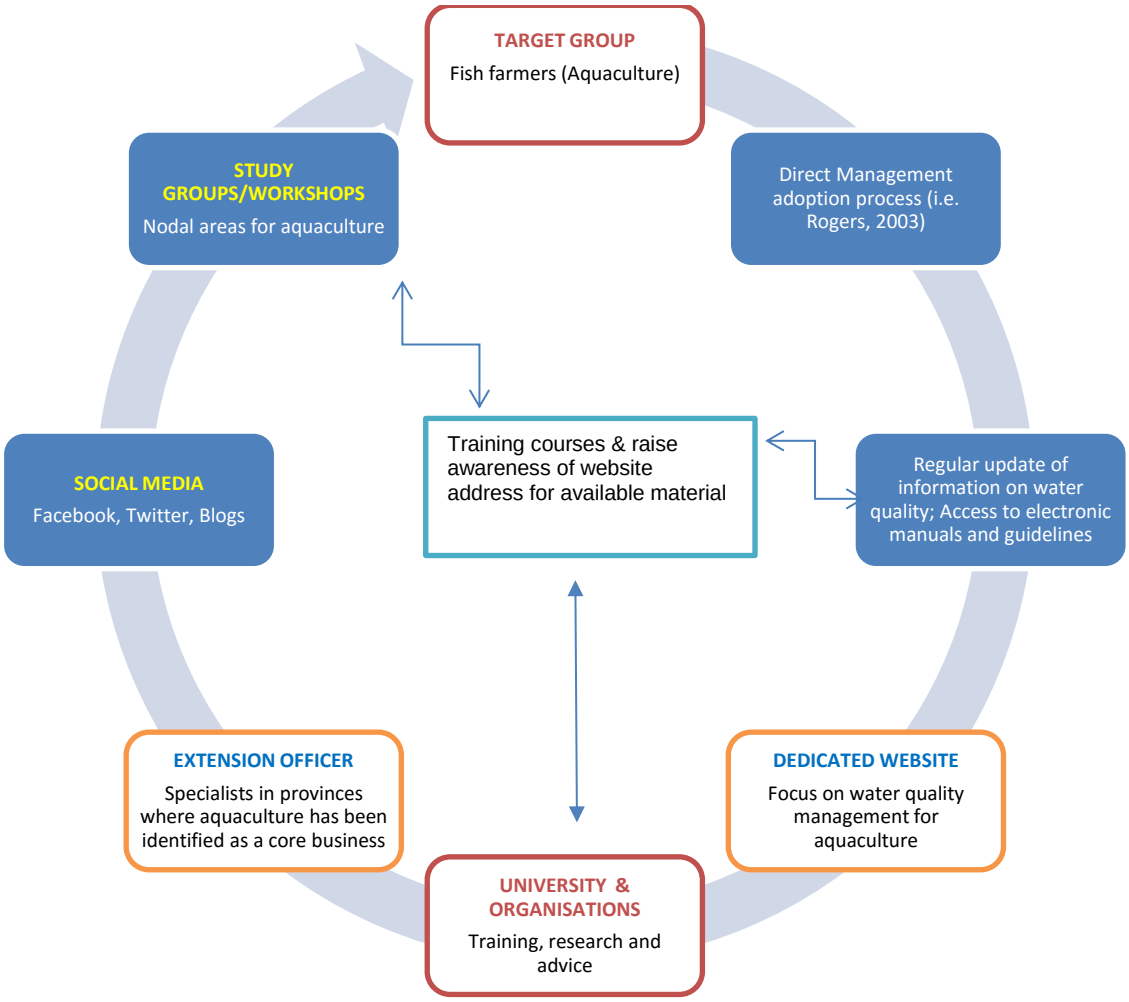

Fig. 4.2. Linking extension officers with fish farmers & with continuous involvement of university staff (Compiled by K Salie based on framework presented by GR Backeberg).

4.3.2 Stellenbosch University's website forum

Background

Web-based applications and forums are mainstreaming information searches and promotion of services in offering. Apparently, acceptance of website-based applications is related with six major factors: internet trust environment, perceived usefulness, and perceived ease of use, facilitating conditions and terms, system complexity, and social influences. Organisations that launch internet applications should be more aware of these factors. Firstly, organisations should actively seek ways to improve internet trust environment to bring security and privacy concerns in their applications, thus forging wider participation. The value of such forums is undermined if users feel that their security and privacy are not protected. Secondly, organisations should add value through these websites, and complement existing forums. Thus it is important to evaluate in which way fish farmers are using internet access to their advantage. Therefore, the investigation should indicate the importance, intention to accept the offering and value the perceived usefulness and ease of use (Lu *et al*., 2014).

Conceptualisation and general design

A dedicated website, based on the Aquaculture Association of Southern Africa (AASA) and the Department of Agriculture Forestry and Fisheries' (DAFF) designs, is proposed to be implemented. The rational to review AASA and DAFF's is that these are two important portals which are consulted by emerging and operational fish farmers. The Project Team envisaged that the web-based contribution should complement existing facilities and minimise duplication as far as possible. Importantly, such a design should focus on Water Resource Management as main content. The design of such a website could follow the following approach:

- **Home**: Contains a fixed header menu used to navigate between different pages built into the website. The menu bar (Home, About, Forum etc.) will be the main navigation bar for the website.
- **About**: A static page providing a general overview of this site, its connection, purpose etc. For users to get a feeling what the site is about and its potential application in benefiting subsistence and commercial aquaculture through working with universities, exchange students, and other potential organisations of learning and teaching.
- **Forum**: The forum will be a communal communication portal where users can post questions, join discussions, contact farmers, and generally just liaise and network.
- **Farmers, directory**: A directory in the form of a list and map (that will be linked) will be set up with of all the fish farmers in South Africa whom are registered with the forum. This directory will contain information such as location, species farmed, links to forum contribution, farm size, and other additional information. The farmers are permitted discretion should they not wish to share information that they feel might have a potential negatively influence on their operation and future outlook.
- **Species database**: A species database will be made available with links to specific pages on sites such as FAO, World Aquaculture Society's publications and popular networks such as Sustainable Aquaculture Research Networks in Sub Saharan Africa (SARNISSA) and WorldFish Centre. These networks are forging a new era for strengthening African Aquaculture and provide information to fish farmers regarding species farmed/listed and specific standard operational procedures.
- **Internship programme/graduate curriculum vitae's**: A student internship and exchange programme has been identified as a valuable outreach mechanism for technology exchange. Further talks and planning with different organisations (DAFF, AASA, Ghent University and Wageningen University and Research) are continuing. It will be established what is required and determine how it could be incorporated into the layout of the site.

The website will also serve as a base to which WRC published material, and other will be incorporated to improve the electronic availability and accessibility to fish farmers.

<u>Case study and implementation</u>

It is envisaged that the website will be linked to the Department of Animal Sciences, Stellenbosch University's existing portal. The initial phase will include a demonstration made available to the respondents in the study. They will be tasked to provide information on usage including to critically visualise the technology exchange technique and supply input to the design and continued implementation. Hereafter, a fully operational website is planned to be launch in the in the near future.

<u>Assessment</u>

The proposed assessment will be conducted via making the forum available to the participating 38 fish farmers in the knowledge exchange project. In return the farmers must provide feedback on their experience in terms of i.e. user-friendliness, usefulness, application and other suggestions of improving or changing the design.

4.3.3 Social media such as student aquaculture blogs, Facebook, Twitter, etc

Background

The usage of social media (i.e. Facebook, Twitter, Instagram, Blogs, Whatsapp, etc) is making headway in being a convenient and relatively inexpensive way of sharing, interfacing and communicating in local and global networks. The Project Team's interaction with fish farmers also accentuated the potential of social media to make a meaningful contribution to disseminating information. It can be measured at three levels—supplier, retailer, and customer—the authors can test social media effects and their ultimate impact on multiple performance measures at farm level. Social media can positively contribute to performance and assess user loyalty and input (Rapp *et al.*, 2013). Therefore, the rapidly increasing use of social media and mobile technologies creates opportunities to form local and international partnerships that can facilitate the process of creating, managing, preserving, and sharing of knowledge and skills that are unique to communities in Africa (Owiny*, et al*., 2014; Joshua, *et al*., 2015).

Conceptualisation and general design

After brainstorming about what and which social media usage to consider, the Project Team decided to support the existing blog administered by one of the postgraduate students. However, what is a blog and how does it work? A blog is an easy way to access the internet to publish whatever they want on the internet without learning Hypertext Markup Language (HTML) or doing any kind of website development of their own. There are literally hundreds of different blogging platforms that provide free hosting for blogs. The advantage is that a blog has a unique way of displaying content, in that is shows up all your latest posts right at the top of the page, and older posts further down at the bottom. Most people started out using it as an online diary or journal, but since then many people have used it to showcase their expertise about various topics. (What is a blog?, [s.a.]). However, social media applications should be constructed within context of the requirements of scheduled workshops and envisaged linkages with study groups in the respective regions. Farmer-to-farmer blogs are also encouraged and can be facilitated by the extension officers. However, the content has to be focussed for greater coverage and outreach.

Case study and implementation

An MSc student compiled an aquaculture blog called MACE Lab, and used it to publish information on activities happening in and around his research at University of KwaZulu-Natal. The blog included updating information on his research project entitled: "An assessment of knowledge exchange systems to freshwater fish farmers in KwaZulu-Natal" as well as conveying information on what is happening in aquaculture in the province. He established good relationship with the Rainbow Trout Producers' Association of the Midlands area and exchange valuable information. The wider application is possible for the outreach can be extended to emerging and subsistence fish farmers where short communications can be facilitated in their

home language. This will prove useful for many of the aquaculture guidelines and practices can be best articulated in the local language.

Assessment

The link to the MACE Lab blog could be provided to the respondents. The usage and participation would therefore be monitored. Respondents would therefore be welcomed to air their views and comments as to the efficiency of this type of social media to make information available. The nature and volume of posting could be advised by the Project Team. Suggestions would further be communicated and evaluated for implementation. To establish permanency in accessibility and availability, it is recommended that social media applications should be linked to the extension officer in the province where a business case has been presented for the promotion and implementation of aquaculture projects. The communication with fish farmers should be primarily via the extension officers, and therefore important information such as aquaculture training courses and marketing opportunities could be relayed.

4.3.4 Graduate internship

Background

World aquaculture production of fish accounted for 44.1 % of total production (including for non-food uses) from capture fisheries and aquaculture in 2014. This amounted to 73.8 million tonnes (FAO, 2016). It is predicted that global aquaculture production will provide 62% of fish for direct human consumption by 2030 (Kobayashi, *et al*., 2015). This will involve greater focus on current constraints and issues that need to be overcome through innovation and engagement with a wide range of stakeholders. This will require the input of research, knowledge exchange and human capacity building. The AQUA-TNET thematic network (Ghent University-based) for learning in aquaculture, fisheries and aquatic resource management conducted work in relation to the role of education and training in strengthening the human capital of the European aquaculture sector as a contribution to overall sector development. Further and higher education organisations play a partial but nonetheless significant role in aquaculture sector development. When considering future contributions to the sector, account needs to be taken of the changes taking place within the tertiary education sector as new technologies; global competition and government policies challenge the status quo of current organisation and practice. Though these present risks, they also offer considerable opportunities to build new collaborations, adopt new patterns of teaching and learning and perhaps apply new frameworks for accrediting learning and skills that could benefit the aquaculture sector (Bostock & Seixas, 2015)

An internship is one of the best ways to gain valuable hands-on. There is no substitute for practical experience in the aquaculture sector, and having the right internship experiences on your *curriculum vitae* can make the difference in providing a competitive advantage when applying for jobs. Internship experience can be of particular importance for students who wish to follow highly competitive career paths or limited specialist positions, i.e. students hoping to gain entrance into the aquaculture sector through a research and management position at an abalone farm.

Internships also enable a student to gain insight into the wide variety of potential careers within a field of interest. For example, a student that has an interest in aquaculture nutrition could try a variety of internships in feed manufacturing, alternative protein sources and *in situ*

performance, or educational programme development in association with farmer and trading organisations such as Western Cape Trout Producers and Woolworths. Students could also specialise even further by pursuing an opportunity within a specific group of aquatic animals, like warm water species (i.e. tilapia and catfish) and cold water species (rainbow trout). Furthermore there are also opportunities within crustaceans and molluscs subsectors, which are both expanding with opportunities (adapted from www.animalscareers.about.com).

It is within this framework and model adopted by the European aquaculture sector that the Project Team considered an internship programme to build the capacity of graduates by exposing them to on-farm practises and develop their skills and experience. The Operation Phakisa initiative of DAFF envisages that the skills requirements would be more than 20 000 in total skilled labourers by 2020. The forecast encourages training organisations to re-visit their strategies on teaching and supplementing theory in practice with vocational skills. Internships have proven to be a successful method to up-skill graduates and put them in contact with farmers in the aquaculture sector.

Conceptualisation and general design

External evaluation conducted in 2016 on the *curriculae* of SU's Department of Animal Sciences as well as input from students highlighted the lack of practical exposure and field research. It has been taken aboard as a shortcoming in the university's aquaculture offering. The design of the internship programme entails that graduates, upon completion, have the option of following an in-service or community year (similar to the health sciences) or progress to postgraduate studies with an MSc in Aquaculture. Exploratory discussions were held with DAFF, NGO's and commercial banks to support such plans and possibly provide internships (like the agricultural internship) to which students can apply during their final year of study. The Project Team has further engaged opportunities in the Western Cape, KwaZulu-Natal and Limpopo, and even in Mozambique. Once sponsorships have been procured, there could be dedicated funding to pay students a stipend for the duration of such internships. The implementation of the internship is envisaged to be achieved beyond the timeframes of the existing project.

Case study and implementation

A preliminary internship has been implemented with one of the postgraduate diploma students in the Limpopo province. The Project Team received valuable information on the first attempt and the idea is to formalise a second visit accompanied by DAFF officials to witness the benefits of such intervention, and formalise a programme structure to be followed by the participants. The efforts will be continuing throughout 2017 and the Project Team endeavour to formalise arrangements with the other participating organisations.

Assessment

A formal assessment will be conducted with the student, either via written or orals exams. As a benefit to the fish farmers, the Project Team would ascertain the adoption and success level. These could be achieved through monitoring and evaluating the implementation of technologies i.e. on feed and water management. The logistics and delivery date still needs to be finalised for additional planning is required to provide a sustainable opportunity to future students.

4.3.5 Workshops and seminars

Background

The workshop method of exchanging knowledge has proven to be interesting and effective and new collaboration opportunities are possible with fish farmers and government officials. Participants usually expressed their interest in using such a platform, mostly as a means of interacting with resource persons, but also as an opportunity to market themselves and communicate their successes and failures. Some can even communicate their intention to consider the sharing of some of their technologies and experience, both for their projects and for a wider audience of fish farmers and officials. Workshops have the potential to open a communication channel with the aquaculture community. One of the challenges associated with workshops is the difficulty in attracting wider participation of the sector audience, which is not a simple task for R&D projects (Arranz *et al.*, 2014).

Conceptualisation and general design

The approach was to hold a participatory appraisal with the fish farmers in the Limpopo province and include extension officers, where available. The initiative was used to explain the aims of the WRC knowledge exchange project and the envisaged involvement of the fish farmers. Farmers were also presented the opportunity to raise their concerns about the lack of support they were receiving. Furthermore, they were also encourage to present suggestions on improving delivery as well as required information that can make a difference to their farming operations.

Case study and implementation

In August 2015, a workshop was held with 22 Limpopo freshwater fish farmers in Thohoyandou, Limpopo. The workshop was held at the Department of Agriculture with an extension officer present acting as translator as all farmers' home language is Venda. The workshop was facilitated by a team member and a postgraduate student in aquaculture from Stellenbosch University. Smaller workshops were also conducted in the WC and KZN.

Assessment

An important lesson learnt from the workshop proceedings is that using an extension officer from the same province is not conducive to objective interaction among participants. The reason being that as the workshop started it became apparent that farmers are frustrated and angry with what appears to be a lack of service delivery and inability of extension officers to provide required information. The farmers value and respect academic learning organisation's skills and knowledge as provided by Stellenbosch University and therefore welcomed opportunities to engage. It was time consuming to translate workshop aims and achieve workshop aims. The irritability of all was compounded by friction between farmers and government extension officers.

This is an important learning in technology exchange for the aquaculture sector, especially if it is expected that the government extension officers are the conduits to disseminate information to target audience. In Limpopo province, it is suggested that alternative modes of technology implementation should be used until improved relations develop between fish farmers and government extension officers have improved. It is important to note that in WC and KZN the fish farmers have similar perception that government extension officers are not adequately trained and lack experience. The current situation hampers the ability of using the workshop as a viable technology exchange mode.

At the workshop, farmers value opportunities for specific questions related to their farm operation to be answered rather than generic overview of different components of production. Farmers also have a preference to be visited on farm to explain first hand current production and to demonstrate challenges experienced.

Fish farmers are operating at diverse levels of operations. For i.e. more than five farmers referred to feeding fish with maize and bread, thus needing assistance with developing their own feed as cost of feed was too expensive. In the same group, there were four farmers operating at commercial level with one farmer selling to a local retail outlet.

A recommendation for future fish farmer interactions is to use farmer profile to develop dedicated sessions at similar operational levels or alternatively encourage farmer-to-farmer exchanges where none such exchanges are occurring.

4.4 Technology adoption and implementation

4.4.1 Preface and scope

Aquaculture is practised on an integrated manner with agriculture practices in several irrigation dams and networks in South Africa with significant potential available from these water resources. The need for improved understanding of knowledge applied by farmers in their production practices sourced from peer reviewed and mainstream multimedia is essential to support farmers with growing water demand. There is a lack of understanding on how knowledge is interpreted and applied with technology access considered as key constraint to agribusiness development in South Africa.

Results from this study confirm that much of available knowledge does not reach household and producer level. Technology exchange was most successful when conducted at a time when people had a specific need for it in their projects.

Literature over the last eight years show there is a significant number of technical documents and academic publications available on aquaculture production utilised water sourced from irrigation dams or associated networks with agriculture being its primary use. Despite numerous workshops and information held to disseminate information the technology adoption and implementation is not well understood. This study showed low levels of adoption of one of these key documents, *A Manual on Rural Freshwater Aquaculture,* with only 9% of farmers' surveyed are aware of this document and have implemented information provided.

This study builds on primary data collated in 2014 to assess local knowledge systems in KwaZulu-Natal, Limpopo and the Western Cape wherein farmer selection was based on three criteria. These are that farms are operational; water source is primarily used for irrigation and thirdly that secondary use of water resource is aquaculture. Candidate species included were tilapia, rainbow trout, crocodiles and ornamental fish. Farmers selected for this study use closely related farming systems and are in similar locations in WC, KZN and Limpopo. The majority of farmers selected are similar to those in sample of previous research to expand primary data to improve upon empirical analysis to be undertaken in next phase of research.
Information sources used by farmers are Internet, trial and error, higher learning organisations particularly Stellenbosch University as well as farmer-to-farmer exchange. Current levels of

adoption of these modes together with radio and television (TV), government extension and training manuals (printed, electronic and CD) was accessed with results analysed and discussed in next section.

4.4.2 Modes used for access information

A mixed method approach was used that includes desktop review, semi-structured interviews and focus group discussions with farmers and extension officers to collate primary data. A total of 15 semi-structured interviews were done with seven WC and eight in KZN provinces. The profile of farmers in WC and KZN province is 100% male with average experience of more than 10 years, tertiary academic training in aquaculture and operating at a commercially viable scale. Farmers (33%) in WC and KZN provinces have had exposure and experience to aquaculture internationally. Two members of Underberg and one member of the Western Cape Trout Association were also interviewed. A total of 20 farmers participated in the focus group discussion in a workshop format in Limpopo province. The profile of farmers in Limpopo is 28% female and 72% male with average experience of 2 years, 20% with formal training in aquaculture and 17% operating at a commercially viable scale. The farmer profiles highlight the diverse nature ranging from highly skilled with significant experience to low level of skills with little experience operating at subsistence to commercial scale of operation. Better understanding of modes used to address information needs for diverse group of freshwater aquaculture farmers may provide critical insights into successes in implementation, constraints experienced by farmers and recommendations for improvements.

Extension officers in WC, KZN and Limpopo provinces were contacted to conduct semi-structured interviews. One specialist aquaculture extension officer and aquaculture researcher was interviewed from the Western Cape Provincial Department of Agriculture. Efforts to conduct interviews with extension officer in KZN and Limpopo province were more difficult. At the time of the study it was noted to the knowledge of authors that the Western Cape province is the only provincial agriculture department with dedicated aquaculture extension officer with formal tertiary qualifications and experience in aquaculture.

The main technology modes used by freshwater aquaculture farmers to access information identified by desktop review were:

- Internet using mobile phone and computer (laptop and desktop)
- Government extension officers
- Farmer-to-farmer interactions both locally and globally
- Radio and television and
- Learning organisations

All the interviewed fish farmers (100%) use the internet to access information, 9% received it from extension officers, 13% from farmer-to-farmer interaction, none from radio and television, and 53% access information from learning organisations (Fig. 4.3.). Farmers do watch agriculture programmes on TELEVISION but stressed there is no specific and relevant content on freshwater aquaculture.

There is also an opportunity to promote aquaculture research and development via advertisement on television and radio. The fish farmers felt that such initiatives could go a long way in increasing the awareness of aquaculture and provide access and participation in the wider food producing sectors in the country.

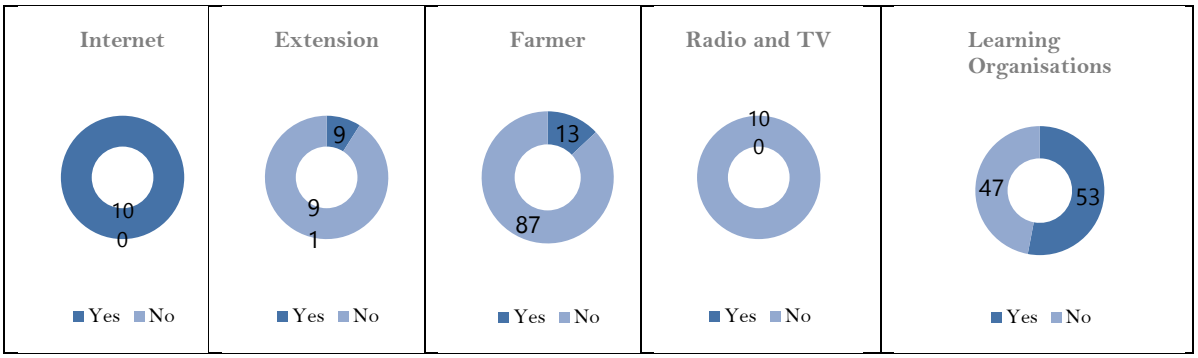

Fig. 4 3. Modes used to access information (Data source: Number of respondents from survey).

4.4.3 Internet

Farmers use search engines to access information to find solutions to problems with no preference cited for dedicated aquaculture web sites.

The Aquaculture Association of Southern Africa's website has significant resources on freshwater aquaculture available online that include publications (sector reports and bimonthly newsletters), blog and twitter feeds, check list for start-ups, list and contact details of associations, conference information, Asia case studies and benchmarking survey, market analysis, etc. Farmers however were not aware of these websites and currently do not access information from them.

The majority (93%) of farmers surveyed own mobile phones and 47% use private mobile phone for business, use both private and business mobile phone as well as sending text messages for business purposes. The ease-of-use of many mobile devices has made it easy for farmers to integrate their private as well as business usage.

Table 4.1. Summary for the use of internet sources.

Use of Internet	% Respondents
Use private mobile phone for business purposes	47
Business has dedicated business mobile phone	27
Both a private and business mobile phone	47
Send text messages for business purposes	47
Receive text messages for business purposes	20
Does the business send or receive money via mobile phone	0

All farmers surveyed make use of internet to access information for farming. The internet is used to access a variety sources. Results in Fig. 4.4 indicated the main topic areas considered with 80% for technical, 67% for feed 60% for market, 53% for weather, and 47% for finance information. The farmers also iterated that the success of the internet use is also dependent of the keyword search. Many felt that they missed valuable sources of information through simply inserting the wrong keywords. However, there is agreement that much of the technical information found on internet is largely for the international audience and thus farmers communicated a need for information to be tailor-made for the South African aquaculture context. It was also felt that other emerging economies in Africa could play a vital role in exchanging information, specifically on freshwater fish species. Many African countries such as Kenya have found innovative ways of improving their awareness of aquaculture and increase the development of fish farming projects (Maina, et al., 2017).

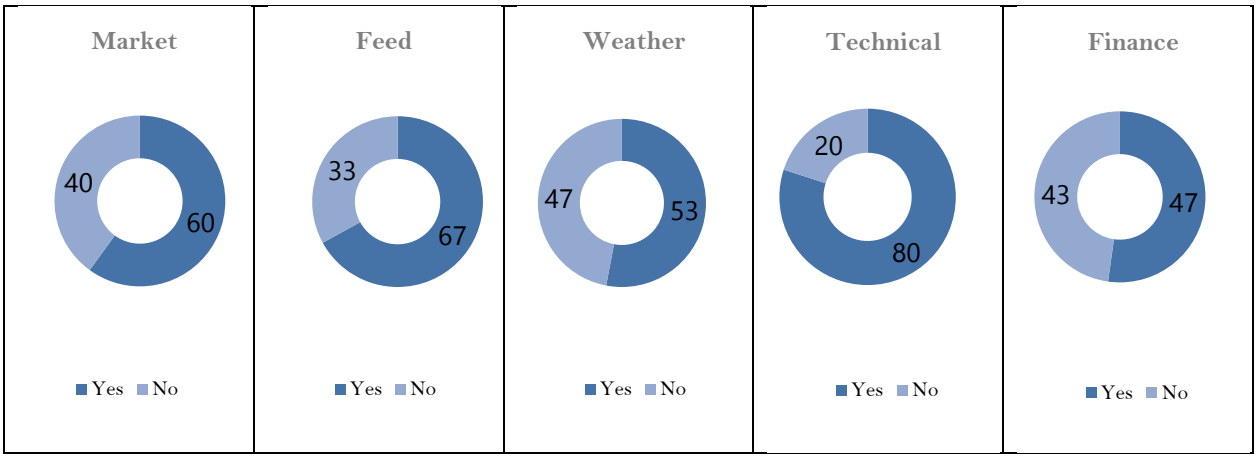

Fig. 4.4. Type of information accessed on internet for fish farming (Data source: Number of respondents in survey).

Farmers interviewed did not experience any limitations to internet use. Farmers did express security concerns related to internet use with 33% being somewhat concerned, 13% very concerned and 13% extremely concerned.

Table 4.2. Security concerns relating to internet use.

Not at all concerned	27
Somewhat concerned	33
Very concerned	13
Extremely concerned	13

4.4.4 Extension

The majority (91%) of farmers interviewed indicated that they were not aware of service offering of extension officers and had not received information or farm visit from them. The 9% of farmers that source information from extension officers do so to gain information on finance (13%), market (7%), technical aspects (7%) and weather (7%) as indicated in Fig. 4.5.

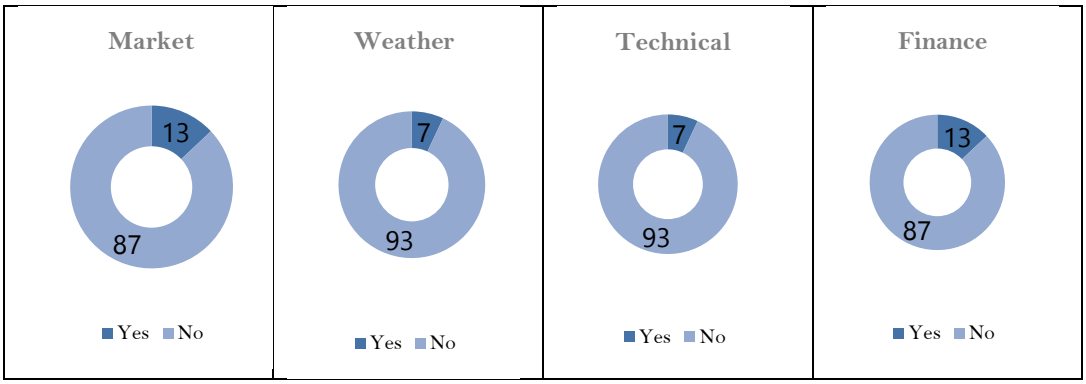

Fig. 4.5 Type of Information accessed from extension (Data source: Number of respondents in survey).

Farmers cited turn-around time of two years to complete the environmental impact assessment needed for production expansion as a problem which it results in significant delay in business operation.

Extension officers in WC, KZN and Limpopo were contacted to complete survey with successful response received from WC. Given this unique skill set and experience of the extension officer in the WC, he is often called upon to support departments in other provinces hence scope may extend beyond Western Cape.

The target audience for Western Cape aquaculture extension officer include large commercial operators, entrepreneurs wanting to start business in aquaculture and potential applicants for government's funding for aquaculture. *Ad hoc* requests for information are received from extension officers in the field or from Western Cape Department of Agriculture at Elsenburg. Extension service includes client support to apply for government funding. Government funding sources that could be considered are Department of Agriculture's Comprehensive Agriculture Support Programme (CASP), Department of Trade and Industry's Aquaculture Development and Enhancement Programme as well as Department of Rural Development and Land Reform. The annual Western Cape Agriculture Department's CASP budget was approximately R7 million for 2016. The allocation is considered to be low considering capital cost to start operation in aquaculture. Information dissemination includes support to develop business plan for funding proposals.

The farmer support unit of the Western Cape government Department of Agriculture focuses on providing support to new previously disadvantaged entrants to the sector. It distributes 15 page information brochures on tilapia and 18 page information on rainbow trout. The information brochures provide a list of contact details for key sector players, production cycle, market trends and references for further reading. There is still expectation by some clients for extension officer to "farm for them" with clients often not doing minimum level of due diligence and "want to be spoon fed". Farmers have limited information on their own operations with example cited that farmers do not know depth of farm dam. Skilled and experienced farmers are provided mentorship and technical skills to small-scale farmers at no cost presenting innovative technology mode that is underexplored. Government funding information available for small-scale farmers is provided by extension officers. Department of Agriculture is looking to improve the data base called Manstrat (http://www.manstratais.co.za) so that all extension officers can have access to required information on aquaculture to solve resource capacity challenge. It is also funding attendance of five fish farmers at annual AASA's biennial conference. It does appear that extension officers tend to focus largely on clients applying for government funding at the expense of existing freshwater aquaculture producers as it is time consuming to provide service to former client.

4.4.5 Farmer-to-farmer

Farmers continue to rely on support and exchange with farmers for information. The ability of farmers to share information with other farmers has been curtailed in the last five years with introduction of stricter intellectual property arrangements making it more challenging to share information due to confidentiality clauses. Commercially viable operations are being managed by knowledgeable individuals with at least 15 years of experience. The type of information shared included feed, weather and technical information with 53% of respondents confirming this as indicated in Fig. 4.6 below. Market (40%) and finance (12%) information are shared to a less extent for this is deemed as providing a competitive advantage other farmers in the area. However, the rainbow trout sub-sector is relatively small and fish farmers engage processors regularly on determining market prices, delivery dates and overall expected quality of produce.

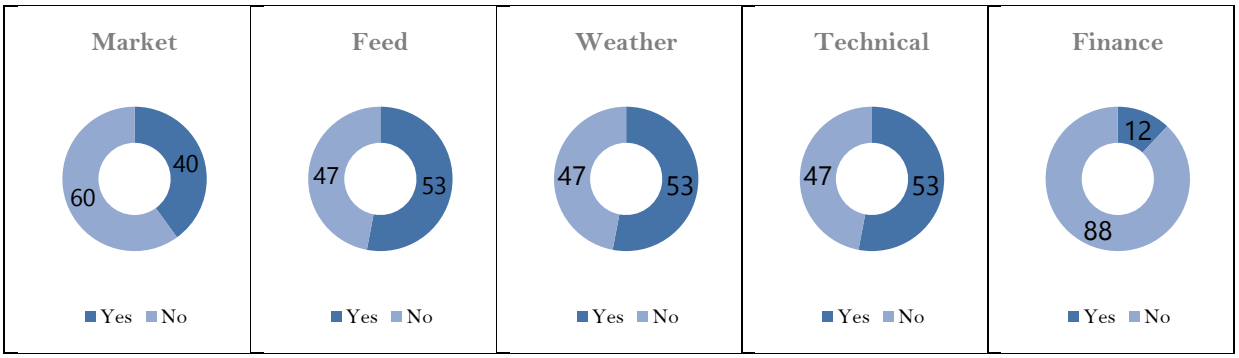

Fig.4.6. Type of information accessed from farmer-to-farmer (Data source: Percentage of responses in survey).

Farmers actively support local trout associations as these may be the vehicle to improve farmer-to-farmer interactions in the presence of strict intellectual property rights.

4.4.6 Radio and television

Farmers do listen to radio and watch television for personal use but not for fish farming. This is attributed to lack of relevant content. Farmers did communicate they would welcome dedicated aquaculture information on radio and TELEVISION.

4.4.7 Higher learning organisations

A large proportion (53%) of farmers makes use of learning organisations to access information. Farmers make use of technical (27%), market (27%), feed (20%), finance (20%) and weather information (13%) and the graphs are shown in Fig. 4.7.

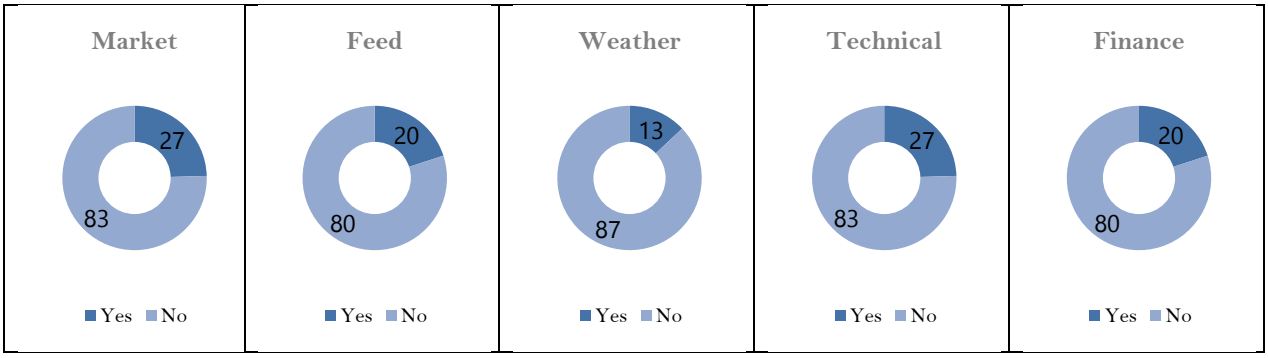

Fig. 4.7. Type of information accessed from higher learning organisations (Data source: Percentage of responses in survey).

The criticism pertaining university courses is that more focus is required to be placed on practical hands-on case studies to avoid over-estimation of performance of imported technology that has not been demonstrated to work in South African conditions. An example raised was the case where Aquaponics technology was recommended by a university although it had not been successfully proven to work in local conditions. Recommendation was made for short courses to be offered in home language of farmers where it is financially feasible.

Farmers value the role of universities in knowledge sharing particularly in building foundations for students and new entrants to the sector to answer the “why” question. It was also stressed that hands-on experience gained on farm is critical for success.

The learning organisations cited by farmers that have been used to source information are Stellenbosch and Rhodes Universities in South Africa and Stirling University in Scotland. Stellenbosch University offers graduate and postgraduate programmes as well as certificate and diploma courses with information available online. Rhodes University's service offering is provided by the company, EnviroFish, and includes business services to new entrants, research, environmental compliance and due diligence. Many farmers surveyed have received academic training at Stellenbosch University doing the structured graduate programme and certificate course.

Recommendations based on farmer responses to improve information access from this mode are to create platform on website for Stellenbosch University Certificate alumni to interact on the Department of Animal Sciences website, create on-farm internships for university students in general and in particular in Limpopo, provide dedicated technical information pieces for i.e. Aquaponics on university websites and conduct capacity building of extension officers with attendance of formal aquaculture curriculum using hands-on case studies and in-field visits to farms and commercial operations.

4.5 Assessing technology implementation

Sahal (1981) stresses that in the study of technology exchange and diffusion it is inadequate to focus only on product but also the use and application. In measuring use and application it is important to identify who is doing the technology exchange, how they are doing it, what is being exchange and who is the receiver. In assessing technology implementation the product focus is Manuals on freshwater aquaculture intended for use by government extension officers when training or in field interacting with farmers.

In 2008 Stellenbosch University published a Training Manual for Small-scale Rainbow Trout Farmers in Net Cages on Irrigation Dams (Salie *et al*., 2008) whereas as well, in 2010 Rhodes University published a Training Manual for Rural Freshwater Aquaculture (WRC, 2010). The primary target audience as described in both manuals were to train government extension officers and to be used in field when interacting with fish farmers. Hence it may be implied that the secondary target audience is farmers who will receive training and in-field farm visits from extension officers. The manuals are available in English in three formats, such as, electronic copies on websites of National Department of Agriculture and WRC's Knowledge Hub, hard copies and CD's are available by order from the WRC.

The application and use of the manual were assessed with both primary (government extension officers) and secondary (fish farmers) target audience. Extension officers and farmers were provided with hard copies of the manuals and asked to assess application on farm productivity and water quality.

4.5.1 Manuals on freshwater aquaculture

Farmers were introduced to the manuals by enumerators and asked to elicit response on which section (s) of the manual would be most valuable. Farmers surveyed in KZN and WC provinces were presented with hard copies of the manuals and asked whether they are aware of or had knowledge of the manual. Despite the existence of both manual for almost six years in different published formats, the farmers surveyed were not aware of document. The primary audience of

manuals was for extension officer to use in training and during farmer interaction in-field. Given that only 9% of farmers interviewed access information from extension officers it could explain why farmers were not aware of these manuals. Although these manuals are available online, one needs to assume that farmers were not accessing these sites for information. Farmers did confirm that search engines are used to access information and not specific aquaculture websites. Fish farmers in the WC also did not specifically consider reading further the rural aquaculture manual for they thought it was not applicable to their bigger scale operations.

More focus groups discussions are needed to test and experiment best online platforms to provide information for i.e. farmer-association websites. It may be of value for dissemination of manuals or learning material in future to create feedback mechanism for readers to track profile of reader, elicit responses to understand value of manuals in all three formats and ask for recommendations from readers. The semi-structured interviews and workshop format used in this study has been a good example of feedback mechanism. It is also recommended that this exercise is repeated every two years before information is out of date.

For electronic version of manuals available on web sites farmers can be asked to complete short feedback form prior to downloading the document and contact list of all respondents that order directly from the WRC. Of the critique on the manual format included that it is too “text heavy” and suggestion was made to use more graphics or photographs. Farmers identified most valuable sections are those focused on feeding, production forecasting, hydrology, fish and trout biology.

The Western Cape extension officer and researcher interviewed were familiar with two WRC manuals and has found useful when interacting with farming and prospective applicants of funding for government grants. In the WC province, the home language of many farmers is Afrikaans hence suggestion made that manual be made available in more than one language spoken by farmers. The ability to measure impact of technology mode adoption to success of farming was posed to farmers interviewed by asking them to identify key metrics used to measure success. In Table 4.3 the qualitative results are shown on most appropriate metrics to measure impact on both farm productivity and water quality showed feed conversion ratio is most significant indicator. This is particularly relevant as information on feed was highlighted as key area for research.

Table 4.3. Appropriate measures to measure impact on farm productivity (data source: survey).

Farm Productivity	Water Quality
Production volumes	Oxygen,
Quality	Temperature
Food conversion ratio (FCR)	pH
Mortalities	Turbidity

Farmers cited cost of water quality testing as a deterrent to conduct such tests. None of the farmers had received farm visits from Department of Water Affairs to assess water quality. For water quality farmers highlighted the key issue is to remove fish faeces particularly during drought periods. A few farmers are implementing Quality Health Management Programme by private veterinary consulting services completed three months per year that incudes diagnostic tests on fish health and water assessment. Farmers in the WC cited market access requirement for compliance with voluntary seafood certification programme called (South African Sustainable Seafood Initiative (SASSI) as key driver to conduct water assessments.

Farmers benchmark success using key metrics identified with farmer-to-farmer exchanges via internet or social media what's app exchanges as well as using international websites.
Recommendations provided by farmers and extension officers interviewed were:

- Monitor distribution of manuals in all three formats and ask readers to provide feedback.
- Update contact details in manuals in print or electronic format.
- Provide reference to resources for more advanced level to cater for diverse range of farmers.
- Provide web links to manuals download on learning organisation and farmer association websites.
- Products developed are made available in home language of fish farmers.
- Ease of read and use may be improved by including more graphics and photographs.

4.5.2 Workshop with small-scale fish farmers

Workshops remain an effective way of knowledge exchange. However, the facilitation is planned events are crucial to achieve the desired outcome. Using a knowledgeable person such as an extension officer could to conflict situations, especially if the official is serving the same audience. In Limpopo it became apparent that fish farmers were frustrated and angry with the lack of assistance provided and as a result inadequate service delivery. The farmers described the situation as the inability of extension officers to provide required information. It was further discovered that fish farmers in general and respect organisations of higher learning for their skills and knowledge and welcomed any opportunity to engage and exchange knowledge. Time allocated to workshop proceedings should also be kept in mind for it requires a lot of time to translate workshop aims and repeat participants' comments. Furthermore, a workshop could easily be side-tracked if issues outside the agenda is discussed or debated as a result of facilitator-participant conflicts.

This is an important lesson learned in knowledge exchange in the aquaculture sector and the assumption that the best technology mode is to distribute information via government extension officers for it is primary their responsibility to provide information via different sources. In Limpopo province in the current context alternative modes of technology implementation is needed until improved relations develop between fish farmers and government extension officers. In the WC and KZN the farmers also have perception that government extension officers were not adequately trained and lack experience to advise them sufficiently. In general fish farmers do not recall receiving regular farm visits from government extension officers. The governmental source is basically used to access information on funding available and what assistance is provided with performing environmental impact assessments.

In the workshop in Limpopo 3 out of 22 fish farmers were familiar with and had knowledge of the training manuals. They found the sections on fish biology, feed and production systems as valuable. Furthermore, farmers usually valued the opportunity to pose specific questions related to their farm operation and expected it to answered rather than providing generic overview of different components of production. In the three provinces farmers exhibited that they had a preference to be visited on farm for it would provide first hand explanation of current production challenges. Therefore, it is recommended that government officials as well as personnel of higher learning organisations compile farmer profiles as background information prior to facilitating knowledge exchange sessions.

4.6 Conclusions

The constraints to technology exchange as experienced by the fish farmers include a range of factors from those associated with lack of ICT (information and communication technology, i.e. access to internet) to that of understanding the importance of regular monitoring and evaluating the water quality on the farm to ensure long term sustainability of their fish farming operations.

Most of the farmers have problems with managing predation. Predators such as fish eagles, cormorants, frogs and otters hunt fish and cause huge losses and damages to systems. The farmers were calling for information sessions on appropriate management for some of these species are threatened or protected by law. The general feeling is that the farmers would like to work with the authorities and not destroy or bewildered predators indiscriminately. However, predation leads to huge financial losses when fish are captured or wounded during hunts.

Although there is a lot of information available, farmers also find it difficult to navigate through literature. They were not sure whether it is outdated, or is it relevant to their production systems. The farmers also find it difficult to determine if the information is reliable and sources can be trusted. Farmers tend to put more value on the information provided by older or seasoned farmers than that available on the internet. They believe that farmers whom have been active for many years have encountered problems and managed to find workable solutions.

Many farmers did not conduct any water quality testing for they assume the water provided by springs and streams is of good quality. Farmers were also dependent on the Department of Water Affairs to perform regular water testing in the area. Furthermore, in some cases farmers were monitoring basic parameters such as dissolved oxygen and temperature, whilst other did not even monitor these basics. The farmers indicated that they observe fish regularly and can tell when something is wrong. They would also apply reactive treatment such as salt dosing as a standard procedure to treat ill-appearing fish.

Information was clearly lacking on the legislative framework governing aquaculture. Farmers believe that the aquaculture sector is unduly bureaucratic and “over-regulated”, thus not creating an enabling environment for the sector to grow. They express a need to communicate regularly with government officials to receive the latest policy development supporting growth, and held officials accountable for delivery or lack thereof. Farmers also require direction on relevant issues such as permits, impact assessments, producer representation and certification and exclaimed in many ways that they usually receive conflicting views from the different state departments involved in aquaculture. They express not only the lack of communication from government to farmers, but even communication among the different departments is appalling.

All the farmers called for market intelligence to expand their operations. They are not informed about potential markets, product development and trading incentives as provided by the government, i.e. Department of Trade and Industry. Farmers also indicated that there is lack of development finance and sponsorship, as well limited access to loans from commercial banks. Furthermore, no real investment is ploughed into the sector. The farmers indicated that they could not find suppliers or stores selling fish feed, thus making it difficult to maintain good feeding practices. This is considered the reason for underperforming or unsuccessful projects.

In Limpopo, specifically, farmers felt that the knowledge obtained at workshops cannot be applied as they were made to believe during their training sessions. This leads to insecurity in managing their fish farming operations, and is further exacerbated by minimum support from extension officers. In many instances farmers were given starter packs and were made to sort

operations all on their own. Therefore, they had no way of telling what they were doing is correct or how well the fish were performing in the production system.

Other aspects mentioned that constraint their aquaculture developments include, lack of specialised equipment, theft, and disease outbreaks. The farmers were calling for an independent body/person to conduct regular water testing and disease monitoring. They realise the value of early detection to prevent mass mortalities.

Fish farmers also felt that the sustainability of the operations are threatened by climate change, unpredictability in water supply from streams and boreholes, strong winds destroying cage culture infrastructure, and the occurrence of algae blooms affecting product quality and dissolved oxygen concentrations in the water column. Farmers with cold freshwater species were very concerned about the onset of warm water temperatures earlier in the season, thus shortening their production timeframe and increasing risks associated with farming into the warm water period. They would welcome some sort of prediction charting to consult and anticipate inclement weather patterns.

The above-mentioned were the main constraints associated with technology exchange and the farm environment in general, as recorded during the interviews with the fish farmers. There were already multi-media and other modes available of exchanging information. These included cell phones, radio and television and agricultural farmer's days. The onus is now on the decision-makers to interrogate these constraints, and provide possible modes of knowledge exchange. Furthermore, one needs to build in processes at farm level to ensure successful adoption and implementation.

Fish farmers were using a range of technology modes to access information that were relevant to their operations and did not use modes that did not add value. The internet is certainly the dominant technology mode used in the WC and KZN province but is to a lesser extent existent in Limpopo province. A significant amount of information is available on the national departments' aquaculture website. However few farmers were aware of information or have accessed it.

Farmer-to-farmer interaction continues to be a critical information source in WC and KZN and to lesser extent in Limpopo province. A growing reality that may become a future constraint to farmer-to-farmer exchange as identified in WC is intellectual property rights which prohibits farmers from sharing information and may requires creative private public sector collaboration on non-competitive areas of value for the sector.

Farmers continue to hold learning organisations in high regard, but criticised them of not focussing on practical hands-on case study teaching methods. Given this and the volatile situation in Limpopo province regarding poor relations between farmers and government extension officers, higher learning organisations might have potentially a critical role to play in facilitating and leading as technology mode for information access. Suggestions related to the study were highlighted and included to monitor distribution of manuals in all three formats and ask readers to provide feedback. It was also proposed to update contact details in manuals in print or electronic format, provide reference to resources for more advanced level to cater for diverse range of farmers. It should also provide web links to manuals download on learning organisation and farmer association websites and the products developed are made available in home language of fish farmers. Ease of read and use may also be improved by including more graphics and photographs.

A key learning from this study is lack of visibility of government extension officers providing information or extension at farm level in all three provinces. In some instances, as in Limpopo province it has created animosity between farmers and extension officers with no apparent solution in the short term. It does however present opportunity to focus on technology modes that farmers currently are valuing and for learning organisations to play role in capacity building if this technology mode is found to continue in future.

Opportunities for future research or technology exchange identified with farmers in Limpopo were to place dedicated postgraduate interns from Stellenbosch University at selected farms. Furthermore it should be investigated whether technology demonstration centre could be implemented either on farms or at one of government owned facilities. Lastly, given lack of internet facilities, it is suggested to test short message service or voice message service as an additional source to provide focus on feed, finance and market information.

Opportunities for future research or technology exchange identified with farmers in Western Cape were public private sector collaboration on feed research, structured mentoring programme for farmers and postgraduate students and learning exchanges with other provinces as well as internationally. In Limpopo province, there is urgent need for technology exchange skills and most cost-effective way to achieve this may be placement of postgraduate intern with farmers, training on financial management and market requirements as well as support to encourage more contact sessions between farmers.

The interaction with farmers has highlighted the need to work with farmers to understand their needs at farm level and has to be led by organisation and or individual (s) that farmers trust and recognise as having relevant skills and experience. Given the small numbers of farmers in the three province solutions need to be tailor-made to specific needs and cost effective. Technology modes available using internet, voice and SMS present opportunity to cater to these needs with specific recommendations identified from this study to act upon in the next phase of this WRC project.

The four key technology modes recommended to assess in more detail is Stellenbosch University website platform for *alumni* of short course graduates, postgraduate student blog started at University of KwaZulu-Natal for aquaculture, student placed as intern in-field and lastly workshop with small-scale farmers.
The technology exchange techniques selected and implemented by the Project Team provided valuable insight to the efficacy of such modes. This is the first step towards improving delivery and dissemination of much needed information at farm level. However, the application should be seen in context with the constraints to technology exchange as experienced by the fish farmers. These include a range of factors from those associated with lack of access to ICT (information and communication technology) to that of comprehending basic practices and principles pertaining the importance of regular monitoring and evaluating the water quality on the farm, conducting frequent subsampling to calculate feed conversion ratios (FCR's), and feeding fish appropriate diets to minimise wastage and water quality deterioration. Furthermore, fish farmers do not always realise the extent of the consequences of their actions and how it can compromise the long-term sustainability of their fish farming operations.

During the engagement with fish farmers, most of them raised specific concerns and problems they experience on the farm, such as low dissolved oxygen levels, sick fish, and the prevalence of predators. Although these problems were *ad hoc* farmers usually want rapid response in terms of receiving the relevant information and advice. They were also much aware that they are dealing with live animals which require immediate attention, and need to act to minimise losses. Therefore, irrespective of technology exchange technique, farmers were calling for information on appropriate management to the current situation. The general input received is that the farmers would like to work with the authorities and improve the communication between them.

The four technology exchange techniques are at different stages of progress. There is a lot of information available pertaining to each technique, as well as a multitude of other to be considered, such as formal qualifications at different educational levels, cellular phone-based short messaging services, demonstration stations, seasoned fish farmers in the area, etc. Fish farmers were already at a lost trying to navigate through mass literature on aquaculture, and therefore the demand and needs to receive and interpret took priority over continued supply of information. Fish farmers expressed many a times that they require information that is reliable and sources can be trusted. Farmers tend to put more value on the information provided by older or seasoned farmers than that available on the internet. This person to person exchange still has much value to farmers and they appreciate “old hands” whom have been active for many years and revised ways and means of dealing with problems through workable solutions.

There is a disjunction as to the responsibility for technology exchange. Government is expected to deliver this service according to the legislative framework for aquaculture research and development. Farmers believe that the aquaculture sector is unduly bureaucratic and “over-regulated”, thus not creating an enabling environment for the sector to grow. They express a need to communicate regularly with government officials to receive the latest policy development supporting growth, and held officials accountable for delivery or lack thereof. They further expressed not only the lack of communication from government to farmers, but even communication among the different departments is appalling. Furthermore, academics generally also believe that it is not their role to facilitate technology exchange. Academic organisations are there to generate information and provide/packaged it in formats conducive and available to be disseminated.

In Limpopo, farmers felt that the knowledge obtained at workshops cannot be applied as they were made to believe during their training sessions. This leads to insecurity in managing their fish farming operations, and is further exacerbated by minimum support from extension officers. In many instances farmers were given starter packs and were made to sort operations all on their own. Therefore, they had no way of telling what they are doing is correct or how well the fish are performing in the production system. Thus, the exchange mode is not insufficient, but rather the type of information presented at this forum. This could lead to workshops being dispelled as not effective, if facilitation is not well-prepared and fail in articulating appropriate information. Thus, it is crucial that once off workshops are followed up with a mentorship programme or ‘after service support” to provide a continuum of theory in practice backed by knowledgeable intervention when required.

A component of the knowledge exchange project is to sensitise the fish farmers on sustainability and their important role in achieving it. Surprisingly, farmers expressed a good understanding of sustainability as defined by their own interpretation, and exclaimed that their fish farming operations are threatened by climate change through the unpredictability in water supply from

streams and boreholes, strong winds destroying cage culture infrastructure, and the occurrence of algae blooms affecting product quality and dissolved oxygen concentrations in the water column. Fish farmers with cold freshwater species were very concerned about the onset of warm water temperatures earlier in the season, thus shortening their production timeframe and increasing risks associated with farming into the warm water period. Fish farmers want to be in it for the long run and generally appreciate efforts towards achieving that goal.

The above-mentioned four technology exchange techniques were proposed based on almost three years of working with fish farmers in the respective provinces. The farmers were bought in from the onset of the project for the Project Team realised early that knowledge exchange can only be accomplished when there is full participation and farmers are regularly briefed and kept up to date about progress and developments. Thereby they were incentivised to be part of identifying appropriate technology exchange techniques, relevant information to be disseminated and suggesting fish farmer solutions for fish farmer problems.

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CHAPTER 5: Knowledge dissemination and technology development agenda

5.1 Introduction

"Water resource management acts as an interface between the public and the environment, making sure waters of various qualities are accessible to make them suitable for consumption, usage and discharge. The particular technologies and products used will influence environmental quality as well as the efficiency of the utilisation process itself. However, the uptake of new technologies aimed at overall improving of multiple-functioning water bodies is often hampered by a lack of appreciation and understanding concerning the complexity of issues which influence adoption and utilisation decisions. Understanding the nature and variety of agendas which preoccupy potential technology adopters is arguably a significant form of knowledge for both product developers and, in a wider context, policy makers" (Clark et al., 2000).

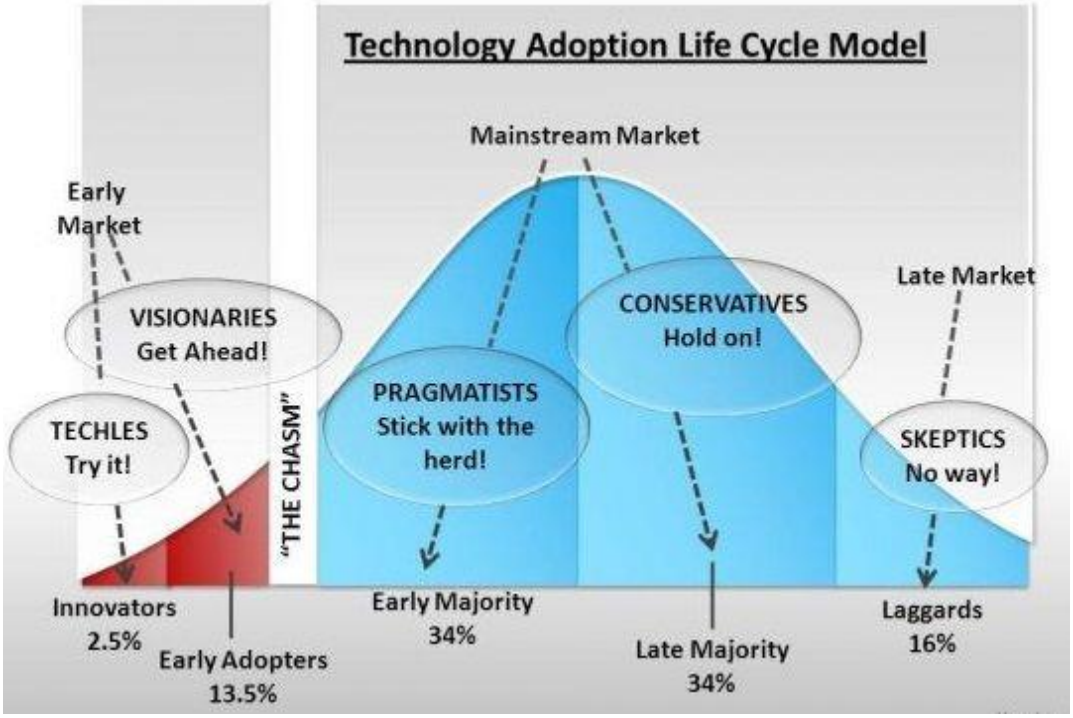

Fig.5.1. Technology adoption life cycle model (Rogers, 1995).

The argument presented is that the technology development agenda is driven by numerous factors, of which various aspects were beyond the control of the ordinary fish farmer. We have basic comprehension on what the fish farmers perceived to be desirable technologies and which ones are practical and affordable. The technology adoption life cycle model is illustrated in Fig.5.1 and depicts the different phases and extent to which technology adopters respond. Most fish farmers are considered to be in the mainstream market with having a conservative view ("hold on") and a pragmatic approach ('stick with the herd"). Furthermore, we had numerous discussions on farmers' current perspectives of aquaculture development in South Africa as well as their future expectations. It was revealed that most felt completely disillusioned with the imbalance between the promotion and awareness for aquaculture and the tangible delivery on the ground. The interaction of the three core sectors influencing sustainable development, *inter*

alia, social, economic and environment is shown in Fig.5.2. Ultimately it boils down to the cost-benefit to the farmer employing different technology strategies and implementation.

Fig.5.2. Three core sectors influencing sustainable aquaculture development (source: www.trisapgroup.com).

Ultimately, we argue for: equal consideration of ecological, social and economic issues in aquaculture policy-making; pro-active identification of likely social impacts; integration of fish farmers and context-specific social conditions into planning; addressing the social disconnection between demand and supply and, encouragement of creative combinations of theories and methods to assess and interpret the social dimensions of aquaculture technology exchange (Krause *et al.*, 2015). Aquaculture applications are required that will ensure timely renewal and expansion of information for new emerging problems and changing conditions associated with sector development and growth (Matuha *et al.*, 2016).

Technology adoption hinges on many factors like area ownership, farm distance from household, and market including the type of strategy needed to enhance technology uptake. Collaboration among research and development organisations and local partners is critical in training and empowering fish farming communities to adopt aquaculture technologies (Rouhani & Britz, 2004; Baticados *et al.*, 2014). Furthermore, the nature and extend of technology can also constraint the efficacy of exchange.

Presenting the dissemination and technology development agenda as part of the knowledge exchange project is exonerated by the fish farmer experience to the current situation as well as the future outlook and expectations. The Project Team encouraged dialogue around this topic and explored reasons for their perspectives based on social interactions and collaborations with other fish farmers and local and provincial government officials. Cross-cutting thematic areas where identified and these included:

- Disparity between aquaculture needs at fish farming level and government policy for assistance and promotion.
- Cost-benefit of technology for conducting viable businesses in a slow-growing economy.
- Importance of the economy of scale modelling for sustainable growth and development.

- Disillusion among emerging fish farmers and entrepreneurs to unlocking the potential of aquaculture to contribute to social-economic goals of the country.

Fish farmers presented a multitude of different appreciation of current technology dissemination routes as applicable to their operations. The status quo enlisted that the demand for technology is not appropriately addressed, specifically by the governmental supportive structures in the areas. The situation is exacerbated by the prevailing political and socio-economic driving forces in the different regions. There is also a dichotomy between the expectation that technologies should be provided at subsidised or free of costs, and what the government is mandated to deliver.

The value of the knowledge exchange project is in talking to fish farmers and gauging their management as the first approximation of the analyses of factors limiting or enhancing the growth and development of the aquaculture sector in South Africa. Regular visits and continuous communication with fish farmers were important components of the protocol and serve to keep farmers engaged from the onset and through the process. Fish farmers buy-in improved the output by providing quality information. The Project Team could list new ideas, additional constraints and communicate it to the respondents. At many farm visits the Project Team could identify production aspects that required attention. By way of taking cognisance on how and when to apply appropriate engagement and discussions, the Project Team was successful in exchanging the information to farmers and share their understanding and thereby determining and proposing mitigation measures to address it.

This chapter presented a discussion on technology dissemination, the technology development agenda, as well as future expectations of fish farmers. In addition, recommendations were offered to develop relevant policies for organisationally the government has the mandate to support emerging farmers.

5.2 Technology dissemination

5.2.1 Background

Fish farmers face constraints in obtaining external inputs. The packaging of frequent follow-up training with self-monitoring shows that farmers with training tend to add the management of additional resource flows and manage those flows more effectively. Integrated aquaculture-agriculture technologies and concepts are clearly attractive to farmers as a means of increasing their productivity and subsequently thus the revenues from their enterprises (Crissman & Antle, 2013). However, one's understanding of how well the adoption of technology has been maintained or achieved in the last three years is improving all the time. A synopsis is presented including newly obtained information.

5.2.2 Suggested modes

The previous chapter discussed different modes of which three could be considered, *inter alia*, a dedicated website, expanding the outreach of the extension officer, and structuring workshops with regional focus groups. The next phase of implementation and adoption was assessed through the functioning of these modes and in return the farmers had to provide feedback on their experience in terms of i.e. user-friendliness, usefulness, application and other suggestions of improving or changing the design.

The workshop method of exchanging knowledge has proven to be interesting and effective and new collaboration is possible with fish farmers and government officials. Participants usually expressed their interest in using such a platform, mostly as a means of interacting with resource persons, but also as an opportunity to market themselves and communicate their successes and failures. Some can even communicate their intention to consider the sharing of some of their technologies and experience, both for their projects and for a wider audience of fish farmers and officials. Workshops have the potential to open a communication channel with the aquaculture community. One of the challenges associated with workshops is the difficulty in attracting wider participation of the aquaculture sector audience, which is not a simple task for R&D projects (Arranz *et al.*, 2014).

5.3 Technology development agenda

Contact of fish farmers with various resource persons, especially government officials, is still perceived as an important vehicle to successful operations in South Africa. However, in a global study it was established that regularity and satisfaction through aquaculture shows and exhibitions was ranked highest among fish farmers through the Garrette Ranking Method, whereas the same for sharing of technology packages through internet ranked last (Joshua *et al.*, 2015). This finding alluded to the value of demonstration and exhibiting as ways and means of performing workable fish farming projects. Therefore, government policy should take cognisance and be driven by this imperative to achieve greater success in developing appropriate technology and thereby increase the adoption rate.

The engagement of the Project Team with the fish farmers provided valuable insight to the aspects that should be considered in drafting or proposing a technology development agenda. This approach could facilitate and enhance delivery and dissemination of much needed information at farm level. It also provides full participation of the fish farmers. However, reparative work is required to instil faith in fish farmers regarding the potential of aquaculture and the likelihood of realising the benefits.

During the field visits with fish farmers, most of them were still optimistic about the value aquaculture can bring, but lack of support and the prevalence of failing projects, is eroding their motivation. Although these sentiments were prevailing, farmers' aspirations were rekindled when they heard about renewed commitment by government to fast-track aquaculture research and development. Developmental aquaculture in all three provinces is in dire need of rapid response in terms of receiving the relevant information and advice. Most of them took initiative in starting their operations and is now appealing for the relevant support to either expand their projects or improve their efficiency levels. Therefore, irrespective of the current technology development agenda, fish farmers were calling for information on appropriate management addressing their plights. Fish farmers responded generally with the notion that they would like to work with the authorities and improve delivery for all concerned. Fish farmers perceived the promotion of the "blue revolution" as unrealistic for it has not delivered adequately.

Therefore, failure of the blue revolution is a global risk. The international problem is that there is a gap in knowledge exchange between the aquaculture industry, policy makers trying to support aquaculture development, and people who depend on aquaculture for a job and/or food source. Thus, governments and international organisations promoting aquaculture as the solution to improving food security, nutrition and income were failing to optimise production of natural aquatic resources.

Studies identified a “people–policy gap”, and suggested that this is an understudied constraint, which needed to be overcome before worldwide food security could be achieved from aquatic environments. This gap leads to uneven distribution of benefits, a disconnection between benefits and local needs, and detrimental effects on human health and food security, all of which can have negative repercussions on human communities and ecosystems (Krause *et al.*, 2015).

5.3.1 Recommendations for bridging the people–policy gap (Krause et al., 2015).

The people–policy gap can lead to a disconnect between flows of benefits and intended beneficiaries, uneven distribution and generation of ecosystem services at multiple scales, and detrimental effects on health and food security, all of which can have negative repercussions on human communities and ecosystems, as well as the broader utilisation of scarce resources such as water. These, in turn, affect the overall sustainability of aquaculture development. To avoid this, attention is needed with respect to:

- Equal consideration of ecological, social and economic issues in aquaculture policy-making that supports management choices that are practical and implementable.
- Pre-emptive identification of likely social impacts of aquaculture operations (using appropriate system boundaries) before any attempts are made to introduce aquaculture so that proactive steps can be taken to avoid negative consequences to the environment, people, their livelihoods and associated businesses.
- Integration of people- and context-specific social framing conditions into planning and policy review so that resultant management measures are more likely to add value to a particular socio-economic and ecosystem.
- Addressing the social disconnect between global consumption and production via stakeholder participation and continuous trans-disciplinary dialogues.
- Encouragement of creative combinations of theories and methods widely applicable to assess and interpret the social dimensions of aquaculture in multiple contexts.

Many aquaculture developments can be outright social failures due to a lack of effective bottom-up involvement, thus wider stakeholder participation is needed. Furthermore, it is incumbent that stakeholders understood how fish farmer’s activities and lack thereof influence their operations. Only through this engagement and can we improve our understanding and begin to successfully address associated concerns. Steps to increase understanding of this complexity will enable bridging of the people–policy gap and lay the foundations for sustainable aquaculture development to continue and to fulfil its important role worldwide in decades to come. This approach could act as the catalyst required to provide much needed interaction through including people in decision-making about aquaculture development and thus closing gap between knowledge demand, supply and implementation to enable aquaculture to help addressing the global societal issues of food insecurity, meaningful employment and tangible socio-economic development (Krause *et al.*, 2015).

Fish farmers expressed many a times that they require information that is reliable and sources that can be trusted. Farmers tend to put more value on the information provided by older or seasoned farmers than that available on the internet. There is a much deeper appreciation for the demonstrative value of aquaculture, thus person to person exchange that have been active for many years and revised ways and means of dealing with problems through workable solutions.

A component of the technology development agenda is to expose fish farmers and amplify the fact that today's improved practices and principles are the building blocks to achieve sustainability in the longer term, thus highlighting their important role as purveyors in achieving this goal. However, fish farmers generally expressed that their biggest concern affecting sustainability is the associated risk profile labelling aquaculture. Fish farmers across all three provinces have indicated that they can substantially reduce project failures if they can expand their current operations and reach a viable economy of scale appreciated by the financing and marketing sectors.

5.4 Future expectations

"Intensify assistance to the small-scale farmers, recognising that the small-scale (resource-limited and/or subsistence) farmers comprise the vast majority of aquaculture producers in the world and recognising further that they are the most vulnerable to impacts of natural and economic risks" (Phillips *et al.*, 2013).

The importance of small-scale farmers' contribution to world aquaculture production is accentuated and therefore acknowledging the future expectation of fish farmers will provide an agenda for implementing effective technology exchange initiatives. Through intensive discussions with fish farmers the Project Team managed to compile existing sentiments. This chapter addressed the situation and shares the experiences for each of the three provinces.

5.4.1 Sentiments from the Western Cape

<u>Fish farmers</u>

I. Fish farmers felt that the last three years have been a challenging time in the rainbow trout subsector due to weather (low rainfall and relatively dry conditions) and the unreliability of our main electricity supplier, ESKOM. It is also buying and selling electricity to other countries in the Southern African Development Community (SADC), and subsequently diminished supplies. The unprecedented and sudden power cuts were especially damaging to hatchery operations reliant on power supply to service air blowers and pumps. Many farmers could implement contingencies i.e. back-up generators, but many of the small-scale operators could not afford such huge capital expenditure. With rising electricity tariffs, farmers were lobbying for different pricing for aquaculture.

II. The rainbow trout market has experienced an oversupply of fish for the past two years, thus prices have not gone up while important input costs such as feed and fingerlings increased. It is felt that if government imposed import tariffs on seafood products, the local farmers would be in a better position to compete with cheaper imports.

III. Furthermore, fish farmers expressed concern about their economies of scale and proposed expansion of their operation to reduce unit cost and improve profitability. However, obtaining the required capital is expensive and most cannot afford/justify loan finance in the current economic forecast.

IV. Fish farmers also felt that they cannot continue on the same trend for it does not present a viable business. It is difficult to encourage anybody to start with fish farming projects if they themselves were struggling with keeping the business going. At the moment, most farmers are delivering product to one or two processors and they felt if assistance could be rendered in developing new markets it will create opportunities for better pricing. Furthermore, many farmers were still operational for they have initiated a smaller sales market in the catering and hospitality sector. This presented diversity in the market sector, but to further realise its potential organisational support is required.

V. The current market for small-scale growers is not conducive to new entrants. Too much rainbow trout products were entering the South African market placing pressure on "price takers". Prices paid to the fish farmers have reached a plateau and mostly larger commercial fish farms can absorb lower prices for their unit cost is lower. Therefore, fish farmers proposed if technology is available to improve economies of scale and efficiency in operation, is must be supplied at a certain affordability level. At the moment, most technology in terms of the "nice things to have "are beyond the reach of the small-scale fish farmers.

VI. The rainbow trout farming subsector is characterised by a bottleneck in supplying the market for most of the fish farmers in the Western Cape province are harvesting at the end of the year within a three-month period (usually September-November). Thus, the processing market cannot absorb all the production within this time slot. Therefore, fish farmers to consider alternative markets and diversify their product offering.

VII. There is a perception and concern among fish farmers that funding is provided for the development and exchange of technology, but the farmers do not see the results thereof. It was also expressed that the government gets involved in putting up a fish farm but does not assist with the production costs. Therefore, it leaves the question as to whether it is useful to go into aquaculture. Furthermore, a general perception exist that many aquaculture grants and funding was being spent, but limited visible results were achieved on the ground. One fish farmer believes that there is scope for future aquaculture development, but the lack of dedicated funding models is hampering the growth.

<u>Government officials</u>

I. The extension officer/farmer support indicated that currently he is the only person that provides services. There is no indication that additional personnel will be employed to assist aquaculture. The proposal is for tertiary organisations to assist with technology exchange and provide input to farmers.

II. It was raised that many technology packages are available to emerging and operational fish farmers. However, usage and compliance is low and accountability is lacking. The extension officer suggested that where technology and know-how are available, proper monitoring and evaluation systems should be implemented to improve the adoption level. Such prerequisites should be imbedded in the grant and funding model.

III. Another aspect raised was insufficient business planning and management. According to the provincial aquaculture support office the high rate of project failures is a direct result of poor planning. Fish farmers are required to be much more business savvy which will enable them to produce viable entities and contribute substantially to the success rate of aquaculture.

IV. There are several platforms specifically structured for emerging fish farmers which could assist with funding applications. Government is aware that specifically emerging farmers are ill-prepared to complete proper business plans required for funding applications. Therefore, organisational support is available to provide emerging farmers with the best possible chance to be successful with their applications. However, it was tabled that in many instances lack of failure to provide required information on time, resulted in incomplete applications and ultimately rejection.

V. Lastly, from the government sector, emerging fish farmers are encouraged to investigate and compile data on appropriate species selection. According to past experiences there were specific species requirement and if these are not met within the proposed area and

climatic zone, such projects are destined for failure. Again, tertiary organisations are encouraged to present such information and create the necessary platforms for dissemination.

5.5.2 Sentiments from KwaZulu-Natal

Fish farmers

I. The existing drought has been affecting the fish farmers immensely in the province and many immediately felt that their priority needs were around drought relief in the form of funds and information.
II. The fish farmers still value information days and called for regular initiatives to provide advice and advances on any technology development and availability.
III. The business development and success is constraint by the lack of basic services i.e. extension as supplied by the government.
IV. Many raised the issue of the availability of grant funding for projects as a well as funding structures to procure start-up finance to especially emerging fish farmers.
V. Fish farmers also expressed concern about the regulatory environment not supporting aquaculture development. Many felt that there should be clarity on candidate species for aquaculture in the province as well as a streamlined legislative process supporting it when it comes to licensing, transport and marketing.
VI. Fish farmers are receiving information from the existing farmer organisations, but appealed to government to provide organisational support in elevating their overall delivery.
VII. Fish farmers also support each other via communication among each other, but felt that much more can be achieved with a mentorship programme to support upcoming/emerging fish farmers for not enough time can be provided by operational farmers.
VIII. Together with farmers' days, the workshop concept is also supported as a way of disseminating information. However, farmers cautioned that these should be organised in accordance with the fish farming seasons in the area.
IX. Suggestions were also made as to "fast-tracking" the growth of the aquaculture sector through using existing infrastructure, i.e. Ushaka Aquarium as a resource centre and outreach facility.
X. A general point was raised on the technical skills level of operational projects; the skills-set are not adequate to grow their businesses.
XI. A few fish farmers also questioned the value of technology exchange if it is too expensive or the cost-benefit is not clearly demonstrated.
XII. Fish farmers believe that government should provide assistance with start-ups.

Government officials

It is acknowledged that trust and reliance in government officials need to be reinforced.

There is generally little confidence in that government officials could be able to provide; thus posing the question how can any technology exchange be successful under such circumstances? Further explanations follow:

I. There is still perception of the associated risk profile of aquaculture, and therefore awareness need to be created intergovernmental about the realistic risks and proposed intervention to minimise it.
II. Aquaculture is still in the infancy stage and the potential for small-scale development is not realised.
III. Lack of departmental structures is a constraint to provide information easily to local fish farmers.
IV. They believed if knowledge exchange is successfully achieved, it will improve collaboration with the fish farmers.
V. The province has a strategic plan for aquaculture implementation, but the lack of clearly defined policy and actions is a blockage.
VI. Many officials felt that there is a shortage in resources including, technical expertise, funds to start projects and enabling legislation to enhance delivery.
VII. These contribute to what they describe "the missing links in the chain" to achieve tangible aquaculture success
VIII. They would like to provide regular stakeholder engagement for it is deemed as a successful forum to provide information.
IX. There is a shortage in appropriate aquaculture research been conducted in the province, and more focus should be local research with local terms of reference.
X. The province only has a few commercial ventures and no real opportunities were explored.
XI. There is too much reliance on external expertise in the form of service providers including consultants.
XII. The province does not have a dedicated aquaculture unit which can serve as a focal point for technology exchange and interaction.
XIII. There also an urgent need to motivate government officials and instil urgency to deliver, even though not all the required resources are in place. This will go a long way to improve the interaction and dispel the disillusion and mistrust.
XIV. A skill audit can be good starting point to assess the skill-sets of officials and fast-track training to enhance their expertise.

5.4.3 Sentiments from Limpopo

<u>Fish farmers</u>

I. One fish farmer has not given up on his dream to have a larger scale tilapia farm to serve the high demand for fish in the area. He sees great opportunity in developing the Dzindi Fish Farm as part of a community-private-public partnership (CPPP) initiative and wishes to be intricately involved in setting up and managing such a scheme. Such enthusiasm and ambition should be applauded and assisted.
II. The vision is further expanded via developing those ponds by enlarging and increasing their number; building a hostel for Venda University next to it, with a catering unit supplied with fish from these ponds, and also buying in fish from local fish farmers in the area. This scenario presented a much more positive outlook to what benefits aquaculture can bring.
III. At the moment, the vision is just an idea and although sharing this with Dzindi Fish Farm as well as with the Department Agriculture Forestry and Fisheries, not much has materialised.

IV. The drafted Aquaculture Bill has been presented to fish farmers, but they felt that the Act is discriminatory against rural areas and freshwater aquaculture opportunities. Furthermore, they felt that the government is putting too much emphasis on co-operatives and not on individuals. The co-operatives in their province are believed to be not working.

V. Fish farmers felt that the priority inputs should be subsidised by the government and once farms are operational they should be able to manage independently. The call is for colleges and universities to development such a business model which should be tried and tested for 5 to 10 years.

VI. Another aspect raised is that part of the problem of developing aquaculture in the Limpopo province is that certain public land falls under the auspices of Limpopo Department of Environment and Tourism (LDEAT) and would have to be exchanged to the national Department of Agriculture, Forestry and Fisheries before it can be utilised for fish farming.

VII. One concerning occurrence is that when team members visited the Dzindi Fish farm, employees assigned to promote tourism and aquaculture had no plan or purpose to perform their duties. This could be deemed unacceptable and a waste of state resources, especially in the context where basic support and extension is so desperately required.

VIII. Fish farmers feel that they could make a bigger profit if they receive subsidised fish feed. The availability and cost of good quality fish feed is still a major constraint to viable operations. The fish farmers in the region were not properly skilled to investigate alternative feed supply or formulation from local available raw materials.

IX. Successful fish farmers are regularly visited by guests of governments, but no meaningful assistance is offered afterwards. Thus, although such farms have been paraded as a success story of small-scale fish farming in the region, there has been no progress with respect to support and assistance happening after visits.

X. Fish farmers generally felt that training manuals and information packages should be translated to Tshivenda to improve it usage.

XI. One fish farmer expressed the desire to apply for the start-up funding which government is making available to small-scale farmers but is struggling with drawing up the required business plan as it is a very complicated process. She cannot afford to pay a consultant to do it for her as she was told it can be quite expensive to make use of their services.

XII. Fish farmers also encourage service providers and government officials to involve the local chief in planning and implementation. The blessing of the chief for aquaculture development in the region would be supportive when additional land is required for expansion or local markets need to be developed.

XIII. Fish farmers were harshly affected by this year's drought in their province. Farmers were disillusioned for they could not grow their operations. However, they were hugely encouraged and invigorated by the visits of the Project Team and gave them renewed hope in the possibility of farming with different fish species.

XIV. Many fish farmers explained that they have never had any visits from extension officers, and therefore posed the question for reasons certain fish farms were visited and others were not. This situation exacerbated the mistrust between fish farmers and government officials.

XV. One fish farmer is interested in expanding his fish production so that he can tap into the international market.

XVI. There is also the case where a fish farmer is eager and would like to dig more dams on his property as he has more space available for at least three more large dams. However, his appeal is for physical assistance/machinery to do this as he hurt himself digging the last dam using a spade only.

XVII. There is not a lack of self-investment by fish farmers for one paid seventeen thousand to have a borehole sunk on his property, but unfortunately it has come up dry.

XVIII. The available of and access to water is now an important issue. Many fish farmers felt that they could increase their production if they have more access to a stable supply of water.

XIX. There was a good response when the Project Team took aspirant/emerging fish farmers to other successful operations where they could view and experience what is required to put together a project. This again underlines the importance of demonstration projects as a means of promotion and awareness of aquaculture.

Government officials

I. One university academic has been testing freshwater in the region as part of a research portfolio. Preliminary results indicated that the water in the dams of some of the small-scale fish farmers has toxic cyanobacteria populations.

II. The academic thinks the added nutrients provided by the fish feed and the warm temperatures were causing the algal increase. Further tests were planned for nitrates, phosphates and heavy metals and these results from the laboratory could potentially provide further proof of the contribution of fish farming projects to the eutrophication in the area. However, it is also important to view the impact of aquaculture in context of the total contribution of all polluting agents.

III. There is a general lack of regular water testing by government officials. Therefore, government has no supporting documentation of the perceived impact of aquaculture and appropriate mitigation if required.

IV. Many government officials in the province received substantial aquaculture training abroad, but are not exchanging and implementing these practices and principles.

V. The plight of these officials is that they have not enough staff to support emerging fish farmers effectively.

VI. It was noted that training for 13 fish farmers were supplied on how to aerate their water as well to separate the males and females as a way of increasing the fish growth. However, participants were unsuccessful in achieving the latter. This scenario raised the importance of appropriate technology exchange to achieve greater success in implementation.

VII. It is evident that a basic lack of planning and associated actions is hampering aquaculture development.

5.5 Conclusion

The Western Cape presented a much better picture of the current status and future expectations. There is a much larger fish farming commercial base and almost all the farmers are

aware of farming methods necessary to achieve success. Their technology requirements hinges on i.e. market intelligence to diversify products and procurements, and source funding and investment to expand operations to meet critical economies of scale. The organisational support is also much better structured and although there is a shortage in capacity at government organisations, there is a farmer support unit where emerging fish farmers can leverage information and assistance. The success of rainbow trout farming is also exacerbated by several larger commercial farms, thus providing critical volume in production to maintain the market delivery. The aquaculture strategic development plan is also comprehendible through a functional producer association acting as forum where issues can be discussed pertaining emerging farmer development as well as research requirements. The provincial government has also achieved funding models and start-up projects have a much greater chance of successful procuring capital provided their business plans are in order. Such funding models are however absent or not delivering in the other two provinces.

KwaZulu-Natal is struggling with farmer-official dynamics where there is a high level of mistrust on what the government promotes as unlocking the potential of aquaculture. Many fish farmers were disillusioned about the lack of support and opportunities to implement projects. It presents a stale mate on development and government officials blamed limited delivery on lack of human resources, technical skills, organisational plan and basic funding. Furthermore, fish farmers view it as incompetency and failure to list aquaculture as a priority sector for socio-economic development in the province.

Most small-scale fish farmers in the Limpopo specifically have limited access to reliable information about improved technology and farming methods. None of the farmers knew about the importance of knowing the water quality in their ponds, how to neither test for it nor do they have any equipment to conduct tests. It can be argued that sampling equipment is expensive, but it is expected that at least the fish farmers need to take responsibility for basic understanding of important practices and principles. However, the situation is much more complicated and is influenced by various external factors, thus rendering it difficult to access these fundamentals. These fish farmers are subsistence-based operators who earn a meagre income or no income from their fish. Therefore, they were unable to turn their fish farming into profitable businesses due to lack of funds, infrastructure, training, mentorship and other required inputs. During the Project Team's visits, it became evident that they have had no meaningful support from local government officials to aid their progress in the farming of fish. Although a few had cursory visits, others have never been contacted by any officials. The motivation is low and the future of fish farming in the region remains bleak and there is yet no tangible evidence of a goal-directed plan from local or national government to drive this process.The technology development agenda is clear and it is believed that action can be driven once "all the links in the chain are achieved". However, the associated bureaucratic process to realise this goal, is hampering the evident plight of the fish farmers as well as the ambition of potential ones. Although everyone realises it is by mandate the role of government to drive the policy for enhanced delivery, fish farmers on the ground is eager to receive/access information from any other source or organisation. Unfortunately, it is a vicious circle where everyone is refraining from accountability. Many other African countries are moving ahead with speedy deliveries on aquaculture developments. Uganda, per example, is exploring novel technology exchange modes in using mobile phones while Nigeria is implementing social media and radio and television advertisement to achieve wider outreach. The success of many other African countries is imbedded in excellent strategic

plans backed by government policy and timeous execution. South Africa falls flat on rolling out action plans, amidst excellent infrastructure and organisations. Therefore, it is desperately required to galvanise and consolidate efforts.

However, it cannot be expected that fish farmers should be innovative in exploring the possibilities, irrespective whether they are entrepreneurial-driven or labour-orientated. The challenge is now to adopt the technology development agenda and combine that with the future expectations of fish farmers to provide the packages so much required.

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CHAPTER 6: General conclusions and recommendations for future studies

6.1 Overall summary

This study focused on the process and dynamics associated with knowledge exchange on principles and practices at fish farmer level. It enhanced our understanding and comprehension and presented opportunities for sustainability to integrated aquaculture and agriculture management systems. The project's scope included both small- and large-scale producers, keeping in mind that the scale of operation is relative for large-scale producers in South Africa are considered small-scale when yield is considered in other countries such as Chile, Denmark, Norway and Scotland. The report followed the FAO's definition of small-scale aquaculture. The common criteria considered for selection of respondents were: fish farmers were operational, and the water source is primarily use for agriculture irrigation and secondary for aquaculture practices. The project also endeavoured to ultimately present a holistic structure to the promotion and regulatory authorities whereby most concerns and challenges could be addressed through empirical and descriptive results stemming from this investigation.

The primary objectives of this Project were i) to investigate what information is available to farmers as local and captive knowledge; ii) to evaluate the sources and accessibility of this information; iii) to determine the level of interpretation that is associated with farming dynamics and context; iv) to evaluate the impact of the applied exchanged technology; v) and to create a new set of instructions and learning material for academics and development practitioners. Furthermore other aspects were considered such as, what quality of information is available locally as well as internationally; the level of accessibility, affordability and adoption levels; the different types of media or methods used to disseminate and access necessary information; what constraints farmers experience when gathering information; the farmer's ability to interpret and understand gathered information; the level of success of farming associated with the attained knowledge; benchmarking the success levels; and finally, considering the cost-benefit and transaction cost to farmers.

However, one of the expected outcomes of this Project is to get knowledgeable fish farmers on par with local and international aquaculture development trends. This can be achieved through the application of broader perspectives attempting to improve accessibility to information systems for fish farmers; promote the useful application of information and basic understanding; improve communication between farmers, academia, government and media; create formalised research agendas based on sector requirements; and to propose appropriate policy and strategy to complement management guidelines. Although the project is crucial to the promotion of the aquaculture sector in South Africa, the core issue of promoting sustainable multi-utilisation of our water resources is highlighted. The project presented and discussed best management guidelines with fish farmers which were available through existing resources, thus ensuring our water resources are utilised and managed optimally to stringent regulations for both aquaculture and agriculture practices. To improve overall management of water, the current practices and principles applied were investigated and evaluated.

The **first objective** of fish farmer profiling included information on farmer demographics, and availability of local and captive knowledge. In the WC farmers were generally more organised with organisational support from a farmers' organisation and regular intervention from the

public sector. The KZN farmers were mostly functioning independently and leverage support from prominent electronic media and one-on-one consultation with prominent aquaculture experts in the industry. Many of KZN farmers are set in their ways and not very susceptible to outside views and perspective. However, once it has been realised that the cost-benefit is positive and has the potential to improve turnovers and profits, farmers exhibited keen interest. The farmers in north-eastern Limpopo were mostly isolated and indicated a desperate need for assistance on training and intervention to improve and expand their ventures. Emerging farmers were the ones marginalised. Limpopo indicated a lack of support, especially once the farm is operational

The challenge with the local knowledge systems is not the in the abundance of resources, but more on the comprehension and application to improve operations. Although there is a myriad of information available on the internet, farmers were still sceptical about it and in most instances overwhelmed by the different way of doing things. In these cases, it was found that farmers opted for practices and systems which were demonstrated to them and shown to work. Although the efficiency level was not clear, farmers would rather follow the latter for at least they are assured that the system will function. Generally, fish farmers also expressed that the mere interaction with the project provided information on different aspects which they did not have before and therefore has improved their knowledge base.

A re-thinking on research output is required to facilitate a process of successful dissemination and adoption. This strategy coupled with demonstration stations and complying farmers will enhance knowledge exchange and use. Farmers should lead the way in setting the agenda for knowledge creation as well as successful exchange and implementation. The discussions with the farmers have provided greater insight to what is deemed to be important to achieve improved management of our water resources. It can be encapsulated as “fish farmers first to provide fish farmer perspective on issues”

The **second objective** of the project included the evaluation of sources and accessibility of this information and it covered many related aspects which were considered during this investigation. Fish farmers were using a range of technology modes to access information that are relevant for their operations and do not use modes that were considered not to add value. The technology exchange techniques selected and implemented by the project provided valuable insight to the efficacy of such modes. This is the first step towards improving delivery and dissemination of much needed information at farm level. However, the application should be seen in context with the constraints to technology exchange as experienced by the fish farmers. These include a range of factors, *inter alia*, those associated with lack of access to ICT to that of comprehending basic practices and principles pertaining the importance of regular monitoring and evaluating the water quality on the farm. Furthermore, it also included other tasks such as conducting frequent sub-sampling of fish population to calculate feed conversion ratios (FCR’s), and feeding fish appropriate diets to minimise wastage that can lead to water quality deterioration. However, fish farmers do not always realise the extent of the consequences of their actions and how it can compromise the long-term sustainability of their fish farming operations, thus it remains important to brief them regularly on the cause and effect. The success of a particular fish farming operation is vital to the overall growth and development of the aquaculture sector.

During the engagement with fish farmers, most of them raised specific concerns and problems they experience on the farm, such as low dissolved oxygen levels, sick fish, and the prevalence of predators. Although these problems were *ad hoc,* farmers usually required rapid response in terms of receiving the relevant information and advice to act swiftly. They also realise that they are dealing with live animals which require immediate attention, and need to act to minimise losses. Therefore, irrespective of which technology exchange source is available or in use, farmers were calling for information on appropriate management to the current situation. The general input received is that the farmers would like to work with the authorities and improve the communication.

There is a lot of information available pertaining to technology exchange techniques, as well as a multitude of others to be considered such as, formal qualifications at different educational levels, cellular phone-based short messaging services, demonstration stations, seasoned fish farmers in the area, and different forms of social media. Fish farmers were already at a lost trying to navigate through mass literature on aquaculture, and therefore the demand and needs to receive and interpret takes priority over continued supply of information. Fish farmers expressed many a times that they require information that is reliable and sources can be trusted. Farmers tend to put more value on the information provided by older or seasoned farmers than that available on the internet. This farmer-to-farmer exchange still has much value to farmers and they appreciate “old hands” whom have been active for many years and revised ways and means of dealing with problems through workable solutions at local level.

The internet is certainly the dominant technology mode used in the Western Cape and KwaZulu-Natal provinces but less than one third of fish farmers in Limpopo had access or used it. A significant amount of information pertaining aquaculture is available on South Africa’s national departments’ websites. However, few farmers were aware of such information or have accessed it.

Farmer-to-farmer interaction continues to be a critical information source in the Western Cape and KwaZulu-Natal and to a lesser extent in Limpopo province. A growing reality that may become a future constraint to farmer-to-farmer exchange as identified in Western Cape is intellectual property rights which prohibits certain farmers from sharing information and may requires creative private public sector collaboration on non-competitive areas of value for the sector.

Fish farmers continue to hold learning organisations in high regard albeit with criticism of not focussing on practical hands-on teaching. It was suggested that such teaching methods could incorporate relevant case studies presented to participants. Given this experience and particularly the volatile situation in Limpopo province regarding poor relations between farmers and government extension officers, learning organisations such as Stellenbosch University may potentially have a critical role to play in facilitating and be a leading agent as a higher learning organisation and thus a technology mode for knowledge.

A key learning aspect from this study is lack of regular visibility of government extension officers providing information or extension at farm level in all three provinces. In some instances, as in Limpopo province, it has created animosity between fish farmers and extension officers with no apparent solution in the short term. It does however present opportunity to focus on technology

modes that farmers currently were valuing and for learning organisations to play role in capacity building if this technology mode is found to continue in future. In Limpopo province, there is urgent need for technology exchange skills and the most cost-effective short-term way to achieve this may be placement of post-graduate intern with farmers, training on financial management and market requirements as well as support to encourage more contact sessions between farmers. Given that most fish farmers have internet access it may be worth considering exploring a voice or SMS service as technology mode.

The interaction with farmers has highlighted the need to work with farmers to understand their needs at farm level and has to be led by organisations and or individual (s) that farmers trust and recognise as having relevant skills and experience. Given the small numbers of farmers in the three province solutions need to be tailor-made to specific needs and be cost-effective. The four key technology modes recommended to assess in more detail is Stellenbosch University website platform for alumni of short course graduates, postgraduate student blog started at University of KwaZulu-Natal for aquaculture, student placed as intern in-field and lastly workshop with small-scale farmers.

The **third objective** of the project is to determine the level of interpretation that is associated with farming dynamics and context. Herewith the constraints to technology exchange as experienced by the fish farmers include a range of factors from those associated with lack of ICT, i.e. access to internet) to that of understanding the importance of regular monitoring and evaluating the water quality on the farm to ensure long term sustainability of their fish farming operations. Most of the farmers have problems with managing predation. Predators such as fish eagles, cormorants, frogs and otters hunt fish and cause huge losses and damages to systems. The farmers were calling for information sessions on appropriate management for some of these species are threatened or protected by law. The general feeling is that the farmers would like to work with the authorities and not destroy or bewildered predators indiscriminately. However, predation leads to huge financial losses when fish are captured or wounded during hunts.

Although there is a lot of information available, farmers also find it difficult to navigate through literature. They were not sure whether it is outdated, or is it relevant to their production systems. The farmers also find it difficult to determine if the information is reliable and sources can be trusted. Farmers tend to put more value on the information provided by older or seasoned farmers than that available on the internet. They believe that farmers whom have been active for many years have encountered problems and managed to find workable solutions. Many farmers did not conduct any water quality testing for they assume the water provided by springs and streams were of good quality. Farmers were also dependent on the Department of Water Affairs to perform regular water testing in the area. Furthermore, in some cases farmers were monitoring basic parameters such as dissolved oxygen and temperature on the farm, whilst other did not even monitor these basic ones. The farmers indicated that they observe fish regularly and can tell when something is wrong. They would also apply reactive treatment such as salt dosing as a standard procedure to treat ill-appearing fish.

All the farmers called for market intelligence to expand their operations. They are not informed about potential markets, product development and trading incentives as provided by the government, i.e. Department of Trade and Industry. Much of market exploration and development is conducted by the farmers themselves. However, they iterated that such

initiatives could be far-reaching if better expertise and experiences are applied. Farmers also indicated that there is lack of development finance and sponsorship, as well limited access to loans from commercial banks. Furthermore, no real investment is ploughed into the sector. The farmers indicated that they could not find suppliers or stores selling fish feed, thus making it difficult to maintain good feeding practices. This is considered the reason for underperforming or unsuccessful projects.

In Limpopo fish farmers felt that the knowledge obtained at workshops cannot be applied as they were made to believe during their training sessions. This leads to insecurity in managing their fish farming operations, and is further exacerbated by minimum support from extension officers. In many instances farmers were given starter packs and were made to sort operations all on their own. Therefore, they had no way of telling what they are doing is correct or how well the fish are performing in the production system. Other aspects mentioned that constraint their aquaculture developments include, lack of specialised equipment, theft, and disease outbreaks. The farmers were calling for an independent body/person to conduct regular water testing and disease monitoring. They realise the value of early detection to prevent mass mortalities.

Fish farmers also felt that the sustainability of the operations are threatened by climate change, unpredictability in water supply from streams and boreholes, strong winds destroying cage culture infrastructure, and the occurrence of algae blooms affecting product quality and dissolved oxygen concentrations in the water column. Farmers with cold freshwater species were very concerned about the onset of warm water temperatures earlier in the season, thus shortening their production timeframe and increasing risks associated with farming into the warm water period. They would welcome some sort of prediction charting to consult and anticipate inclement weather patterns.

The **fourth objective** of the project is to determine the level of interpretation that is associated with farming dynamics and context. Most small-scale fish farmers in the Limpopo specifically have limited access to reliable information about improved technology and farming methods. None of the farmers knew about the importance of knowing the water quality in their ponds, how to neither test for it nor do they have any equipment to test their water. It can be argued that sampling equipment is expensive, but it is expected that at least fish farmers need to take responsibility for basic understanding of important practices and principles. However, the situation is much more complicated and is influenced by various external factors, thus rendering it difficult to access these fundamentals. All of these fish farmers are subsistence-based operators who earn a meagre income or no income from their fish. Therefore, they are unable to turn their fish farming into profitable businesses due to lack of funds, infrastructure, training, mentorship and other required inputs. It is also evident that fish farmers in general have had no continued meaningful support from local government officials, since they were last visited, to monitor and evaluate their progress in the farming of fish. Although a few had cursory visits, others have never been contacted by any officials. The motivation is low and the future of fish farming in the region remains bleak and there is as yet no tangible evidence of a goal-directed plan from local or national government to drive this process.

However, the Western Cape presents a much better picture of the current status and future expectations. There is a much larger fish farming commercial base and almost all the farmers are aware of farming methods necessary to achieve success. Their technology requirements hinges

on i.e. market intelligence to diversify products and procurements, and source funding and investment to expand operations to meet critical economies of scale. The organisational support is also much better structured and although there is a shortage in capacity at government organisations, there is a farmer support unit where emerging fish farmers can leverage information and assistance. The success of rainbow trout farming is also exacerbated by several larger commercial farms, thus providing critical volume in production to maintain the market delivery. The aquaculture strategic development plan is also comprehendible through a functional producer association acting as forum where issues can be discussed pertaining emerging farmer development as well as research requirements. The provincial government has also achieved funding models and start-up projects have a much greater chance of successful procuring capital provided their business plans are in order. Such funding models were however absent or not delivering in the other two provinces.

KwaZulu-Natal is struggling with farmer-official dynamics where there is a high level of mistrust on what the government promotes as unlocking the potential of aquaculture. Many fish farmers were disillusioned about the lack of support and opportunities to implement projects. It really presents a stale mate for government officials blame limited delivery on lack of human resources, technical skills, organisational plan and basic funding. Furthermore, fish farmers view it as incompetency and failure to list aquaculture as a priority sector for socio-economic development in the province.

The technology development agenda is clear and it is believed that action can be driven once “all the links in the chain are achieved”. However, the associated bureaucratic process to realise this goal, is hampering the evident plight of the fish farmers as well as the ambition of potential ones. Although everyone realised it is by mandate the role of government to drive the policy for enhanced delivery, fish farmers on the ground is eager to receive/access information from any other source or organisation. Unfortunately, it is a vicious circle where everyone is refraining from accountability. Many other African countries were moving ahead with speedy deliveries on aquaculture developments. Uganda, per example, is exploring novel technology exchange modes in using mobile phones while Nigeria is implementing social media and radio and television advertisement to achieve wider outreach. Kenya has an aquaculture stimulus programme and launched a campaign on “eat fish today for a healthy living” to promote aquaculture research and development. The success of many other African countries is imbedded in excellent strategic plans backed by government policy and timeous execution. South Africa fell flat on rolling out action plans, amidst excellent infrastructure and organisations. Therefore, it is desperately required to galvanise and consolidate our efforts.

The **fifth objective** of the project included areas to create a new set of instructions and learning material for academics and development practitioners. The organisational arrangement to support fish farmers viz, extension services, remains the first port of call. However, there is disjunction as to the responsibility for technology exchange. Government is expected to deliver this service according to the legislative framework for aquaculture research and development. Farmers believed that the aquaculture sector is unduly bureaucratic and “over-regulated”, thus not creating an enabling environment for the sector to grow. They expressed a need to communicate regularly with government officials to receive the latest policy development supporting growth, and held officials accountable for delivery or lack thereof. They further expressed not only the lack of communication from government to farmers, but even

communication among the different departments is appalling. Furthermore, academics generally also believed that it is not their role to facilitate technology exchange. Academic organisations are there to generate information and provide/packaged it in formats conducive and available to be disseminated.

Workshops as modes of knowledge exchange were not always successful applied. Some fish farmers felt that the knowledge obtained at workshops cannot be applied as they were made to believe during their training sessions, or they found it was practical at farm level. Thus, the exchange mode is not insufficient, but rather the type of information presented at this forum. This could lead to workshops being dispelled as not effective, if facilitation is not well-prepared and fail in articulating appropriate information. Thus, is crucial that once off workshops are followed up with a mentorship programme or 'after service support" to provide a continuum of theory in practice backed by knowledgeable intervention when required.

A component of the knowledge exchange project is to sensitise the fish farmers on sustainability and their important role to in achieving it. Surprisingly, farmers expressed a good understanding of sustainability as defined by their own interpretation, and exclaimed that their fish farming operations are threatened by climate change and were aware of its potential threats. Fish farmers want to be in it for the long run and generally appreciate efforts towards achieving that goal.

The above-mentioned instructions and learning materials were proposed based on almost three years of working with fish farmers in the respective provinces. The farmers were involved bought in from the onset of the project for the Project Team realised early that knowledge exchange can only be accomplished when there is full participation and farmers were regularly briefed and kept up to date about progress and developments. Thereby they were incentivised to be part of identifying appropriate knowledge exchange modes and techniques, and relevant information to be disseminated and suggesting fish farmer solutions for fish farmer problems. However, the focus remains on how farmers can access and use available information on water resource management.

6.2 Recommendations and future studies

The study concluded that knowledge exchange as encountered in the three provinces, WC, KZN and Limpopo is motivated and driven by several factors involving service delivery through government extension services, accessibility and affordability of ICT, specifically in rural Limpopo, and eventually the cost-benefit of using available information or purchasing specialised equipment to incorporate technical knowledge. Although the scope of the study was limited to the three provinces keen interest was expressed by fish farmers in Mpumalanga and Eastern Cape to be participate in similar studies hence future work could engage these farmers to provide a more comprehensive overview of SA's footprint in freshwater aquaculture. Therefore, the improvement of water resource management in agriculture-aquaculture farming systems is enhanced and therefore it is recommended that future studies need to focus on:

- The promotion of platforms providing information for improved water resource management. This can be achieved by optimising the website and extension services to facilitate effective knowledge exchange.
- Monitoring and evaluate operational procedures at different farming levels through accounting the continuum of external factors affecting the use-and-loss of aquaculture

principles and practices. This can be achieved through qualifying the usage and presenting guidelines to maintain and improve it usage.

- The policy environment surrounding fish farmer support and assistance needs to be understood by fish farmers. This can be achieved through incorporating regular focus group discussion discussions and smaller group workshops to improve communication and accountability to the farmers.

Furthermore, the report is the final one and concludes the series of studies conducted over the last decade on the interaction of fish farming and irrigation in farm dams. It is proposed to consolidate the outputs and further the impact of existing sources for advancements at fish farmer level. Other suggestions related to the study were highlighted and included to monitor distribution of training manuals in all three formats and ask readers to provide feedback**,** update contact details in manuals in print or electronic format, provide reference to resources for more advanced level to cater for diverse range of farmers, provide web links to manuals download on learning organisation and farmer association websites, products developed are made available in home language of fish farmers and improve ease of read and use may be improved by including more graphics and photographs. Opportunities for future research or technology exchange identified with farmers in Limpopo included firstly, the placement of dedicated postgraduate interns from Stellenbosch University with selected fish farmers who could provide hands-on information, and secondly the investigation of the feasibility of technology demonstration centre either situated on an operational fish farm or to implemented at one at one of the government-owned facilities and thirdly, to test short message service or voice message service as a viable source to provide information on particular topics such as feed management, market information, and access to finance and funding opportunities. This could be prevalent in areas where internet access is limited.

Opportunities for future studies on technology exchange identified with farmers in Western Cape are public private sector collaboration on feed research, structured mentoring programme for farmers and postgraduate students and learning exchanges with other provinces as well as internationally. Of interest are:

- Functional dedicated website on integrated agriculture-aquaculture farming systems listing all WRC related publications,
- Improve existing publication which were identified to be too text heavy or lees comprehendible due to the language it's made available,
- Link fish farmers to other structures such as producer associations, academia and research organisations to improve efficiency of local facilities.

However, it cannot be expected that fish farmers should be innovative in exploring the possibilities, irrespective whether they are entrepreneurial-driven or labour-orientated. The challenge is now to adopt the technology development agenda and combine that with the future expectations of fish farmers to provide the full package so much required. The added value of such an initiative could provide the required fact-based agenda to the fish farmers to elevate the status of their operations and grow the aquaculture sector in South Africa.

Farmer Name	
Location	
Species	

Section A: Technology use

Please indicate if technology listed below is being used.	YES	NO
1. Is water quality regularly monitored, Particularly for Total Phosphorus, Total Nitrogen, Total Suspended Solids, pH and Biological Oxygen Demand?		
2. Is oxygen saturation regularly measured on-farm and in effluent where applicable?		
3. Is oxygen measured before each feeding session?		
4. Is temperature measured before each feeding session?		
5. Is feed quality evaluated in terms of dust and floatability?		
6. Is feed conversion ratio measured regularly?		
7. Are uneaten feeds measured?		

APPENDICES

Appendix 1: Survey Questionnaire [i]

Stellenbosch University is conducting a Farmers' Survey funded by the Water Research Commission. We value your insights and inputs to better understand existing Water and Feed Quality technology adoption levels to improve aquaculture productivity and water resource management. Please complete the survey below by inserting your response in relevant box.

Section B: Barriers to adoption					
Please indicate barriers preventing technology use listed below by circling the relevant number.	Cost of Technology	Time required to do so	Lack of information	Insignificant benefits	**Likert Scale**
1. Regular water quality monitoring particularly for Total Phosphorus, Total Nitrogen, Total Suspended Solids, pH and Biological Oxygen Demand.	1	1	1	1	**Strongly Agree**
	2	2	2	2	**Agree**
	3	3	3	3	**Undecided**
	4	4	4	4	**Disagree**
	5	5	5	5	**Strongly Disagree**
2. Regular measurement of oxygen saturation on-farm and in effluent where applicable.	1	1	1	1	**Strongly Agree**
	2	2	2	2	**Agree**
	3	3	3	3	**Undecided**
	4	4	4	4	**Disagree**
	5	5	5	5	**Strongly Disagree**
3. Measurement of oxygen before each feeding session.	1	1	1	1	**Strongly Agree**
	2	2	2	2	**Agree**
	3	3	3	3	**Undecided**
	4	4	4	4	**Disagree**
	5	5	5	5	**Strongly Disagree**
4. Measurement of temperature before each feeding session.	1	1	1	1	**Strongly Agree**
	2	2	2	2	**Agree**
	3	3	3	3	**Undecided**
	4	4	4	4	**Disagree**
	5	5	5	5	**Strongly Disagree**

Please indicate barriers preventing technology use listed below by circling the relevant number.	Cost of Technology	Time required to do so	Lack of information	Insignificant benefits	**Likert Scale**
5. Evaluation of feed quality evaluated in terms of dust and floatability.	1	1	1		**Strongly Agree**
	2	2	2	2	**Agree**
	3	3	3	3	**Undecided**
	4	4	4	4	**Disagree**
	5	5	5	5	**Strongly Disagree**
6. Monthly measurement of feed conversion ratio.	1	1	1	1	**Strongly Agree**
	2	2	2	2	**Agree**
	3	3	3	3	**Undecided**
	4	4	4	4	**Disagree**
	5	5	5	5	**Strongly Disagree**
7. Measurement of uneaten feeds.	1	1	1	1	**Strongly Agree**
	2	2	2	2	**Agree**
	3	3	3	3	**Undecided**
	4	4	4	4	**Disagree**
	5	5	5	5	**Strongly Disagree**

Thank you for your inputs!

Appendix 2: List of Electronic Documents Available for Download on SA Websites

Document title and source/link
A step by step guide on authorisation
https://www.google.co.za/search?q=Guideline+to+the+Authorisation+Requirements+for+Aquaculture+in+the+Western+Cape&oq=Guideline+to+the+Authorisation+Requirements+for+Aquaculture+in+the+Western+Cape&aqs=chrome..69i57.425j0j1&sourceid=chrome&es_sm=93&ie=UTF-8
Environmental Impact Assessment Guidelines for Aquaculture
URL: https://www.environment.gov.za/sites/default/files/gazetted_notices/eia_aquaculture_guidelines.pdf
Legal Guidelines for Aquaculture in South Africa 2013
http://webapps.daff.gov.za/AmisAdmin/upload/The%20User%20Friendly%20Legal%20Guideline%20for%20the%20Aquaculture%20Sector%20in%20South%20Af.pdf
Marine Aquaculture and Environment Consultant Database 2012
http://www.nda.agric.za/doaDev/sideMenu/fisheries/03_areasofwork/Aquaculture/Aquaculture%20and%20Environmental%20Consultant/Consultant%20database%202012.pdf
Guidelines on Aquaculture Development and Enhancement Programme 2012
http://www.nda.agric.za/doaDev/sideMenu/fisheries/03_areasofwork/Aquaculture/economics/ADEP%20Guidelines%20Document.pdf
Guidelines on Aquaculture Development and Enhancement Programme 2013
http://www.nda.agric.za/doaDev/sideMenu/fisheries/03_areasofwork/Aquaculture/economics/ADEP%20guidelines%20Brochure.pdf
Application Form for Aquaculture Development and Enhancement Programme
http://www.daff.gov.za/daffweb3/Branches/Fisheries-Management/Aquaculture-and-Economic-Development/Aquaculture-Technical-Service/Aquaculture-Economics
Glossary of Terms for DTI Incentive Scheme
http://www.nda.agric.za/doaDev/sideMenu/fisheries/03_areasofwork/Aquaculture/economics/ADEP%20glossary.pdf
Directory of Development Finance & Grant Funding Organisations for Aquaculture operations in South Africa 2013
http://www.nda.agric.za/doaDev/sideMenu/fisheries/03_areasofwork/Aquaculture/economics/A%20Directory%20of%20Development%20finance%20and%20grant%20funding%20organisations%20for%20aquaculture%20operations%20in%20South%20Africa.pdf
Claim Form for Aquaculture Development and Enhancement Programme
http://www.nda.agric.za/doaDev/sideMenu/fisheries/03_areasofwork/Aquaculture/economics/ADEP_Claim_form.doc
Aquaculture Yearbook 2015
Freshwater Registration Form
A Manual for Rural Freshwater Aquaculture: www.wrc.org.za
Training Manual for Small-scale Rainbow Trout Farmers in Net Cages on Irrigation Dams: www.wrc.org.za
Globefish Highlights 2009
Southern African Development Community: Protocol on Fish
A study on the Status of Aquaculture Production and Trade
Aquaculture Annual Report 2011
Introduction to Aquaculture in the Eastern Cape

Best Management Practices for Hawaiian Aquaculture
Best Management Practices: A Manual for Maryland Aquaculture
Best Management Practices for Responsible Aquaculture

Appendix 3a: Semi Structured Questionnaire Guide for Extension Officer Interviews

Key Research Questions

- What information is available to farmers?
- Are the current information sources accessible?
- At what level is information being interpreted?
- What has the impact been of technology adoption?
- What opportunities exist to create new learning material?

Aquaculture extension in Western Cape

- Please describe target group of extension.

i.e. Small-scale versus commercial (production volume, species, member of association, etc.), geographical area.

- Please outline protocol applied in providing advisory service.

i.e. Frequency, content, face to face visits, ad hoc or via reservation, field days, extension material dissemination.

Current modes, adoption levels and evaluate impact

- Discuss current status quo in KZN using baseline research as reference point.
- Discuss impact of two Water Research Commission funded extension products.

Appendix 3b: Semi Structured Questionnaire Guide for Fish Farmer Interviews (I)

a. Impact of technology transfer modes on productivity and water quality

1. Mobile and Internet

Mobile Phone Use	**Indicate with X**
Use private mobile phone for business purposes	
Business has dedicated business mobile phone	
Both a private and business mobile phone	
Send text messages for business purposes	
Receive text messages for business purposes	
Does the business send or receive money via mobile phones	

Mobile Phone Ownership		**Indicate with X**
Is your mobile phone capable of browsing the internet?	Yes	
	No	
Do you share your mobile phone with others?	Once a week	
	Several times a week	
	Several times a month	
	Occasionally	
What mobiles are being used for?	Making and receiving calls	
	Missed call / please call me etc.	
	Sending and receiving text messages (SMS)	
	Personal organiser / diary / notebook / watch	
	Playing games	
	Listening to music / radio	
	Taking photos / video clips	
	Browsing the internet	
	Facebook / Twitter / Mxit / Other social networking	
	Download applications to mobile phone	
	Transfer airtime	
	SMS to Radio or TELEVISION Programs	
	International calls	
	Sending or receiving money	
	Roaming when abroad	
	Skype	

Internet Access and Use		**Indicate with an X**
Where did you use the Internet in the last 12 months?	Any place via a mobile phone	
	Home	
	Work	
	Place of education	
	Internet cafe	
How often on average have you used the internet in the last 3 months?	Every day or almost every day	
	At least once a week	
	At least once a month	
	Less than once a month	

	There is no interesting content for me	
	Lack of local language content	
What limits your use of the internet?	The internet is very low	
	Too expensive to use	
	Too few people to communicate with via the Internet	
How concerned would you be about security of your credit card or banking information when or if you ever bought something on the internet? Would you be?	Not at all concerned	
	Somewhat concerned	
	Very concerned	
	Extremely concerned	

Reasons for not using the internet for farming	**Indicate with an X**
I do not know what the internet is	
I have no interest or it is not useful	
I do not know how to use it	
I have no computer or internet connection	
It is too expensive	

Most common means of sending and receiving money for payments and income	Mode	Rank 1-5 with 1 most frequent and 5 less frequent
	Pay myself (in person)	
	Bank	
	Send cash with someone	
	Western Union	
	Post office	
	Mobile money	
How do you communicate with suppliers and customers?	Mode	
	In person	
	Mobile phone	
	Landline	
	SMS	
	Fax	
	Email	

For what type of farming information do you access via mobile and internet?	**Description**	**Rank 1-5 with 1 most frequent and 5 less frequent**
Market	Prices, new market channel, etc.	

Feed	Supplier, cost, feeding regime, etc.	
Weather information	Temperature, wind speed, humidity, etc.	
Technical	Production systems, other tech, etc.	
Finance	Products, application process, etc.	
Other – please list		

2. Extension Services

For what type of farming information do you get from government extension officer?	**Description**	**Rank 1-5 with 1 most frequent and 5 less frequent**
Market	Prices, new market channel, etc.	
Feed	Supplier, cost, feeding regime, etc.	
Weather information	Temperature, wind speed, humidity, etc.	
Technical	Production systems, other tech, etc.	
Finance	Products, application process, etc.	
Other – please list		

Extension Services	**Examples**	**Indicate X**	**Farm Productivity Impact**			**Water Quality Impact**		
			Low	**Medium**	**High**	**Low**	**Medium**	**High**
Training	Farmer or field days							
Input supply	Provision of contacts for inputs							
	Supply of tools and equipment							
	Supply of agrochemicals							
Water quality	Measuring water quality							
Information dissemination	Electronic media							
	Manuals							
	Information on events							

Advisory service	Technical							
	Credit facility							
	Input use							
	Marketing							

3. Farmers

For what type of farming information do you get from farmers locally and internationally?	**Description**	**Rank 1-5 with 1 most frequent and 5 less frequent**
Market	Prices, new market channel, etc.	
Feed	Supplier, cost, feeding regime, etc.	
Weather information	Temperature, wind speed, humidity, etc.	
Technical	Production systems, other tech, etc.	
Finance	Products, application process, etc.	
Other – please list		

What platforms do you use to connect with farmers on any of the following?	**Description** **For i.e. blog, chat room, skype, sms, etc.**
Market	
Feed	
Weather information	
Technical	
Finance	
Other – please list	

4. Radio and TELEVISION

Please list radio or TELEVISION programmes that you access for information on farming.		
For what type of farming information do	**Description**	**Rank 1-5 with 1 most frequent and 5 less frequent**

you get from radio and TELEVISION?		
Market	Prices, new market channel, etc.	
Feed	Supplier, cost, feeding regime, etc.	
Weather information	Temperature, wind speed, humidity, etc.	
Technical	Production systems, other tech, etc.	
Finance	Products, application process, etc.	
Other – please list		

5. Training and Learning Organisations

Please list training and learning organisations that you have found valuable information on farming and water quality.		
Which type of farming information do you get from training and learning organisations?	**Description**	**Rank 1-5 with 1 most frequent and 5 less frequent**
Market	Prices, new market channel, etc.	
Feed	Supplier, cost, feeding regime, etc.	
Weather information	Temperature, wind speed, humidity, etc.	
Technical	Production systems, other tech, etc.	
Finance	Products, application process, etc.	
Other – please list		

Appendix 3c: Semi-structured Questionnaire Guide for Fish Farmer Interviews (II)

b. Impact of technology transfer modes on productivity and water quality

6. Mobile and Internet

Mobile Phone Use		**Indicate with X**
Use private mobile phone for business purposes		
Business has dedicated business mobile phone		
Both a private and business mobile phone		
Send text messages for business purposes		
Receive text messages for business purposes		
Does the business send or receive money via mobile phones		
Mobile Phone Ownership		**Indicate with X**
Is your mobile phone capable of browsing the internet?	Yes	
	No	
Do you share your mobile phone with others?	Once a week	
	Several times a week	
	Several times a month	
	Occasionally	
What mobiles are being used for?	Making and receiving calls	
	Missed call / please call me etc.	
	Sending and receiving text messages (SMS)	
	Personal organiser / diary / notebook / watch	
	Playing games	
	Listening to music / radio	
	Taking photos / video clips	
	Browsing the internet	
	Facebook / Twitter / Mxit / Other social networking	
	Download applications to mobile phone	
	Transfer airtime	
	SMS to Radio or TELEVISION Programs	
	International calls	
	Sending or receiving money	
	Roaming when abroad	
	Skype	
Internet Access and Use		**Indicate with an X**
Where did you use the Internet in the last 12 months?	Any place via a mobile phone	
	Home	
	Work	

	Place of education	
	Internet cafe	
How often on average have you used the internet in the last 3 months?	Every day or almost every day	
	At least once a week	
	At least once a month	
	Less than once a month	
	There is no interesting content for me	
	Lack of local language content	
What limits your use of the internet?	The internet is very slow	
	Too expensive to use	
	Too few people to communicate with via the Internet	
How concerned would you be about security of your credit card or banking information when or if you ever bought something on the internet? Would you be?	Not at all concerned	
	Somewhat concerned	
	Very concerned	
	Extremely concerned	

Reasons for not using the internet for farming	**Indicate with an X**
I do not know what the internet is	
I have no interest or it is not useful	
I do not know how to use it	
I have no computer or internet connection	
It is too expensive	

Most common means of sending and receiving money for payments and income	Mode	Rank 1-5 with 1 most frequent and 5 less frequent
	Pay myself (in person)	
	Bank	
	Send cash with someone	
	Western Union	
	Post office	
	Mobile money	
How do you communicate with suppliers and customers?	Mode	
	In person	
	Mobile phone	
	Landline	
	SMS	
	Fax	

	Email	

For what type of farming information do you access via mobile and internet?	Description	Rank 1-5 with 1 most frequent and 5 less frequent
Market	Prices, new market channel, etc.	
Feed	Supplier, cost, feeding regime, etc.	
Weather information	Temperature, wind speed, humidity, etc.	
Technical	Production systems, other tech, etc.	
Finance	Products, application process, etc.	
Other – please list		

7. Extension Services

For what type of farming information do you get from government extension officer?	Description	Rank 1-5 with 1 most frequent and 5 less frequent
Market	Prices, new market channel, etc.	
Feed	Supplier, cost, feeding regime, etc.	
Weather information	Temperature, wind speed, humidity, etc.	
Technical	Production systems, other tech, etc.	
Finance	Products, application process, etc.	
Other – please list		

Extension Services	Examples	Indicate X	Farm Productivity Impact			Water Quality Impact		
			Low	Medium	High	Low	Medium	High
Training	Farmer or field days							
Input supply	Provision of contacts for inputs							
	Supply of tools and equipment							
	Supply of agrochemicals							

Water quality	Measuring water quality							
Information dissemination	Electronic media							
	Manuals							
	Information on events							
Advisory service	Technical							
	Credit facility							
	Input use							
	Marketing							

8. Farmers

For what type of farming information do you get from farmers locally and internationally?	**Description**	**Rank 1-5 with 1 most frequent and 5 less frequent**
Market	Prices, new market channel, etc.	
Feed	Supplier, cost, feeding regime, etc.	
Weather information	Temperature, wind speed, humidity, etc.	
Technical	Production systems, other tech, etc.	
Finance	Products, application process, etc.	
Other – please list		

What platforms do you use to connect with farmers on any of the following?	**Description** **For i.e.. blog, chat room, skype, sms, etc.**
Market	
Feed	
Weather information	
Technical	
Finance	
Other – please list	

9. Radio and TELEVISION

Please list radio or TELEVISION programmes that you access for information on farming.	

For what type of farming information do you get from radio and TELEVISION?	**Description**	**Rank 1-5 with 1 most frequent and 5 less frequent**
Market	Prices, new market channel, etc.	
Feed	Supplier, cost, feeding regime, etc.	
Weather information	Temperature, wind speed, humidity, etc.	
Technical	Production systems, other tech, etc.	
Finance	Products, application process, etc.	
Other – please list		

10. Training and Learning Organisations

Please list training and learning organisations that you have found valuable information on farming and water quality.	

Which type of farming information do you get from training and learning organisations?	**Description**	**Rank 1-5 with 1 most frequent and 5 less frequent**
Market	Prices, new market channel, etc.	
Feed	Supplier, cost, feeding regime, etc.	
Weather information	Temperature, wind speed, humidity, etc.	
Technical	Production systems, other tech, etc.	
Finance	Products, application process, etc.	

Other – please list		

Farm Productivity and Water Quality

All the modes discussed are aimed to improve on your farming operation's productivity and water quality.	1) What key metrics you use to measure farm productivity and water quality?
Please share with us your experience on a few key issues.	2) What you consider to be the most important metric for farm productivity and water quality?

Impact of WRC Manuals on farm productivity and water quality
Manuals are available at http://www.wrc.org

Have you seen these manual before?	Yes	
	No	
Which chapters would be most useful to improve farm productivity?	Farmer	List chapters
	Manager	
	Farm worker	
Which chapters would be most useful to improve water quality?	Farmer	
	Manager	
	Farm worker	
Please make suggestions on how best to improve these Manuals.		

Appendix 4: Captured Stories Shared by the Fish Farmers in the Three Provinces

Western Cape
Farm 1: Unlimited Olive People's Trust
Fish farmer profile 1

Name	Male
Age	42 years
Children	2
Language	Afrikaans and English
Education	High school
Housing	At the farm together with his family

Farm profile: Rainbow trout farm

- The rainbow trout farm is managed by him. From 2001 a group of fish farmers managed the fish farm. Since 2009 he is in control of the fish farm. There is one other man who supports him with fish farming.
- First there were discussions about farming Mozambique tilapia, but they've chosen trout.
- From the start of the fish farm nothing changed, everything stayed the same. Only little changes happened (other feeding habits for example).
- Trout production is best in winter. Survival rates are better in winter.
- They produce about twelve tons of fish per year.
- Fish production contributes fifteen to twenty % of the entire profits.
- Feeding the fish is done manually. The amount of feed is based on their biomass (rate: 1,2 of biomass). Feeding happens three times a day, that's a total of 480 kg of feed per day.
- For him water quality is really important, he gives it a 10/10. To him the water quality of the fish farm seems good and tests are not necessary. There are no death rates.
- Predators: birds and otters.
- Four cages in total. Two cages with smaller fish (3500 x 2 and 3100 x 2).
- The nets are five meters deep. Total depth of the dam: 13 to 14 meters. For cleaning the nets, they are brushed off.

- The fish are sold locally, to smokehouses in Franschhoek and to guesthouses and restaurants.
- Fingerlings were purchased from Lourensford (Somerset West).

Fish farm 2: Olive farm

- The olive farm exists since the 1950's.
- The water quality is important for the irrigation of the olive groves.
- Olives: all year production, but the harvesting is seasonal.
- Olive production: 1000 tons. Harvesting: February until August.

Knowledge exchange

- In 1999 he first heard about aquaculture.
- He started fish farming because he likes it. He saw the dams and spoke to one of Stellenbosch's staff about the idea of a fish farm.
- He had no experience in fish farming before. Other fish farmers taught him and he gained a lot of information from Stellenbosch University.
- When he has questions, he still contacts Stellenbosch University. He followed courses and had some training at the university.
- He thinks these are interesting and helpful especially for technical stuff.
- The farm can still be improved. For new information he uses the internet. In the past he contacted SU for new information. For the cage system he uses research results from the university.
- He prefers CD's and DVD's as information sources, but they need to be presented by someone. Electronic sources like email or text messages are also good.

Fish farm 2: Three Streams Trout
Fish farmer profile

Name	Male
Age	37 years
Children	1
Language	Afrikaans and English
Education	Masters in Aquaculture at Stellenbosch University
Housing	Stellenbosch

Farm profile: Trout and salmon farm

- The fish farm is in operation since 1986. He is currently the aquacultural manager of the Three Streams Holdings. Other workers on the farm: 1 manager and three farm workers.
- There are no diseases, but sometimes there are parasites in summer. Predators: birds and otters. Nets are used to protect the fish.
- At the farm they almost don't use electricity, they use the gravity. So the costs can stay as low as possible to reach market prices.
- Temperature and oxygen are tested daily. For him water quality is important. He rates it at 8/10, but he thinks that for trout the temperature and oxygen level is more important (10/10).
- 20 000 fish in tank 1 (600 kg), eight tanks in total
- The fish are moved from the hatchery (cooled water) to the nursery (after one month).
- The eggs are imported from America and Denmark.
- The farm uses formulated feed. He said that it's better to overfeed in the hatchery. The small fish are being fed eight times a day, the fingerlings three times a day.
- At the farm they use a feed table from the feed company, which he adapts and adjusts weekly using the growth ration curve. (1.5 – 3 tons per month, less in summer)
- The fingerlings are sold to Lourensford Trout.
- Salmon: 20 000 fish in two tanks
- Year production: 900 000 live fish and 12-16 tons of plate size.

Knowledge exchange

- He did his Masters in Aquaculture at Stellenbosch University where he learned the basics of cultivating fish.
- After graduating he started working in South Africa with catfish and tilapia. Then he moved to Scotland for six years where he learned a lot about fish farming.
- Now he's the senior manager at Three Streams Trout (TST) since three years. It is also linked to the Three Streams Smokehouse (TSS) brand.
- He trains his own staff and uses his own knowledge for these trainings.
- He would like to improve the farm. He gets new information from internet by reading articles and websites.
- There are no other farms in Franschhoek to share experiences, but he's still in contact with farmers in Scotland and Denmark.
- He has twelve years of experience as a fish farmer.

Fish farm: 3 Lourensford Trout Farm
Fish farmer profile

Name	Male
Age	38 years
Children	2
Language	Afrikaans and English
Education	Degree in Aquaculture
Housing	On the farm, at Lourensford Estate

Farm profile: Rainbow trout farm

- The farm started in 2000 with the building of the cages.
- The first year he worked on this own, and now he has three guys working for him and during harvest time there are some extra guys who help him.
- He is the co-owner of the farm.
- Experiences as a trout farmer: 15 years.
- In the first year: 12 tons produced, now 30 tons in the cages and 50 tons in raceways.
- He sells the trout to the Three Streams Smokehouse (85 % of all the fish) and a small percentage he sells to local restaurants.
- For him water quality is really important, he gives it a 10/10. Water quality tests are done four times a year at least and if necessary more tests are done.
- Predators: birds and otters. No diseases.
- Feed for the fish: 120 tons
- The idea of using cages as a farming system was based on his own experience.
- In 2015 he lost ten tons of fish because of bacterial infections in the second week of October.
- The dam on which he farms is a buffer dam for other dams in the area.
- He makes changes every year: new methods, methodologies, etc.
- He is involved in several experiments and also involve in a research project in collaboration with Cambridge University and other research organisations.

Knowledge exchange

- First he wanted to study medicine but he went to his genetics supervisor to speak about his future. He spoke about all his hobbies: fishing, diving and fly fishing and there was the link with aquaculture and so the idea started to make a career out of his hobby.
- He did a degree in aquaculture. He didn't follow training courses about fish farming.
- He went for two years to England to work on a trout farm where he gained some knowledge about trout farming.
- He explained that a trout farm here in Somerset West is in another environment than in Europe so it is not possible to apply everything he learned overseas.
- He gets his knowledge by making mistakes (trial-and-error) and consulting other farmers, because trout farming is a local/ small subsector where everyone helps each other.

Fish farm 4: Nuwejaarsrivier Forelboerdery
Fish farmer profile

Name	Male
Age	40 years
Children	2
Language	Afrikaans and English
Education	Degree in Tourism
Housing	At the farm together with his family

Farm profile: Rainbow trout farm

- He is the manager and a farm worker at the trout farm. He really enjoys working at the farm.
- He prefers working with as few farm workers as possible, because they've got to know the fish.
- Since six years they have new cages in another dam, because of the bad water quality (sediments) in the previous dam.
- There are two cages with each housing 3000 fish. The nets are five meters deep.
- He uses clove oil as an anaesthetic after the fish have been harvested.
- The trout farm was one of the 33 projects that received donor funding for implementation; now there are only two farms left.
- He finds that fish farming can be profitable, but there's a high risk involved. A few years ago he had a total loss of his stock in two days. Probably due to a lightning strike.

- The average fish weighs about 1,3 kg.
- He wants to expand, but expanding the farm depends on the amount of water that's available. He considers farming tilapia as well but this also depends on the water quality.
- There haven't been any big changes; he only looks at small things like cleaning the nets more often to improve lateral water flow through the cages.
- The fish are sold to the Three Streams Smokehouse, to local restaurants and about 1500 fish are sold to local dams for fly fishing purposes.
- The fingerlings come from Lourensford.
- Previously to determine the amount of feed he needed to use, he consulted a specific website; now he feeds them until they don't eat anymore.
- The fish farm only contributes up to five % of total profits.
- Harvesting only in winter: 7,5 tons of fish per season.
- The water quality is good in the new dam, but sometimes he has algae problems in summer. He rates water quality 10/10. He tests the quality of the water before he stocks and sends it to an independent water analysis laboratory. A veterinarian comes to check the pH-level, oxygen, nitrites and nitrates and general condition of fish.
- Predators: cormorants.
- Diseases: no, mainly algae problems.

Farm

- Since 1995.
- Cattle, vegetables and instant lawn.
- In summer they use the water of the dam for irrigation.

Knowledge exchange

- He has studied Tourism and worked as a guide in Tsitsikamma. His parents owned a farm in the Eastern Cape and moved to the Western Cape in 1995 to start a new farm.
- He started working on this farm (almost 20 years now).
- He has always been interested in fly fishing and that's why he began to farm fish. He received training at the Jonkershoek Hatchery, but most of the knowledge he received from his father and using his common sense and experience (trial-and-error).
- He has about five years of experience as a fish farmer. He relies on fish farmers in the area when he has certain questions.

Fish farm 5: Thambo Lentlanzi Jonkershoek
Fish farmer profile

Name	Male
Age	35 years
Language	Afrikaans and English
Education	Certificate of aquaculture
Housing	Jonkershoek

Farm profile: Rainbow trout farm

- The trout farm is managed by him. He works together with two other farm workers.
- He has been working for thirteen years at the farm.
- The farm started twenty years ago. They started with four cages, now there are four big cages and four small cages located in the Kleinplaas Dam in the Jonkershoek Reserve.
- He uses clove oil as an anaesthetic after the fish have been harvested.
- Most of the fish are sold to Three Streams Smokehouse.
- They produce 40 tons per season.
- The water quality gets tested by a student, once every two month. He finds that water quality is important for trout farming. There is enough water movement in the dam, so there are no oxygen problems. However, they have experienced fluctuating oxygen levels which could influence performance.
- If problems occur, they try to solve them their selves.
- Predators: otters and some fish eagles/cormorants.

Knowledge exchange

- He has taken several courses in fish diseases and management. He learns a lot during these courses.
- If he has problems with the farming of the fish, he always contacts the Stellenbosch University.
- He also relays on the knowledge of one of the other farm workers, who has a lot of experience in fish farming.

6. Fizantakraal Trout
Fish farmer profile

Name	Male
Age	32 years
Children	1
Language	English and Afrikaans
Education	Languages at Stellenbosch University
Housing	At the farm together with his family

Farm profile: Rainbow trout farm

- Fizantakraal Trout is one of the six farms from the company Molopong, who is the owner.
- He is the general manager from Fizantakraal and another person is the marketing manager.
- This farm is unique because of the low water temperatures (maximum 19.5 ºC).
- At the farm there are twelve ponds (6+6) with their own filter. In every pond there are 3 500 (big) fish. In the ponds with small fish there are 100.000 (because they just came from the hatchery). -> 45-60 kg / m3
- The hatchery starts with 100.000 eggs. The temperature is 8 ºC. When they are about six grams they move to another place with natural water degrees.
- Every two weeks he makes a framework of the process of growth of the fish.
- At the farm there is a farm and a fish farm. The other farm generates revenue through rental of property (main income), tourism, wild flower harvesting and honey.
- He has ten years of experience as a fish farmer (start in 2002).
- There are seven workers on the farm: two women and five men. Three of them live permanently on the farm.
- He is a member of the Western Cape Trout Association.
- The trout is sold to local processing houses: Three streams Smokehouse.
- They produce 75 tons per year (this changes every year)
- For him, water quality is really important. He rates it with a 10/10. The water quality at the farm is tested every week on Friday in the dead spots in the ponds.
- The fish are being fed manually and it is about eight tons of feed per month.
- Sometimes the fish have diseases. He explained that he had to give fish in two ponds a chemical treatment.
- In summer the water is reused. In winter there can be problems with wind and snow.

- At the farm there is also a processing room.
- The brood stock comes from Denmark.
- They sell three products: caviar, kilo fish and plates. Next year there will also be fertilized fish.
- There are no predators because of the electric fences around the farm, but sometimes there can be a water mongoose.

Knowledge exchange

- Fish is a big passion for him. He started with fly fishing before he became a fish farmer.
- He went to several trainings and workshops from Stellenbosch University about fish farming.
- For him the most useful forum to gain knowledge is from the Western Cape Trout Association where everyone is sharing their knowledge.
- Molopong gets their advice about fish farming from their partnership with AquaSearch (for example information about the fish eggs). They also have a partnership with Coppens International feed company.
- An interactive forum or website is for him the best option to gain knowledge and ask questions. He considers internet to be useful, but the information is not applicable for the local conditions for the farm at Fizantakraal.
- He concluded that the primary information is mostly available among fish farmers. For the future a knowledge or demonstration centre would be the best option.

Fish farmer 7: Soetfontein
Fish farmer profile

Name	Male
Age	44 years
Children	2
Language	Afrikaans and English
Education	Grade 12 and 2 years diploma in agriculture
Housing	At the farm together with his family

Farm profile: Rainbow trout farm

- Fish farm, and also farm with onions, butternut, sheep, pears and apples.
- There are ten ponds (hexagons) since four years, the porta pools are not being used for the moment.

- Molopong will rent the fish farm from him next year.
- He started in 2005 with fish farming in the dams and has eight years of experience as a fish farmer.
- To him, water quality is really important. He rates it eight or nine on a scale of ten.
- At the farm he works together with one full time farm worker (five extra workers in harvest period).
- He is a member of the Western Cape Trout Association (WCTA).
- The trout is sold to a local processing company in Stellenbosch Fish House for the moment.
- Production per year = all year around
    - In winter: 18-20 tons
    - In summer: 12 tons
- The good things about the location of the farm are the strong wind and the good water temperatures.

Knowledge exchange

- He always liked fish; everything about fish is interesting to him.
- He went to some training offered at SU. From these and other training programmes he gets the course material, and that helped him very much.
- These are useful to him to receive valuable information about water quality for example.
- The design of the system of the farm (with the filters), he figured it out by himself.
- He uses the internet to get some new information and if he has a problem on the farm he calls someone from Molopong or other fish farmers in the area.

Fish farm 8: Langekloof Trout
Fish farmer profile

Name	Male
Age	65 years
Children	2
Language	Afrikaans and English
Education	Electronics
Housing	At the farm together with his family

Farm profile: Rainbow trout farm

- The fish species at the farm are trout and tilapia.
- There are ten little pools for growing out the baby fish and six porta pools.
- He works on the farm together with one other farm worker.
- The total amount of production per year: 5 tons.
- He buys the fingerlings fish from Molopong.
- He sells the fish to local restaurants, individual buyers in town and sometimes to smokehouses.
- He uses clove oil as an anaesthetic.
- The quality of the water has been tested a number of times. He finds that especially the pH and the water temperature are important to control.
- They use one bag (25-30 kg) of feed per day.
- The effluent water from the porta pool production system, he considers very good for irrigation.
- There are no predators on the farm.
- Diseases: almost every summer the fish suffer from *Trichinella* sp. disease

Knowledge exchange

- He worked in computers (engineering, architecture, sales).
- Since eight years he manages a fish farm, and has now eight years of experience in fish farming. He is a member of the Western Cape Trout Association.
- He has never been to any training or aquaculture courses.
- He figured everything out by himself (a lot of trail-and-error),and searches for new information on the internet (Google). If there is a problem with the fish he contacts local aquaculture vets.

Fish farm 9: Nuwedam + Lomond
Fish farmer profile

Name	Male
Age	29 years
Children	1

Language	Afrikaans and English
Education	1 year course in aquaculture at Stellenbosch University
Housing	Gansbaai (not on the farm)

Farm profile: Rainbow trout farm

- He manages two fish farms in two different dams: Nuwedam and Lomond.
- Lomond: four big cages (12 m x 12 m; 8 m deep) and one small cage
- Nuwedam: 12 cages (10 m x 10 m and smaller; 5 m deep)
- The water of the Lomond dam is also being used for irrigation of the vineyards and for drinking water.
- He works on the two dams, together with three other farm workers (two men and one woman).
- The farms are only operational in winter. In summer he takes the cages out of the dams to prevent damage.
- Total amount of production per year: 80 tons (40 + 40).
- He buys the fingerlings from Molopong.
- He sells the fish to Three Streams Smokehouse.
- He uses clove oil as an anaesthetic.
- The quality of the water gets tested twice a year. The quality is good, although it can get muddy, which presents problems to him in terms of affecting the FCR's.
- The fish are being fed twice a day.
- The water used in de porta pools is very good for irrigation.
- Predators: birds and otters.
- No diseases.
- He manages another farm in Swellendam with cattle (dairy) and sheep. Five months per year (during summer) he stays at this farm in Swellendam.

Knowledge exchange

- He has studied aquaculture during a one-year course at Stellenbosch University. When he graduated he started fish farming with koi and goldfish.
- Now he manages Nuwedam and Lomand for seven years, and has nine years of experience as a fish farmer.
- He is a member of the Western Cape Trout Association.

If he wants to expand or improve methods or when a problem occurs he will use the internet as information source or he will contact another fish farmer

KwaZulu-Natal
Farm 1: Amatikulu Ornamentals
Fish farmer profile 1

Name	Male
Age	40
Marital status	Married
Children	2
Education level	Studied Horticulture
Home language	English
Second language/s	Afrikaans
Farmer status	Farmer, manager
Housing	Not on the farm
Member of any organizations	SAPTA (South African Pet Traders)
Duration in aquaculture	7 years at this site
Has access to internet	Yes

Farm details

Farm name and address	Amatikulu Aquarium Plants, Dokodweni Reserve, Kwazulu-Natal
Farm co-ordinates	29º4’15.989’’S and 31º38’56.76’’E

Farm profile

Aquaculture species farmed	Tropical and cold water ornamentals
Other farming activities	Water plants
Purpose of Aquaculture system	Live sales
Land	It is tribal land, which they lease
Farm size	Use about 2 ha of the 5 ha for aquaculture

Water source/s	Ground water
Water outflow	Flows out onto surrounding land
When was aquaculture first started	1970's for prawns and guppies
Is farming seasonal or all year round	All year round
Number of staff	1 secretary, 8 others
Other known aquaculture farmers in the area	Fish Designs

- With regards to the history of the farm, it began as a prawn farm in the early 70's. The owner at that time however, was also interested in fish and thus put up some tunnels in which he started breeding guppies. The business went extremely well, so the owner built more and more infrastructure. Sanctions were then introduced which took a toll on the export loads and slowly the business crumbled until it had to be sold. The following owner only took a portion of the farm, but ran it into the ground and left. The present farm was started after this episode.
- Amatikulu Ornamentals produce, and then also buy and sell about 100 different species of ornamentals including tetras, mollies, swords, guppies, catfish, and many more.
- The system is made up of concrete ponds predominantly found in tunnels, as well as glass tanks. There are more than 20 tunnels of approximately 8 x 30 m. There are also about 20 other larger tunnels which are not currently in use.
- He uses roughly 300 to 500 kg of feed per month, all depending on the fish he has stocked at that period.
- He delivers fish roughly twice a week, depending on orders, with about 20 boxes of live fish going out per day with on average of 500 fish per box.
- Customers include wholesalers and pet stores from Johannesburg, Cape Town and Pretoria.
- At this stage production of ornamentals makes up 100% of his overall profits.
- He claims that the constraints to his system include frogs (especially in spring) and birds, the Malachite Kingfisher in particular, as predators; as well as transport issues (as fish need to be transported live).

Knowledge exchange

- He first heard about aquaculture in his childhood, and here and there the topic would come up as he grew older.
- He started off by growing water plants at Amatikulu and later began farming ornamentals due to the available space and resources which offered a worthwhile opportunity to make some extra money.

- In terms of water quality, they check pH mostly, as he says they can't really do much about oxygen and temperature. If something goes wrong, it is generally due to a pH change or due to new fish coming in.
- He considers water quality highly important in any aquaculture system.
- Apparently the Koi Herpes Virus was a problem at one stage, so now they only buy certified disease-free koi from Israel, and other countries from where fish are imported.
- He has not attended any aquaculture workshops and claims that his knowledge was self-taught.
- When he wants to solve a problem or look for new information he uses the internet, advice from overseas farmers, or trial and error.
- New knowledge that he has come across lately on the internet included information about disease control with advice to use prebiotics to prevent disease.
- According to him, the main expenses are feed, transport, land and electricity with transport being the biggest expense; especially when importing and re-selling.
- He said that there is a demand for tilapia; however it costs too much to produce them in comparison to ornamentals. He says that there is a big market to use 10-15 cm tilapia as live bait on long liners, and they will take between 5 000 and 10 000 fish per week at roughly R5 a fish. He said that even with this high demand, he feels that it is too expensive to grow them to this size as well as there being the challenge of getting the fish to survive in salt water.

- If a blog/discussion forum was made available:
    - He said that he would follow it.
    - He would like to see information on alternative feeds and on frog control.
    - He said, however, that he would not use this source very often and would probably not post ideas or questions as he feels that ornamental fish farming is a very competitive niche market.
- If workshops were made available:
    - He said that all the workers on the farm are unskilled when they start, so everything they need to know about farming is taught to them on the farm.
    - He would maybe send his workers to a once-off workshop that involved management training.
    - Issues he may have with workshops are firstly how much they will cost, and secondly where the workshop will be held, as he will not consider workshops that are expensive and far away.

Farm 2: Kel Mark Trading
Fish farmer profile 2

Name	Male
Age	49
Marital status	Married
Children	3
Education level	Agricultural college
Home language	English
Second language/s	Afrikaans
Farmer status	Farmer, manager
Housing	On the farm
Member of any organizations	No
Duration in aquaculture	33 years with crocodiles, experimented briefly with tilapia
Has access to internet	Yes

Farm details

Farm name and address	Kel Mark Trading - Riverview farm, Wartburg Road, Kwazulu-Natal
Farm co-ordinates	29º28’12.331’’S and 30º28’51.146’’E

Farm profile

Aquaculture species farmed	Crocodiles (experimented with tilapia)
Other farming activities	None
Purpose of Aquaculture system	Crocodile skins and meat
Land	Owned by him
Farm size	40 ha
Water source/s	Umgeni River
Water outflow	Into settling dams, irrigation dams or back into the river
Is farming seasonal or all year round	All year round
Number of staff	20

Other known aquaculture farmers in the area	Amatikulu up the road

- The Nile crocodile dwindled to almost nothing due to poaching, and in about 1981 it became endangered. CITES changed the Nile crocodile's status to appendix 1 (same status as the rhino), which meant they could no longer be shot in the wild for skins. This created a shortage on the market, which led to the birth of crocodile farming. He claims that there are now more crocodiles on his farm than there were in total in Africa in 1975. Crocodile farming started in Zimbabwe and Zambia and then filtered into South Africa in the late 70's, early 80's. Once the numbers increased on farms, CITES changed the status to appendix 2 and numbers have been growing ever since.
- The crocodile industry changed a lot after the recession. According to him, it is no longer about quantity but more about quality. The prices are still excellent, especially the market overseas for handbags, belts, wallets, etc. and skins from Trevor's farm are exported and used by popular brand names such as Gucci, Prada and Louis Vuitton.
- What he felt is lacking is the subsidiary businesses that can feed off the crocodile industry i.e.. crocodile meat. They have been trying to grow the market for meat and there has been a surge in demand in the last two years by the African locals in South Africa. Presently, crocodile meat fetches roughly the same price as chicken, and he hopes that later it will grow into its own category.
- He used to export meat, but the government has certain regulations to comply with regards to sampling, which can only be done in Onderstepoort. However, they couldn't get samples there in one day, as samples needed to be done daily. Sampling would thus need to be done privately, which was not really worth it, so they thus prefer to sell locally.
- At the moment he has 40 earthen ponds of about 30 x 15 m and 2 m deep. He also has indoor ponds in a house which holds roughly 300 000 litres of water.
- They harvest around 100 to 500 crocodiles on a monthly basis.
- There are about 10 000 crocodiles on the farm at a time and they consume roughly 500 tons of meat per year. The baby crocodiles eat crickets with older crocodiles consuming left-over chicken and cattle meat from abattoirs.
- They stop feeding crocodiles in the second week of May and starts feeding again in the second week of August.
- Disease is not too much of an issue in the system, however if it does occur, it is usually in the hatchlings, the disease being similar to that in chickens.
- He feels that the biggest constraint to his system is cold water and therefore water temperature is constantly monitored in the crocodile system.

Knowledge exchange

- He first heard about aquaculture in the 1980's.
- He has experimented with tilapia co-culture as crocodile farming uses a huge amount of water, which is bombed out, high in nutrients, into settling dams, irrigation dams or back into the river.
- The farm also has an indoor system, where he put Mozambique tilapia in the ponds with the crocodiles. He found that they did really well, however KZN conservation authorities (Parks Board) stopped it as it is apparently illegal to keep predator with prey.
- He is considering doing co-culture in the new house they are building, with the fish above and the crocodiles below. He could then use the heated crocodile water for the fish. The new house is going to be approximately 2 500 m^2.
- He said that 100 000 litres of water at 32°C is thrown out per day which would be great for fish farming.
- However, he felt that he will require help to get a fish system in place and running as he has little knowledge about fish.
- He has not participated in any aquaculture training session or workshops and says that he gets most of his information from the internet and other farmers.
- He also feels that the information for fish farming that he has found to date is not specific enough, i.e. to start out.
- He feels that there should be government funded training courses where one can get a certificate to be able to farm fish. He says that the details of these training workshops should then be given to municipalities for community-based fish farming initiation.
- He also says that generally crocodile farmers have side initiatives such as curio shops, etc. for tourists to help support their businesses.

- If a blog/discussion forum was made available:
    - He said that he has never used a blog or discussion forum before, but he would try and follow one if it existed.
    - The information he would like to see on this site is methods to grow fish in marginal climate zones.
    - He reckons he would visit the site once a month and would participate by posting ideas and questions.
- If workshops were made available:
    - He would like to know the basics about farming with tilapia.
    - He thinks a workshop should be held maybe once a year and the biggest issues he would have with a workshop is time and travel costs.

Farm 3: Giant's Cup Hatchery
Fish farmer profile 3

Name	Male
Age	64

Marital status	Married
Children	4
Education level	Grade 10
Home language	English
Second language/s	Afrikaans, Hebrew, Dutch, German, Xhosa
Farmer status	Farmer, manager
Housing	On the farm
Member of any organizations	Trout South Africa, The South African Trout Producers Association, FOSAF (Federation of Southern African Flyfishers)
Duration in aquaculture	28
Has access to internet	Yes

Farm details

Farm name and address	Giant's Cup – Goshen Farm, Giant's Cup Wilderness Reserve, Underberg, Kwazulu-Natal
Farm co-ordinates	29º43'52.972''S and 29º22'23.699''E

Farm profile

Aquaculture species farmed	Rainbow trout
Other farming activities	A few sheep, (guest cottages for trout fishermen)
Purpose of Aquaculture system	Live sale (eyed-over, fingerlings, table size); value-added products (whole, fillets, smoked, pate)
Land	He is a 40% shareholder of the land
Farm size	110 ha of land; 2.5 to 3 ha used for ponds; 25 ha lake
Water source/s	Lake on Umzimkulwana River
Water outflow	Back into the river
Is farming seasonal or all year round	All year round
Number of staff	7

Other known aquaculture farmers in the area	Splashy Fen and Crystal Waters

- Aquaculture was first started on the farm in 1980 when the owner was just experimenting with fish farming. He then began his fish farming on the farm in 1987.
- He has a hatchery and uses earthen ponds and circular, plastic ponds for the grow-out phase.
- He uses roughly 2 to 3 tons of feed per year and has an on-going harvest depending on demand.
- He sells his products to wholesalers and live fish to local farmers for the stocking of their dams.
- He has his own abattoir and also does his own fish smoking. He thus has a full product range.
- Predators include fish eagles, cormorants, otters and herons, and Wolf has tried to use nets to prevent their entry, however he also says that these predators are all part of nature and are beneficial for visiting sightseers, so he doesn't mind them too much.
- In terms of disease, Wolf says that issues only arose when fish were brought in from other farms. Grass carp from the government hatchery at Albert Falls came with *Ichthyophthirius multifiliis* that took 12 years to get out of his hatchery. Fish from Lunsklip, came with drug resistant streptococcus, from pig farms further upstream that feed antibiotics in their pig feed, thus breeding super bacteria. He has, however, overcome both these issues.

Knowledge exchange

- He first heard about aquaculture in 1957 when he was visiting a few carp ponds in Israel.
- He was originally a photographer and when asked why he decided to become a fish farmer, replied with, "Because it beats working for a living."
- In terms of water quality, there is a SAS bio-monitoring station at the top of the farm, as well as below the hatchery. The Department of Water Affairs used to come regularly to check water quality, but have since stopped.
- He has not participated in any aquaculture training sessions or workshops.
- He said that his knowledge comes from literature and practical experience.
- When he wants to improve methods on his farm he generally uses Google as an information source.
- He regards water supply, the market, bureaucracy and legal frameworks as constraints to his aquaculture system.

- If a blog/discussion forum was made available:
    - He has made use of a blog/forum before, and would follow such a blog/forum.

- He would however not visit it very often, as he feels he knows what he needs to know and would perhaps look at it if he came across a problem he can't solve logically.
- He jokes that he will only post ideas if he gets paid to do so.

- If workshops were made available:
  - H feels that he could teach his workers as much as they could learn at a workshop, but he would advise other farmers to use workshops as often as possible.
  - He also feels that the success of workshops depends on the capacity and competency of the presenters to give useful or new knowledge.

Farm 4: Crystal Waters

Fish farmer profile 4

Name	Male
Age	75
Marital status	Married for 50 years
Children	5 daughters
Education level	BSc Agriculture
Home language	English
Second language/s	Afrikaans, Zulu, Xhosa
Farmer status	Retired active farmer – current fish farmer, manager
Housing	On the farm
Member of any organizations	KZNFFA (KZN Fly Fishers Association) and FOSAF (Federation of Southern African Fly fishers)
Duration in aquaculture	6 years
Has access to internet	No

Farm details

Farm name and address	Crystal Waters – PO BOX 531, Underberg, 3257, Kwazulu-Natal
Farm co-ordinates	29º43'52.972''S and 29º22'23.699''E

Farm profile

Aquaculture species farmed	Rainbow trout and Brown trout
Other farming activities	Cattle, horses, game, (guest houses)
Purpose of Aquaculture system	Stocking of his dams and surplus is sold live to other farmers for stocking
Land	Forms part of a trust. Arthur is the trust manager.
Farm size	Roughly 712 ha
Water source/s	Umzimude River
Water outflow	Back into the river or into irrigation dams
Is farming seasonal or all year round	He grows the fish to 80/100 g then takes a month/6 weeks break before the next cycle
Number of staff	1 – his wife
Other known aquaculture farmers in the area	Lunsklip in Dalstroom (where they get their ova), they used to get their ova from Bushman's River Hatchery in Giant's Castle. Splashy Fen and Giant's Cup are others they knew about.

- He farms in concrete and metal circular ponds, and hatches out on trays.
- He has six concrete ponds of about 3.5/4 m in diameter and seven metal smaller ponds which are about 2.5 m in diameter. The ponds are all roughly 60 to 70 cm deep.
- He obtains his feed from AVI, and he feeds *ad libitum*. He also uses temperature charts and weight to work out feed amounts.
- He feels that regular grading is important so that shy feeders are given a chance to eat and he generally starts grading fish when they are an inch to an inch and a half long.
- He usually gets his ova at the end of July/beginning of August.
- He then stocks his dam when the fish reach about 15-20 cm in length or 75/80 g.
- Surplus fish are sold locally to the Underberg Fishing Club, the Kokstad Fishing Club, as well as to other farmers to stock their dams.
- Otters and the Malachite Kingfisher are the main predators in his system. He tries to keep them out with netting.
- He said says that they sold about 10 000 fish during this past year and that fishermen who come to do trout fishing make up about 80% of his profits, while around 20% is brought in by the hatchery, depending on fish survival.

Knowledge exchange

- As a child he was always interested in fish and the first time he heard about aquaculture was about 50 years ago.
- He decided to start farming with fish as he had the water resource, so when he retired from active farming, he took up fish farming as more of a hobby.
- He doesn't use any methods to test water quality as the water is fresh and clean from the river. He has had no problems with water quality to date; issues have only arisen when the water supplies have been cut off due to storms, hail, etc.
- If he sees that the fish are not doing so well he generally just adds some salt to the water. He is not completely sure of what it does, but it seems to help the fish recover each time.
- He stops feeding his fish when water reaches 20°C, and he has personally found that the Brown trout are more tolerant to higher temperatures.
- He has not participated in any aquaculture training sessions or workshops.
- He says that his knowledge of fish farming comes from hands-on experience; trial and error; and books. There was also a Parks Board member who worked in hatcheries who helped him out.
- The biggest issue he has had with his system is problems with water flow.
- New knowledge that he picked up recently was from a fellow fish farmer who advised to use salt when the fish weren't doing well.

- If a blog/discussion forum was made available:
    - He would not use it, as he has no computer or internet.
- If workshops were made available:
    - He would like information on how to avoid fish mortalities i.e. like the salt idea.
    - He would, however, not likely attend workshops as he feels he knows enough at this stage to run his system successfully and feels that the methods that he is using works well for him.
    - He also feels that one of the constraints to workshops is that people think they know it all and have too much pride to attend.

Farm 5: Splashy Fen
Fish farmer profile 5

Name	Female
Age	52
Marital status	Married
Children	2 Sons

Education level	Diploma in Agriculture
Home language	English
Second language/s	Afrikaans, Zulu, Xhosa
Farmer status	Old farmer, manager (Recently taken over by Peter Hampson)
Housing	Not on the farm
Member of any organizations	No
Duration in aquaculture	5 years
Has access to internet	Yes

Farm details

Farm name and address	Splashy Fen – Underberg, Kwazulu-Natal
Farm co-ordinates	29º48’5.396’’S and 29º20’24.648’’E

Farm profile

Aquaculture species farmed	Rainbow trout and Brown trout
Other farming activities	Some heifers (Otherwise a holiday home)
Purpose of Aquaculture system	Fish are sold live to other farmers for stocking purposes
Land	Using the river and a small area for aquaculture (Land belongs to someone else).
Farm size	Roughly 15-20 ha
Water source/s	Mountain stream
Water outflow	Back into the stream which joins up with the Mzimude River
Is farming seasonal or all year round	Seasonal
Number of staff	3
Other known aquaculture farmers in the area	Bushmans River Trout, Crystal Waters, Giant’s Cup, Champagne Castle

- The system at Splashy Fen has been operational for 20 years now although it has changed hands quite a few times. It is presently under their management who has had the system for about a year now.
- She said that they used to get the eggs in August, and from then the growth rate was about an inch per month. If fed properly, they could get 15 cm fish by mid-March. Due to it being a flow-through system, they tried to be done by the end of June, as water from the stream would dry up at around this period. If they wanted to carry on with the fish through these months, they had to recycle water.
- They have both rainbow and brown trout; however she found the rainbow ones to be more popular due to their fast growth.
- She became responsible for deliveries in later years and made sure to regulate the fish water before stocking the dams to reduce stress from temperature shock to a minimum.
- The system consists of a hatchery and circular concrete ponds of varying size.
- There are two ponds of about 4 m in diameter, six ponds of about 6 m in diameter, one pond of about 11 m in diameter and eight small ponds of about 2 m in diameter.
- They usually started off with 50 000 eggs and then later stocked about 5 000 fish per pond. They could therefore hold a maximum of 60 000 fish in the concrete tanks in total.
- They used to feed them *ad libitum* and would harvest as often as possible when there was good weather; sometimes daily or sometimes every two weeks. It depended on the temperatures. They generally transported about 500 live fish per trip.
- They supplied fish to both Kokstad and Underberg areas for dam stocking.
- Otters and birds proved to be a problem in their system. Thick, high, concrete pond walls were thus built and netting and chicken mesh was used to keep these predators out. After time however, the mesh rusted and the netting acquired holes. It was later discovered that electric wires just above the ground around the perimeter was very successful in keeping otters out.
- In terms of the contribution of aquaculture to their income, it was not much but did however provide cash flow when other farming activities weren't bringing in money.

Knowledge exchange

- She had heard about aquaculture here and there throughout her lifetime, but it was not until their family took over the system at Splashy Fen that she really got involved.
- They took over the system because her husband thought it would be a good business opportunity for their 19 year old son. He, however, lost interest and she then took over.
- She said says they never used to check water quality, as the water from the stream was very clean. If anything, temperature was the problem; they would measure temperatures and stop feeding once it reached 19°C. The fish behaviour would generally tell them if there were any issues.

- She has not participated in any aquaculture training sessions or workshops.
- She claims that her knowledge comes from practical experience as well as help from other farmers. She also did research on the internet, but found that a lot of the information referred to American systems.
- She says that the main constraint to her system was the minimal water flow during the dry period (end of July to beginning of October) if there hadn't been any snow and rain.

- If a blog/discussion forum was made available:
    - As she makes use of them often for her other hobbies, she says she would definitely have a look.
    - She would like to see a common sharing of knowledge amongst people with hatcheries. One could then see if other farmers were having the same problems and what their solutions were.
    - She would visit such a blog/forum maybe every day or second day, and says she would participate in posting ideas and questions.
- If workshops were made available:
    - She would like to send her workers to learn about fish health so that they can recognise problems in the system by monitoring signs and symptoms. Otherwise she would like her workers to receive management training so that they could assist in managing the system.
    - She feels that a once-off such training session would be sufficient.
    - She also says that fish farming is not rocket science and most skills and knowledge are based on common sense.

Farm 6: Wayfarer Trout
Fish farmer profile 6

Name	Male	Male
Age	60	29
Marital status	Married	Not married
Children	2	-
Education level	BSc in Building	Tertiary education
Home language	English	English
Second language/s	Afrikaans	Afrikaans
Farmer status	Farmer/owner	Partner

Housing	On the farm	On the farm
Member of any organizations	No	FOSAF (Federation of Southern African Fly fishers)
Duration in aquaculture	8 years	8 years
Has access to internet	Yes	Yes

Farm details

Farm name and address	Wayfarer – 21 Hazelmere Estate, Dargle, Kwazulu-Natal
Farm co-ordinates	29º32’18.006’’S and 30º00’25.084’’E

Farm profile

Aquaculture species farmed	Rainbow trout
Other farming activities	Small-scale hay crops
Purpose of Aquaculture system	Sold for consumption, fillets, cold smoked fillets
Land	Owned by farmer
Farm size	30 ha
Water source/s	River
Water outflow	Back into the river which joins up with the Umgeni River
Is farming seasonal or all year round	All year round
Number of staff	3
Other known aquaculture farmers in the area	Giant’s Cup, Peak trout

- Both first began farming trout in 2007.
- They have a small hatchery with trays for growth to fry, and then three small concrete ponds for fingerlings. They also have two circular earthen ponds and two larger grow-out, earthen ponds. In total they have about 150 m^2 of ponds with roughly 230 m^3 of water.

- They use about 120 kg of feed monthly.
- They produce about one and a half tons of trout a year and harvest on a weekly basis.
- They sell their products to local restaurants and hotels and do their own processing.
- They have a smokehouse on their property to produce cold smoked products.
- They say that otters are their primary predators.
- Their aquaculture system contributes 90% of their overall income.

Knowledge exchange

- Both measure the temperature of their water with a thermometer and also just look at their fish for any signs of disease or problems.
- They feel that water quality is very important as trout have specific requirements for optimal growth.
- One farmer said that his has participated in an aquaculture training workshop, while the other said that his knowledge comes from practical experience.
- They both feel that most of their knowledge comes from fishing and liaison with existing hatcheries and when they need to improve methods on their farm they would ask advice from these other hatcheries, use practical observation, the internet or books.
- They both feel that constraints to their system are their water volume and the climate.

- If a blog/discussion forum was made available:
    - One farmer has not used one before, however he would make use of one on a monthly basis if it existed. He would like to see information on water flow and volumes, diseases, rates of growth, and pumps. He feels that he would participate by posting his ideas and questions.
    - The other farmer on the other hand, has made use of a blog/discussion forum before and would make use of one again regarding aquaculture. He would like to see information on problem solving for certain issues that are commonly experienced. He would only consult such a site when necessary i.e. when an issue arises. He would thus participate by posting ideas and questions.
- If workshops were made available:
    - One farmer would probably not attend, however the other would consider attending depending on the topic.
    - He said that valuable information which he would like to gain from a workshop would include the vital basics as well as information regarding maintenance and transport.

Farm 7: Bushman's River Trout

Fish farmer profile 7

Name	Male
Age	59
Marital status	Married
Children	1
Education level	Diploma in Nature Conservation
Home language	English
Second language/s	Afrikaans, Zulu
Farmer status	Manager
Housing	On the farm
Member of any organizations	No
Duration in aquaculture	3 years
Has access to internet	Yes

Farm details

Farm name and address	Bushman's River Trout Hatchery – Giant's Castle, Kwazulu-Natal
Farm co-ordinates	29º12'59.951''S and 29º33'33.685''E
Website	www.bushmansrivertrout.co.za

Farm profile

Aquaculture species farmed	Rainbow trout
Other farming activities	Game farm
Purpose of Aquaculture system	Sold for consumption(fresh, vacuum packed, frozen; 300-350g for hot smoking; 500 g for fillets), sold for stocking (fingerlings of 12.5 cm; and 3 kg live sale)
Land	Owned by independent business person
Farm size	3 ha aquaculture system

Water source/s	Bushman's River
Water outflow	Back into the river which joins up with the Bushman's River
Is farming seasonal or all year round	All year round
Number of staff	2 managers, 9 permanents workers
Other known aquaculture farmers in the area	Giant's Cup, Peak trout

- He said that aquaculture was started about 40 years ago at this site.
- He said that it is a gravity flow-through system which is currently producing about 50 tons a year; however they are now increasing the size of the system and are aiming to produce around 100 tons by next year.
- At present the system consists of eight larger round tanks (3 m in diameter and 1 m deep), eight smaller round tanks (2 m in diameter and 1 m deep), and 10 rectangular runs (each 30 m x 2 m; and 1 m deep).
- They use roughly 45-50 bags (approximately 130 kg) of feed per day when the system is full and they obtain their feed from AVI.
- At present they harvest around 400 to 500 fish daily, 4 to 5 days a week, for processing. In terms of live sales, they deliver around 80 to 100kg a week for stocking.
- The do all their own processing and sell their products to Checkers and Classic Foods, as well as to restaurants and deli's.
- The waste products from the abattoir are given to the locals for animal feeds.
- Problematic predators include otters, grey herons, stalks and iguanas. They have used electric fencing and netting to try to keep these animals out.

Knowledge exchange

- His profession began in Nature Conservation. He worked for the Parks Board from 1976 in the field of marine conservation, checking mostly if fishermen were licensed. He then went to work on a game farm in Bethlehem in 2001.
- He had also worked at Giant's Castle for some time and thus knew of the system. Three years ago, because of his reputation and background; he was offered an interview to work as a manager on this system and has been working there ever since. According to him 100% of his income comes from this occupation.
- In terms of water quality, the Department of Water Affairs usually checks their water every now and then, and apparently the last visit being about a year ago. Otherwise he and his team just monitor the water temperatures and the dissolved oxygen levels.

- He has not participated in any aquaculture training sessions or workshops and says that his knowledge of fish farming comes from other farmers, the internet and common sense.
- When he has an issue he usually consults the owner first. Otherwise he will look on the internet or phone a friend.
- He feels that constraints or issues that may negatively impact the system include high temperatures and low dissolved oxygen levels which can quickly result in large scale mortalities. He has also experienced overstocking problems in the system. Storms have also proven to be an issue as they affect water quality and may also create electrical cuts whereby standby generators need to be used. The supply of electricity is also not reliable and he predicted that power-cuts occur at least once a month.

- If a blog/discussion forum was made available:
    - He has not made use of one before, however he would give it a try if there was an aquaculture themed one made available.
    - He would probably visit such a site on the weekends during his free time and would like to see information on diseases, temperature ranges recommended by other farmers for trout and other experienced farmers' thoughts and suggestions.
    - He feels that he would participate by posting ideas and questions.
- If workshops were made available:
    - In terms of workshops, he would like to attend to learn more about the basics, stocking rates and disease.
    - He reckons workshops could be held once every six months.
    - He does however find that the main reason he would not attend is due to the fact that he would need to take time off from work to attend, which is not often possible as fish farming is a full time job with the system needing to be monitored 24/7. The other issue is the time and costs to get to and participate in the workshops.

Farm 8: Peak Trout
Fish farmer profile 8

Name	Male
Age	33
Marital status	Married
Children	2
Education level	N/A
Home language	English
Second language/s	Slovenian

Farmer status	Farmer
Housing	On the farm
Member of any organizations	Trout SA
Duration in aquaculture	9 years
Has access to internet	Yes

Farm details

Farm name and address	Peak Trout – Cathedral Peak, Kwazulu-Natal
Farm co-ordinates	28º56'43.858''S and 29º11'46.024''E

Farm profile

Aquaculture species farmed	Rainbow trout and Brown trout
Other farming activities	None
Purpose of Aquaculture system	Live sale and processed products
Land	Rented from Cathedral Peak Hotel
Farm size	5 ha
Water source/s	From the stream
Water outflow	Back into the Mlambonja River
Is farming seasonal or all year round	All year round
Number of staff	6 permanent and 3 casual
Other known aquaculture farmers in the area	Bushmen's River Trout

- He has 37 hatching troughs, growing ponds and raceways.
- He uses roughly 40 to 50 tons of feed per year.
- He harvests weekly to every fortnight and the size of his harvest varies.
- In the first year of production (April 2012 to April 2013) they produced 42 tons live weight of trout, and are aimed for 60 tons the following year.
- Processing is done in a plant 40 km away and they supply their products and live sales to a variety of clients.

- Predators include otters and birds.
- The trout system is their sole supply of income.

Knowledge exchange

- He was 5 years old when he first visited a fish farm, and since then he decided that this is what he would like to do.
- Umgeni Water Affairs comes to test his water quality.
- He has not participated in any aquaculture training sessions or workshops, and owes his knowledge to three years of practical experience, countless books, friends and the internet.
- He feels that a periodic magazine with up to date information on aquaculture would be useful in exchanging knowledge.
- He feels that the major constraints to his system are climate change and government. He feels that current issues that face the fish farmer industry are drastic and there is almost no reinvestment.

- If a blog/discussion forum was made available:
    - He has made use of a blog/discussion forum before but says that he would not use one if it was made available for aquaculture farmers. He feels that it doesn't work for a practical person.
- If workshops were made available:
    - He feels that there is not much more for him and his workers to be taught. He also feels that workshops and intellectual meetings are often invaluable or a waste of time, and as fish farming is a 365 days a year job; there is nothing worse than wasted time.

Farm 9: Milestone
Fish farmer profile 9

Name	Male
Age	53
Marital status	Married
Children	3
Education level	Degree in Agricultural Management and Honours in Commerce
Home language	English
Second language/s	Afrikaans

Farmer status	Farmer
Housing	On the farm
Member of any organizations	No
Duration in aquaculture	None
Has access to internet	Yes

Farm details

Farm name and address	Milestone – R614, Wartburg, Kwazulu-Natal
Farm co-ordinates	29º28’2.842’’S and 30º29’34.533’’E

Farm profile

Aquaculture species to be farmed	Mozambique tilapia
Other farming activities	Vegetables and herbs (Aquaponic system), Nguni cows
Purpose of Aquaculture system	Produce fish (gutted and gilled), vegetables and herbs for consumption
Land	Owned by him
Farm size	150 ha
Water source/s	Dam (on Nhlambamasoka River) and borehole
Water outflow	Re-circulating system – small amounts for irrigation
Will farming be seasonal or all year round	All year round
Number of staff	2
Other known aquaculture farmers in the area	Crocodile farm next door

- He recently bought the farm and decided he would like to do some form of intensive farming on it. He considered pig farming, but eventually settled on Aquaponics.

- His system will have three tunnels (8 m x 37 m), comprising of 12 circular fibre glass tanks in total (for the tilapia; 2.3 m in diameter; 1.2 m deep) and 114 trays in total for the plants (2.1 x 1.4 m; and 0.3 m deep set-up in parallel). He will also have one water pump for every nine trays.
- He plans to plant herbs or leafy plants such as basil, rosemary and rocket; and cucumbers and tomatoes in winter.
- He also plans to use heaters to heat the water in winter.
- He plans to get his tilapia fingerlings (he has ordered 1 500) by the end of November 2014 from a supplier in Grahamstown, and also begin planting around this time.
- He is considering obtaining his fish feed from Hillcrest and my also try to grow some duckweed as an alternative feed source.
- He plans to sell his tilapia to the local Spar supermarkets and restaurants and predicts that he will be able to grow fingerlings to plate size (approximately 350 g) within about 5-6 months. There will thus be two cycle per year.
- He hopes to install solar panels to run the air-blowers, heaters and pumps.
- He is using a gravel substrate for the plants.
- He will have roughly 660 fish per round tank and his tanks hold roughly 5000 L which means that in best case scenario; he could harvest about 2 tons.
- He hopes to sell the tilapia at R30/kg or more; as he has seen tilapia being sold in the local supermarket for R29/kg.
- Wind during storms has already proved to be a bit of an issue as the most recent storm has already damaged his tunnels quite badly.

Knowledge exchange

- He attended a 10 day course through Aquaculture Innovations (www.aguaafrica.co.za) on tilapia aquaculture at Rhodes University two years ago and in the process also met one of the aquaculture experts.
- The expert has been working with Aquaponics and Hydroponics for quite some time. The owner has thus used the expert as a consultant in the set-up of his system and all his information has come from him. He said that his system will be an exact copy of the consultant's one.
- If he cannot get information from the consultant then he refers to the internet as an information source.
- He feels that he would like to know more about what the ratio of fish to plants should be and welcomes any information or advice on the matter.
- He says he will monitor temperature closely once his system is up and running.
- He feels that issues or constraints to his system could include electricity costs, feed costs strong winds, very days (which will be fine for the fish, but may cause the plants to wilt).

- If a blog/discussion forum was made available:
    - He has used one before and would happily follow an aquaculture themed blog/discussion forum.
    - He feels that he always has little questions here and there (for example plant to fish ratios) and would thus participate by posting questions and ideas.
    - He would visit such a site once a week.
- If workshops were made available:
    - He says he would attend one which covers start-up and management of an Aquaponics system as well as which deals with general information on Aquaponics.
    - He reckons a workshop could be held every six months.
    - The biggest issue he would have with workshops is the cost and getting there; as the last 10 day workshop he did including accommodation cost around R 18 000 (six people attended this course).

Limpopo
Farm 1
Fish farmer profile 1

Name	Female
Age group	31-40
Marital status	Married
Household size	7
Education level	Secondary
Home language	Tshivenda
Second language/s	Xitsonga and English
Farmer status	Farmer, manager
Housing	The farm is on the yard
Duration in aquaculture	8 years
Has access to internet	no

Farm details

Farm name	Nemubvumoni

Farm co-ordinates	23 °05´94.2" S and 30° 40´66.7" E
Farm Location	Lwamondo

Farm profile

Aquaculture species farmed	Tilapia
Other farming activities	Vegetables
Purpose of aquaculture	House consumption and sales
Land	Own
Farm size	Small-scale (0.1-2.5) ha
Water source/s	Stream
Water outflow	Stream
When was aquaculture first started	2006
Is farming seasonal or all year round	All year round
Number of staff	Casual workers (only when harvesting)

Farm history and current situation

- She lives close to a stream in Lwamondo. She is unemployed and a mother of five children. She started fish farming after receiving a vision in her sleep in 2006. She currently has 8 grown-out ponds and two ponds for juveniles. She farms *Oreochromis mossambicus*, but explained that *Clarias gariepinus "*crawls" from the stream to the fish ponds.
- The farmer harvest twice a year. She makes an announcement on the local radio (Phalaphala FM) and announces the date on which she is harvesting.
- Customers come to the farm to buy fish. She has no scale to weight the fish; hence she set the price using the arbitrary method (i.e. a hand size tilapia may cost R10).
- There is a very high demand for fish; her production does not meet the demand.
- She works hand in hand with her husband, who is a warrant officer.
- She Nemubvumoni has been nominated as the top entrepreneur smallholder-fisheries subcategory

Challenges

- The major challenge that she is facing is theft. She explained that people come in at night to fish in her ponds since there is no fence. She suggested that a security/electric fence may be erected.
- Birds are also feeding from her ponds. The solution to this challenge would be covering ponds with nets
- The other challenge was lack of equipment. The farmer stated that she harvest using a parachute net, which make a lot of noise and scare away the fish when harvesting, hence she is unable to harvest all fish in the pond. The net is now in poor condition
- The stream that is the only source of water for her farming is seasonal; it dries up in winter. She stated that there is a need for constructing a borehole that will act as a back-up when the stream runs dry.
- She further explained that there is lack of finance or sponsors. She wish to expand her farm and introduce different species, make it a place where students will come and learn fish farming, since it's a new and undeveloped sector in the province.
- There are currently no stores that sell fish feed in the local area. She stated that Extension officers organize fish feed for her and bring them to the farm for her to buy.

Knowledge exchange

- She learns new things about aquaculture from the workshops that are held once in a while, extension officers, radio and TELEVISION. She was fortunate to be one of the few farmers who had an opportunity to visit China, to learn how they do fish farming. She had wished to apply what she saw/learned from China, the challenge was lack of finance. The farmer admitted that she still needs more training on aquaculture, to increase productivity.
- The farmer has no access to internet and local library, where she can obtain information but she wish she can be supplied with more information sources to increase her level of knowledge in aquaculture

Farm 2

Fish farmer profile 2

Name	Male
gender	Male
Age group	Over 50
Marital status	Married
Household size	7
Education level	Secondary
Home language	Tshivenda

Second language/s	English
Farmer status	Farmer, manager
Housing	Not in the farm
Duration in aquaculture	4 years
Has access to internet	no

Farm details

Farm name	Nemaguvhuni
Farm co-ordinates	22°59´59.19"S and 30°21´53.23"E
Farm Location	Lwamondo

Farm profile

Aquaculture species farmed	Tilapia
Other farming activities	Vegetables (cabbage and butternut), fruits, maize meal
Purpose of aquaculture	Household consumption
Land	Own
Farm size	3.4 ha
Water source/s	Well and stream
Water outflow	stream
When was aquaculture first started	2011
Is farming seasonal or all year round	All year round
Number of staff	1(permanent)

Farm history and current situation

- He is a police officer by profession, business-minded and a farmer. He first heard about fish farming from a provincial aquaculture project. He then constructed a small fish pond at his home and stocked it with fish from the wild. After few days of stocking, all fish

died. He then thought of his farm where he was planting maize meal. He then went to construct 4 fish ponds, stocked them with tilapia from Nandoni dam, where he is currently farming.

- Nandoni dam is located on the Luvuvhu river near the villages of ha-Mutoti and ha-Budeli just a few kilometers from Thohoyandou in the Vhembe district
- Both owners are good anglers and have been involved in national angling competitions. He and wife are both equally involved in managing all farming practices.
- He sold his fish only once. The fish were sold to a friend.
- The farmer has passion for aquaculture. He is planning to build himself a house in the farm, improve all farming activities so that the farm will be a game reserve and a place where learners and students come to learn about all form of farming (vegetables, fish, fruits and fish)

Challenges

- The major challenge that he is facing is theft. He mentioned that there are people who come to fish from his ponds. But since he reported it to the police, the suspects were arrested and since then, there has not been any theft.
- Reptiles, especially snakes are a big challenge to the farmer, worker and fish. They feed from the fish in the pond. He stated that he has to clean the ponds by removing weed around the ponds, and if it is suspected that that is where the snake might hide.
- Birds also are challenges to fish. The proposed solution to this challenge is to cover the ponds with a net.
- Lack of fish feed is one of the major challenges in the farm.

Knowledge exchange

- He learned new things about aquaculture from the workshop and extension officers.
- Since he is an angler, he obtains some of the aquaculture information from the books at the dam's reception when he go for competitions.
- The farmer has no access to internet.

Farm: 3

Fish farmer profile 3

Name	N.a.
Gender	Male
Age group	31-40

Marital status	Married
Household size	More than 5
Education level	Tertiary (Studied Civil engineering)
Home language	Tshivenda
Second language/s	English
Farmer status	Farmer
Housing	Not in the farm
Duration in aquaculture	5 years
Has access to internet	Yes

Farm details

Farm name	Mudau
Farm co-ordinates	23°00´35.70" S and 30°22´08.23" E
Farm Location	Lwamondo

Farm profile

Aquaculture species farmed	Tilapia
Other farming activities	Vegetables and sugar cane
Purpose of aquaculture	Household consumption
Land	Own
Farm size	Small-scale(0.1-2.5)ha
Water source/s	Stream and well
Water outflow	Stream
When was aquaculture first started	2010
Is farming seasonal or all year round	All year round
Number of staff	5(casual)

Farm history and current situation

- He inherited the farm from his grandfather in 2009, where he started planting cabbage. His cabbage idea was unsuccessful, and that is when he thought of fish farming. The idea of fish farming came after browsing the internet.
- He currently has two fish ponds and one under construction.
- The farmer is farming for household consumption; he has not sold any fish but there is an idea of selling soon.
- The first batch of broodstock was bought from another farmer not far from where his farm is.
- He wishes to extend his pond (the one under construction) to the river and introduce cage-culture production.
- Beside the river and the well in his farm serve as sources of water. The farm itself is considered a wetland.
- He also has sugar cane that he sells to sugar factory

Challenges

- The major challenge that he is facing is theft. He explained that people come in at night to fish from her ponds since there is no fence. He suggested that a security fence may be erected.
- Birds and frogs are also feeding from his ponds. The solution to this challenge would be covering ponds with nets
- He further explained that there is lack of finance or sponsors in the aquaculture sector. he wish to expand his farm and introduce different species, make it a place where students will come and learn fish farming, since it's a need and undeveloped sector in the province.

Knowledge exchange

- The major source where he find/search for new fish farming information is surfing the net.
- One of the latest information he found was the use of cage in fish production
- He also learns from workshop, although he found it not to be very informative. He further stated that information provided or disseminated at the workshops is what he already knows or he learnt from the internet. He has no specific site where he gets new information.
- The other source or method where he gets information is from extension officers.

Farm 4

Farmer profile 4

Name	N.a.
Gender	Male

Age group	31-40
Marital status	single
Household size	5
Education level	Tertiary
Home language	Tshivenda
Second language/s	English
Farmer status	Farmer
Housing	Not in the farm
Duration in aquaculture	3 years
Has access to internet	no

Farm details

Farm name	Tshivhase
Farm co-ordinates	22°57´44.90 "S and 30°23´42.29 "E
Farm Location	Phiphidi

Farm profile

Aquaculture species farmed	Tilapia
Other farming activities	Litchis, goats, chickens, ducks and rabbits
Purpose of aquaculture	Household consumption
Land	Family
Farm size	20 ha
Water source/s	Stream and well
Water outflow	Stream
When was aquaculture first started	2011
Is farming seasonal or all year round	All year round
Number of staff	>20 (casual)

Farm history and current situation

- He inherited his farm from his farther since 2011. He then started being a full time farmer, with lots of projects happening in his farm. He farm animals (goats, indigenous chicken, and egg producing chickens, ducks, turkeys, rabbits and bees), litchis, mangoes, avocados, bananas and fish.
- He farms on a 20 ha farm and has two fish ponds where he is farming tilapia. The major farming activity in his farm is litchis, that contribute over 80% of his farming activities
- The farmer bought the broodstock from the fellow local farmer not far from where he is staying.
- He stated that he never sold fish to anyone, although there is a very high demand for fish in the area.
- His fish farming passion started at a very tender age (when he was in primary), he explained that he once had a small pond in his yard where he stocked it with fish, which later died. However, the fish pond is still present up to this date.
- He is currently feeding his fish with fresh chicken waste.

Challenges

- Unlike other farmers in the area, he does not experience theft. Although his farm is not fully fenced, people in the area where his farm is, are very scared of him since he is a very quiet man.
- The challenge that the farmer is facing is lack of support and financial assistance. This has constrained him from expanding his fish ponds and applying the knowledge that he had learned in the workshop

Knowledge exchange

- He has a certificate from Madzivhandila college of agriculture
- Sources where he obtain fish farming information include workshops and extension officers

Fish farmer 5

Farmer profile 5

Name	N,a,
Gender	Male
Age group	Over 50
Marital status	married

Household size	2
Education level	Secondary
Home language	Tshivenda
Second language/s	English
Farmer status	Farmer
Housing	Not in the farm
Duration in aquaculture	5 years
Has access to internet	no

Farm details

Farm name	Ndou
Farm co-ordinates	22°59´07.56 "S and 30°26´23.49 "E
Farm Location	Muledane

Farm profile

Aquaculture species farmed	Tilapia
Other farming activities	None
Purpose of aquaculture	Household consumption
Land	Own
Farm size	2.7 ha
Water source/s	Stream
Water outflow	Stream
When was aquaculture first started	2010
Is farming seasonal or all year round	All year round
Number of staff	none

Farm history and current situation

- He bought the farm from the local chief. The initial idea of the farm was starting a business. The first and current business running in the farm is the car wash.
- The farm is situated close to the R524 road to Thohoyandou.
- He introduced fish farming in 2010, since the farm is a wetland.
- He farm for household consumption, but has a wish to expand his fish farming to increase productivity, due to a very high demand for fish in the area.
- Beside the stream close to the farm, the farm itself is a wetland.
- He currently operates on 2 earthen fish ponds.
- The farmer wish to introduce cabbage for school feeding scheme, and sugar cane.

Challenges

- The major problem is theft, since the farm is not fenced. Cattle also drink from the ponds.
- He is unable to harvest all the fish from the pond due to the poor ponds structure.
- He further mentioned that he lack knowledge on the aquaculture field.
- The farmer further mentioned that there is no financial support and sponsors in the aquaculture sector.

Knowledge exchange

- He obtained new information about aquaculture from workshops and extension officers.

Fish farmer: 6

Farmer profile 6

Name	N.a.
Gender	Male and female
Age group	Both > 50
Marital status	married
Household size	4
Education level	Both primary
Home language	Tshivenda

Second language/s	English
Farmer status	Full-time farmers
Housing	House on farm
Duration in aquaculture **Access to farm**	9 years On tar and gravel
Has access to internet	no

Farm details

Farm name	Not available
Farm co-ordinates	
Farm Location	Tshikonelo

Farm profile

Aquaculture species farmed	Catfish and tilapia
Other farming activities	Vegetables, chickens and goats
Purpose of aquaculture	For sale
Land	Owns land
Farm size	< 1 hectare
Water source/s	Borehole
Water outflow	Onto crops
When was aquaculture first started	2006
Is farming seasonal or all year round	Seasonal sales; fed all year
Number of staff	None (nephews help at times))

Farm history and current situation

- Both live in Tshikonelo where they are full-time farmers.
- They farm on a small-scale on their own property with fish (Mozambique tilapia and catfish), vegetables, goats and chickens.

- He was observed feeding the tilapia a brown powdery feed (probably a very poor quality feed or the last/bottom of the bag); he feeds them twice daily, at 10 am and about 5 pm.
- The feed is expensive and he pays R500 / 50 kg which he obtains from between R10–R15 per fish to local people in the community and they also consume fish in their own household.
- Their dams leak and they are considering lining it with clay or with a plastic liner.
- Their water supply is also busy drying up and they are producing decreasing amounts of water from their borehole.
- The rain was good from 2006 to 2013 and they kept five productive fish ponds, but since 2014 they have only kept two fish ponds as a result of the drought.
- As there has been no rain the borehole only gives water for about an hour, then they have to wait for 1.5 hours before they can pump water again.
- The two ponds that have tilapia were observed to have very low water levels and the tilapia were gasping at the surface.

Challenges

- They obtained their fingerlings (50 fingerlings at R2/fish) from Mr Mutshu in Tshifudi.
- In summer (December to January) they sell hand-sized fish at to the local community.
- They had catfish in a concrete pond which all died possibly as a result of the water becoming too hot during the day and/or too cold at night. The pond is now empty.
- On one occasion all their fish in one pond were killed by pumping borehole water directly into the pond.
- They were then advised that it was probably the lack of oxygen and that they should pump the borehole water into a pond without fish at first and then use it from there to fill the fish ponds.
- After doing this they have not had a repeat performance of a mass fish kill. She received training in aquaculture at Madzivhandila agricultural training college.
- Among other things she was shown how to separate male from female tilapia.
- In August of 2010/2011 she was entered into a Women's Month competition and won some prize money to use towards her farming activities.
- Their fish are taken by predators such as cormorants and an animal like a big rat.

Knowledge exchange

- The extension officer has visited them–they saw him in February 2015 and once in 2014.
- They started fish farming in 2006. They would like more information on how to increase their production of fish and also how to seal their leaking ponds effectively.

Fish farmer: 7
Farmer profile 7

Name	N.a.
Gender	Male
Age group	41-50
Marital status	married
Household size	6
Education level	Tertiary
Profession	Educator
Home language	Tshivenda
Second language/s	English with good proficiency
Farmer status	Part-time farmer
Housing	House not at farm
Duration in aquaculture	7 years
Has access to internet	Access to internet

Farm details

Farm name	
Farm co-ordinates	
Farm Location	Mandala
Access to farm	On tarred road R534

Farm profile

Aquaculture species farmed	Mozambique tilapia
Other farming activities	Vegetables and goats
Purpose of aquaculture	Food and additional income
Land	Acquired from chief

Farm size	Approximately 3000 m^2, with two small ponds larger one 2 m x 5 m
Water source/s	Wetland ground water, Nzhelele River
Water outflow	Onto land which borders tarred road
When was aquaculture first started	2009
Is farming seasonal or all year round	Harvests some fish during summer
Number of staff	None

Farm history and current situation

- His land, which is of a small-scale, is a short distance from his home and was given to him by the chief. It is vacant land, unkempt with no buildings on it.
- He has two smallish ponds which are in a wetland-like area and the source of the water for his ponds is the wetland i.e. the water table breaks the ground in certain places where the ponds form / could also be a spring as the land he is on is at the base of a slope where it reaches the tar road. He has been busy with fish farming on this plot for about 7 years.
- He gets information from school textbooks on agriculture – there is a section on aquaculture in the grade 11 syllabus (he has access since he teaches agriculture at high school – and this is also what stimulated his interest in fish farming).
- He also learns from other farmers in the area, and also get information from websites.

Challenges

- He feels that training courses are informative and feels that they should be held every three months. He would prefer to have the workshops on a Saturday in his area or even in Polokwane if transport is provided.
- He has been assisted by an extension officer who last visited in 2014, where he has attended meetings at the agricultural offices in Makwarela and from whom he purchases fish feed pellets at R400 per 25 kg.
- He needs more information on different fish species. He wants to able to understand what is “wrong” with catfish.
- He needs to know how to deal with predators that prey on his fish, such as “small crocodiles” – one presumes it refers to water lizard / iguana. He showed faeces (see photograph) containing many crustacean parts (maybe otters?) and also cormorants.

Knowledge exchange

- He needs information on how to improve his production system and processes and he also requires skills in this regard, which he would prefer to have in the form of training courses.
- He farms with Mozambique tilapia.
- He uses his own money to support his fish farming. He has not sold any fish to date, but would like to. He grows vegetables and keeps goats, on his property on which his home is.
- There is a high demand for fish in his area. He has no employees.
- He has not had any problems with fish diseases.
- He has attended workshops.
- Further challenges are the high cost of fish feed (R400 / 25 kg – buys from extension offices), he has no equipment for digging his ponds larger or for making more ponds, fingerlings are expensive (R200/25 fish), feeling of helplessness against predators (he does have a net over the one pond but very loosely covering it) – he has had no meaningful harvest yet and he thinks that the reason is the great losses to predators.

Fish farmer: 8
Farmer profile 8

Name	N.a.
Gender	Male
Age group	29
Marital status	Not married
Household size	7
Education level	Grade 12, plus tertiary (currently)
Profession	Student
Home language	Tshivenda
Second language/s	English - poor
Farmer status	Part-time farmer
Housing	Lives with mother
Duration in aquaculture	emerging
Has access to internet	Access to internet

Farm details

Farm name	
Farm co-ordinates	
Farm Location **Access to farm**	Mandala Gravel road, off-tar road

Farm profile

Aquaculture species farmed	None
Other farming activities	Fruit trees and vegetables i.e. cabbages
Purpose of aquaculture	Wants to raise fish for sale
Land	Mother's land
Farm size	5 hectares
Water source/s	Tshinane river
Water outflow	Onto agricultural land
When was aquaculture first started	Not started yet
Is farming seasonal or all year round	
Number of staff	None

Farm history and current situation

- He is a 29 year old man who has a grade 12 certificate and is currently doing part-time courses in civil engineering at Makwarela College.
- He lives with his mother who owns a 5 ha farm where they farm with various fruit trees and vegetables.
- He would like to farm with fish and he has a small concrete dam measuring 3 m in diameter and < 1 m deep in which he could begin. He does have land available where he could have more ponds dug but he needs assistance with this.
- He is keen to get started with fish farming and wants to sell fish. His English is not good and it was very difficult to get information.

Challenges

- The farmer requires more information on aquaculture practices and principles, including digging of ponds, farmed species, etc.

Knowledge exchange
None was mentioned during the interview.

Fish farmer: 9
Farmer profile 9

Name	N.a.
Gender	Male
Age group	27
Marital status	Not married
Household size	
Education level	Tertiary
Home language	Tshivenda
Second language/s	English – well spoken
Farmer status	Full-time worker in attendance
Housing	Small dwelling for farm worker
Duration in aquaculture	Since 2014
Access to farm	Close to main tar road along bad gravel road
Has access to internet	yes

Farm details

Farm name	
Farm co-ordinates	
Farm Location	Tshivhulani

Farm profile

Aquaculture species farmed	Mozambique tilapia
Other farming activities	Young mango and litchi trees
Purpose of aquaculture	For sale

Land	Owns land
Farm size	5.7 hectare
Water source/s	River/wetland on property
Water outflow	Back into wetland
When was aquaculture first started	2014
Is farming seasonal or all year round	Seasonal
Number of staff	2

Farm history and current situation

- He is a 28 year old entrepreneur who moved to Tshivhulani from Gauteng in 2014.
- He has a matric certificate and studied finance through UNISA.
- He bought 5.7 hectares of land and hired the services of a digger at R500/hour to dig three 9 m by 6 m fish ponds. He intends to have a total of 18 ponds by September 2015.
- He employs two men who live on his smallholding.
- His plot has a river that runs through it which supplies the water to his fish ponds. He intends to install a borehole at a later date. His ponds are stocked with Mozambique tilapia which he acquired as fingerlings from a neighbouring fish farm.
- He attended a workshop run by one of the existing fish farmers and learned about fish farming.
- He also learnt from another fish farmer with whom he served on a fish farmers' committee coordinated through the municipality in Makwarela.

Challenges

- He would like to know more about fish production different systems for raising fish and marketing strategies.
- He has access to the internet.
- He would like to have training on-site at his fish farm but he would also attend workshops at the municipal offices in Makwarela on a monthly basis.
- He got his tilapia fingerlings from a neighbouring fish farmer for free and he bought fish feed from her for R400.
- He has planted small mango and litchi trees and also plans to plant vegetables and with the expansion of his fish ponds he plans to make farming his main income.

- Currently he buys and resells various items to generate an income. His fish are eaten by predatory birds namely cormorants and kingfishers.

Knowledge exchange

- Requires more general information on aquaculture.

Fish farmer: 10
Farmer profile 10

Name	N.a.
Gender	Male
Age group	65
Marital status	Married
Household size	7
Education level	Never attended school
Home language	Tshivenda
Second language/s	Struggles with English, but can communicate
Farmer status	Full-time farmer
Housing	Own house
Duration in aquaculture	8 years
Access to farm	Close to main tar road along bad gravel road
Has access to internet	No

Farm details

Farm name	
Farm co-ordinates	
Farm Location	Dopeni; next door neighbour to Mr Mphaphati

Farm profile

Aquaculture species farmed	Mozambique tilapia

Other farming activities	Vegetables, chickens and cattle
Purpose of aquaculture	Own consumption and sale to local people
Land	Bought land 30 years ago
Farm size	Approximately 1 hectare
Water source/s	Murindi river
Water outflow	Onto crops
When was aquaculture first started	2007
Is farming seasonal or all year round	Seasonal; although tiny 5 cm fish are harvested for own consumption in Winter
Number of staff	1

Farm history and current situation

- He bought his land 30 years ago.
- He farms with various vegetables, avocadoes, cattle and chickens. He has only one fish pond, which is not very large.
- He has attended a five-day skills programme in fish production in July 2007 at the Tompi Seleka Agricultural Training Centre, for which he received a certificate.
- He has had no subsequent visits from nor help from the extension officers.
- He has tilapia which he feeds bread and pap (cooked maize meal).
- He harvests them mainly in summer to sell to his neighbours. He uses a hand net for harvesting, which is probably much less efficient than using a larger net that could cover the whole breadth of his pond.
- He sells the fish at R20 per four hand-sized fish.
- His water quality is very good and flows in from the Murindi River via a black pipe which he has installed in the river/hillside.
- He bought the fish seed in Makwarela. Now he has lots of little fish in his dam. Catfish got into his dam and ate his tilapia but he has since removed them.

Challenges

- Birds eat his fish and he lacks a net to cover the pond.
- He needs feed since it is expensive to feed the fish.

- He needs a larger net to harvest the fish effectively. He would like another dam to be dug – the one he has he dug by hand.

Knowledge exchange

- The farmer requires more general information on aquaculture practices.

Summary for Limpopo's fish farmers' profiles and description

- Ten fish farmers where visited in the Limpopo province, Vhembe District. This is the only district with many small-scale and emerging fish farmers. None of the interviewed farmers studied aquaculture.
- Aquaculture in this province is still in its infancy stage and under developed.
- All ten farmers visited are staying not very far (≤30km) to the University of Venda, where they can obtain advanced and researched information about fish farming. However, none of the farmers obtain information from this organisation
- The major sources where farmers obtain information was through workshops and extension officers (not enough provided).
- The major challenge that these farmers are facing is lack of financial support and sponsors.

Appendix 5: Students Involved in the Project

Student name	Degree & organisation	Presented titles of studies	Status
Ms Eva Nephale	MSc at SU	Local knowledge systems and constraints to transfer and dissemination in Limpopo province	Studies suspended
Mr Stiaan Ellis	MScAgric at SU	Determinants of productivity and water quality improvements of knowledge transfer modes in the aquaculture sector in South Africa	Studies suspended
Mr Sipho Mafuyeka	MSc at UKZN	An assessment of knowledge transfer systems to freshwater aquaculture farmers in KwaZulu-Natal province	Studies ongoing
Mr Ashley Patience	MSc at SU	GIS to determine site suitability for Mozambique tilapia farming in Limpopo province	Studies ongoing


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