

An Analysis of Aquaculture Infrastructure available for Training, Research and Skills Development

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Executive Summary

This report considers the status of aquaculture infrastructure available for training, research and skills development in universities, TVET colleges and Agricultural Training Institutions (ATIs) in South Africa. The report includes a literature review and site-visit analysis of nine universities, three Agricultural Training Institutes (ATIs) and three DFFE-funded facilities, nationwide, that currently offer aquaculture training modules and research facilities.

In summary, the research team found that significant infrastructure is present at universities and DFFE-funded facilities, catering largely for academic training and scientific research. In addition, there is substantial collaboration and sharing of resources (staff and infrastructure) between universities and the DFFE-facilities, particularly the Marine Research Aquarium at Sea Point, thus allowing for a wide range of relevant and innovative research. The infrastructure at ATIs is mostly dilapidated and in need of upgrade and maintenance.

The report recommends that rather than an across-the-board approach to upgrade all facilities, a more targeted approach is adopted, taking into consideration the geographic location of facilities, the skills need and demands of industry, as well as market and socio-economic development opportunities in the aquaculture industry.

1. Introduction

Aquaculture was identified by Operation Phakisa as a critical sector with high growth potential, owing to an increasing demand of fish products globally. During the Oceans Economy planning phase, the 'Aquaculture Lab', comprising stakeholders from industry, government and academia, put forward eight key initiatives required to spur the growth of the sector, including an enabling regulatory environment, funding support, and access to market. One of the critical obstacles identified was the lack of skilled labour and technical expertise, compounded by the lack of certified vocational training for basic aquaculture farming skills.

The growth of the aquaculture sector relies heavily on research and development as it is largely seen as a technology-driven sector. Research and technology development is required to diversify the market through new technology development, improving competitiveness of the existing sector, ensuring environmental and economic sustainability, food safety, and other key focus areas. In general, training and research in aquaculture requires specific infrastructure such as tanks, tunnels, dams, equipment and laboratories.

There is a lack of detailed understanding of the existing infrastructure available to support aquaculture training and research in universities, ATIs and TVET colleges nationally. In 2016, the Aquaculture Skills working group, which included the then Department of Agriculture, Forestry and Fisheries, recommended that an in-depth audit of facilities at institutions that support formal aquaculture qualifications be conducted.

The SAIMI appointed RB Africa to conduct an analysis of aquaculture infrastructure available for training, research and skills development in universities and TVET colleges. This report contains the findings from the study.

2. The Aquaculture Industry in South Africa

Aquaculture refers to the breeding, rearing and harvesting of plants and animals in saltwater or freshwater. In terms of food security and production, aquaculture is acknowledged as a critical industry globally. Aquatic foods are progressively being recognised not just as a source of protein, but also as a unique provider of other micronutrients, and global consumption of aquatic foods continues to rise annually.

In 2020, global aquaculture production reached a record 122,6 million tonnes; aquatic animals accounted for 87,5 million tonnes and algae comprised 35,1 million tonnes (FAO United Nations, 2022, p. xvi). South Africa's aquaculture sector produced around 7769,96 tonnes during 2021, comprising 0,009% of the global production of aquatic animals (Department of Forestry, Fisheries and the Environment, 2022, p. v). Note that South Africa's aquaculture industry comprises fresh and saltwater species, including abalone, catfish, common carp, finfish, marron crayfish, mussels, ornamentals, oysters, tilapia and trout; it does not include algae.

South Africa remains a minor player in the global aquaculture market, and the sector's contribution to the economy is relatively small, amounting to less than 0,029% to the country's GDP (AgriSETA, 2023, p. 10). However, aquaculture remains a key strategic sector with high growth potential, and the industry contributes to employment, food and nutrition security. Notably, the Food and Agriculture Organization of the UN (FAO) predicts that 40% of the global potential growth in aquaculture production is likely to come from Africa. When Operation Phakisa was launched in 2014 with the intention of unlocking the economic potential of South Africa's oceans, aquaculture was identified as a critical sector with the potential to enhance job creation, food security, generate economic development, and provide alternative livelihood opportunities in rural coastal communities.

In 2021, the projected value of various aquaculture services, including marine and freshwater services, was approximately R2 241 342 813 (Department of Forestry, Fisheries and the Environment, 2022, p. 68). Abalone continues to be the highest value commodity: in 2021 the abalone industry accounted for 86% percent of the total value of the aquaculture industry, followed by oysters (6%), tilapia (3%), and mussels (2%) (Department of Forestry, Fisheries and the Environment, 2022, p. 68). Since 2006, South Africa's aquaculture sector has shown fairly consistent growth. Although this trend slowed in recent years, total aquaculture production increased by 1723,99 tons (28%) between 2020 and 2021 (Department of Forestry, Fisheries and the Environment, 2022, p. v).

The graph below is extracted from the Aquaculture Yearbook 2022 and reflects the production growth of aquaculture in South Africa from 2006 to 2021 (Department of Forestry, Fisheries and the Environment, 2022, p. 11).

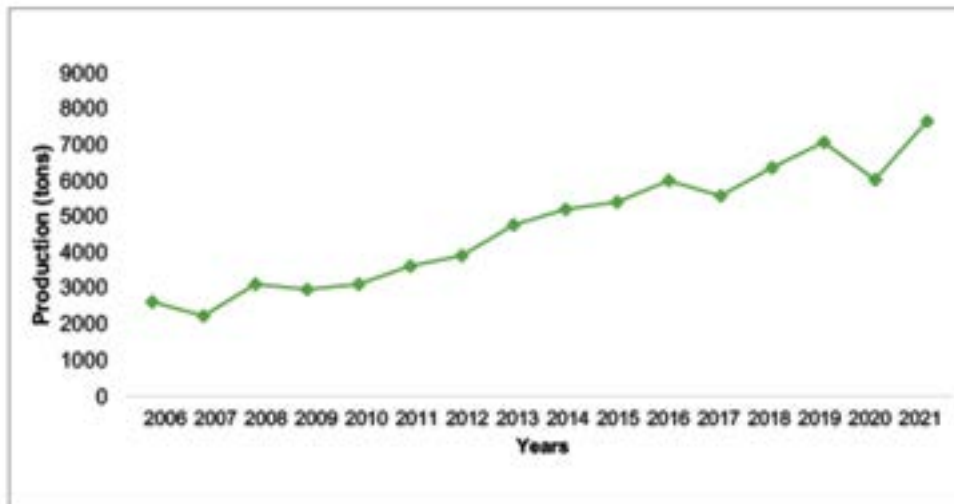


Figure 1: South Africa's aquaculture production growth from 2006 – 2021 (Department of Forestry, Fisheries and the Environment, 2022, p. 11)

According to the DFFE, the aquaculture industry employed about 4 591 people on a full-time, part-time, occasional, or undetermined basis in 2021. Indirectly, over 100 000 people are employed throughout the value chain or in industries related to the sector (Department of Forestry, Fisheries and the Environment, 2022, p. 68). The abalone subsector remains the largest employer, with the majority of jobs based in the Western Cape (Department of Forestry, Fisheries and the Environment, 2022, p. 69).

The graph below reflects South Africa's aquaculture production growth for the marine and freshwater sectors from 2006 – 2021 (Department of Forestry, Fisheries and the Environment, 2022, p. 11).

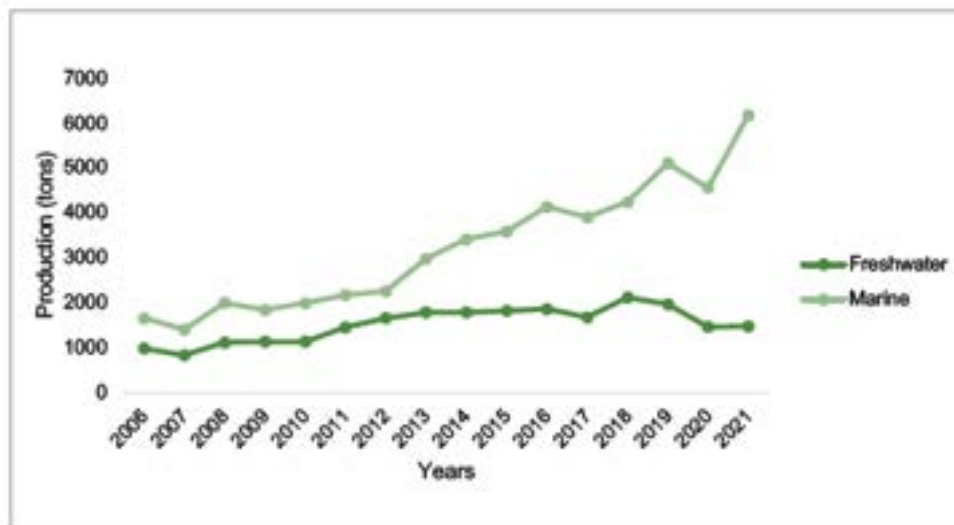


Figure 2: South Africa's aquaculture production growth for the marine and freshwater sectors from 2006 – 2021 (Department of Forestry, Fisheries and the Environment, 2022, p. 11)

The graph reflects a rapid increase in marine production in recent years, whilst freshwater production has decreased in volume. In 2021, marine aquaculture contributed 81% of overall aquaculture production volume.

Our marine aquaculture sector is dominated by abalone and mussels, which collectively comprise 93% of the subsector's production volume. Both of these species are farmed predominately in the Western Cape. The figures exclude seaweed production which is produced largely as abalone feed, and reporting is inconsistent (Department of Forestry, Fisheries and the Environment, 2022, p. 15). The table and graphs below are extracted from the DFFE's Aquaculture Yearbook 2022 and show the breakdown of marine aquaculture farms' production tons per species and per province in South Africa in 2021.

Table 1: Total marine production per province and subsector (Department of Forestry, Fisheries and the Environment, 2022, p. 15)

Subsector	WC	EC	NC	KZN	TOTAL
Abalone	2 245,66	163,37	54,26	0,00	2 463,29
Finfish	13,00	0,00	0,00	0,00	13,00
Mussels	3 420,88	0,00	0,00	0,00	3 420,88
Oysters	308,36	82,13	0,00	0,00	390,49
TOTAL MARINE PRODUCTION (TMP)	5 987,90	245,50	54,26	0,00	6 287,66

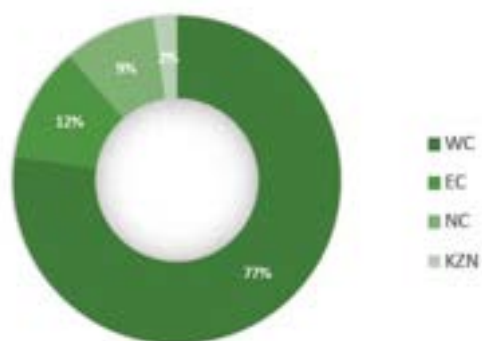


Figure 2: Percentage of marine aquaculture farms per province (Department of Forestry, Fisheries and the Environment, 2022, p. 15)

South Africa's freshwater subsector is dominated by small-scale farms. There were 151 freshwater farms in operation in 2021, marking a notable decline from the 163 farms in 2020. Among these farms, 71 are tilapia farms, followed by trout (34), ornamentals (20) and catfish (19). The highest production volume comes from trout, which comprises 77% of the freshwater subsector's production, followed by tilapia (17%). The majority of farms are located inland in the north of the country:

Gauteng, Mpumalanga and Limpopo; however, the greatest production volume comes from KZN and the Western Cape (55% of the freshwater subsector's total volume (Department of Forestry, Fisheries and the Environment, 2022, p. 30)).

The table and graphs below are extracted from the DFFE's Aquaculture Yearbook 2022 and show the breakdown of freshwater aquaculture farms' production tons per species and per province in South Africa in 2021.

Table 2: Total freshwater production per province and subsector, 2021 (Department of Forestry, Fisheries and the Environment, 2022, p. 31)

Subsector	EC	FS	GP	KZN	LP	MP	NC	NW	WC	TOTAL
Catfish	42,00	0,80	0,00	8,00	2,00	0,00	1,30	0,00	3,50	57,60
Common carp	2,00	0,00	1,60	0,00	2,50	0,00	2,50	0,00	3,70	12,30
Marron crayfish	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2,00	3,00
Ornamentals	3,00	0,00	4,50	4,50	0,80	1,90	1,00	0,00	1,80	17,50
Tilapia	55,60	0,00	7,00	7,00	78,00	45,00	4,00	50,00	0,00	246,60
Trout	11,20	0,00	84,00	403,80	0,00	250,20	12,10	0,00	384,00	1 145,30
TOTAL	114,80	0,80	97,10	423,30	83,30	297,10	20,90	50,00	395,00	1 482,30

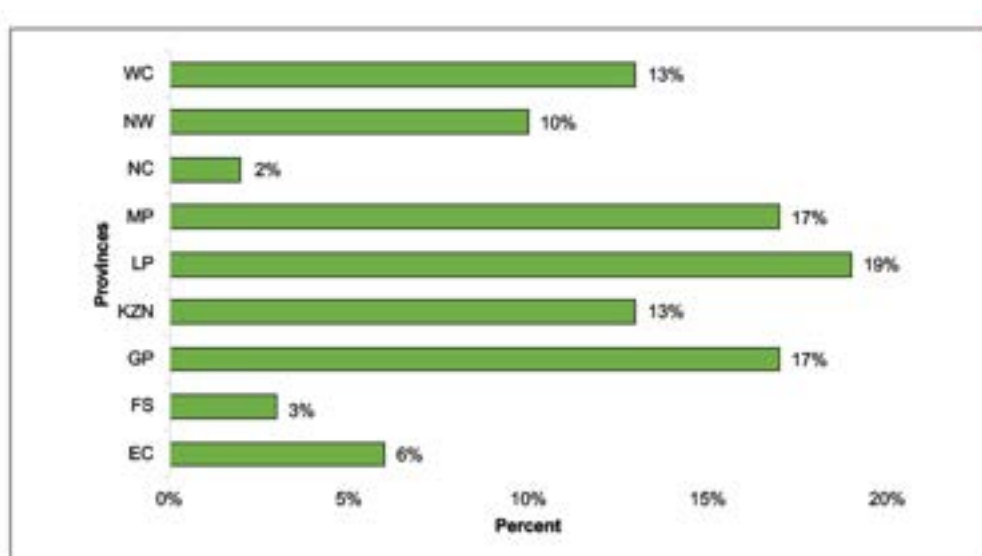


Figure 3: Percentage of marine aquaculture farms per province (Department of Forestry, Fisheries and the Environment, 2022, p. 29)

Aquaculture exports for South Africa are estimated to be 3887,35 tonnes, with a value of R830 million in 2021. This is a 35% increase from 2020, despite a drop in volume. Although the greatest volume of exports comes from tilapia (1630 tonnes), the highest value export is abalone, contributing R717 721,649 or 86% of total aquaculture export value.

Table 3: Total export values per subsector in 2021 (Department of Forestry, Fisheries and the Environment, 2022)p. 71

Species	Quantity (Tons)	Value of Quantity Exported (ZAR FOB)
Abalone	1 294,34	R717 721 649
Catfish	268,00	R5 517 499
Carp	3,01	R48 660
Trout	79,027	R6 662 943
Tilapia	1 630,89	R27 348 213
Atlantic Salmon	16,012	R1 750 045
Pacific Salmon	31,59	R4 925 930
Mussels	291	R15 784 943
Oysters	263,405	R50 060 414
Ornamentals	3,335	R699 160
Scallop	7,740	R318 929
TOTAL EXPORTS	3 887,35	R830 838 385

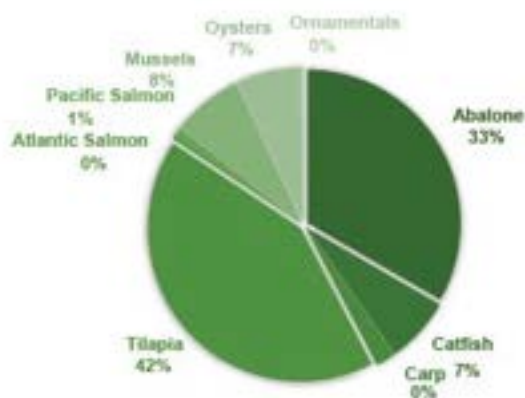


Figure 4: Export volumes per subsector in 2021 (Department of Forestry, Fisheries and the Environment, 2022) p. 71

Consideration of the economic and market trends driving the aquaculture industry is critical in developing a meaningful and sustainable skills development strategy. It is important that the development and upliftment of training and research infrastructure is aligned to identified market opportunities or socio-economic opportunities. The figures above demonstrate a marked decline in the export value of freshwater species, whilst the export value of marine species continues to increase.

Overall, South Africa continues to import more fish and fish products than it exports. This suggests an untapped opportunity for the development and growth of fish farms; however, as the FAO warns, increased aquaculture production must not come at the cost of environmental degradation. Aquatic food systems are a powerful solution for unemployment and food insecurity, but they must be implemented sustainably and with the requisite skills, infrastructure, and legislative support.

3. Scope and Methodology

The objective of the exercise was to gain an understanding of the status of aquaculture training and development facilities at universities and TVET colleges nationwide, and to identify opportunities for collaboration between industry, research entities, and institutions to ensure aquaculture training and development is accessible and adequately equips individuals with the skills required to participate meaningfully in the sector.

The project methodology included the following key steps:

- i. A literature review of relevant reports and studies.
- ii. Desktop research to develop a comprehensive list of all universities and TVET colleges in South Africa, their contact details, and whether they offer aquaculture or aquaculture-related courses.
- iii. Development of an initial screening questionnaire.
- iv. Telephonic engagement with all universities and TVET colleges to establish contact with key personnel, determine whether data gathered online was up to date, and if relevant, to complete the initial screening questionnaire.
- v. Review of data captured online and identification of institutions for physical site visits.
- vi. Conducting site visits at identified Universities, TVETs, ATIs and DFFE-funded institutions.
- vii. Further engagement with identified institutions that expressed an interest in building aquaculture capacity but lacked infrastructure.
- viii. Compilation of findings.

It should be noted that this report is focused exclusively on the aquaculture infrastructure available at educational institutions and does not examine or critique the training material or curricula.

3.1. Data Collection

The data gathered for this report was through a combination of desktop research, telephonic engagement, electronic engagement, in-person meetings and interviews, and physical site visits.

The SAIMI provided an introductory letter, explaining the project and the role of RB Africa which assisted with introductions to institutions and key personnel. A list of all universities, TVET colleges and Agricultural Training Institutions (ATIs) was sourced from the national government website and confirmed with online research.

All engagement was captured and tracked in a Data Capture Google Sheet to facilitate and enable collaborative input and real-time updates. The screening questionnaires were designed in Microsoft Excel and where the respondents struggled with connectivity, were completed telephonically on a call with a member of the project team. All questionnaires were followed up with phone calls and emails. In very few cases institutions were not reached.

Site visits were conducted by a minimum of two members of the project team. Where institutions had already completed the questionnaire, information was verified and validated at the site visits. All institutions permitted photographs to be taken of the equipment and facilities. All institutions welcomed the site visits and went out of their way to ensure staff and personnel were available to take the project team through the facility. Each site visit lasted 1 – 2 hours.

Following the site visits, all technical questionnaires and photographs were categorised and loaded onto Google Drive. The project team collaboratively reviewed the findings and developed the recommendations for the report.

4. Literature Review

The following reports were reviewed in preparation for the study:

- Aquaculture Subsector Skills Plan 2020 – 2021 (AgriSETA).
- Aquaculture Subsector Skills Plan 2023 – 2024 (AgriSETA).
- Aquaculture Skills Inventory and Needs Analysis 2017 (Operation Phakisa, SAIMI).
- Assessment of Facilities and Curricula of Five Agricultural Training Colleges for Piloting Aquaculture Training, 2018 (DAFF).
- Aquaculture Yearbook 2021 – Status of the Sector (DFFE).
- Aquaculture Yearbook 2022 – Status of the Sector (DFFE).

These reports acknowledge that whilst aquaculture has been identified as a priority subsector with high growth potential, the sector has been unable to achieve the targets envisioned by Operation Phakisa. The literature highlights a disjuncture between the national strategic objectives for Operation Phakisa and the ability to achieve such objectives, due to multiple limitations, including:

- Limited availability of skilled personnel in the sector.
- Limited availability and accessibility of education and training opportunities.
- Lack of alignment between Agricultural Education and Training curricula and the challenges facing the sector, especially for new entrants.
- Lack of extension support services available.
- Little awareness of aquaculture as a career or field of study.

The DAFF assessment of Agricultural Training Institutes (ATIs) in 2018 included a technical audit of infrastructure and review of the curriculum at five agricultural colleges: Elsenburg Agricultural Training Institute (EATI), Madzivhandila Agricultural Training Institute (MATI), Tompi Seleka College of Agriculture (TSCA), Tsolo Agriculture and Rural Development Institute (TARDI), and Glen Agricultural Training Institute (GATI).

The DAFF research team found that the ATIs had minimum basic infrastructure or facilities to support formal qualifications. Most of the equipment at the colleges was not functional or operational; however, some of the colleges had access to provincial government or DFFE-funded facilities (e.g., Gariep Agriculture Technology Demonstration Centre), or had informal agreements with local farms for practical learning demonstrations. The team found that the curricula do not consider DAFF's national agricultural strategic objectives, and that the aquaculture courses offered at the colleges provide useful introductory information on fish farming but lack "provision of comprehensive skills required for meaningful entry into aquaculture" (Department of Agriculture, Forestry and Fisheries, 2018, p. 10). In short, basic aquaculture production training with basic infrastructure is available, but the training centres focus on training learners as employees and miss DAFF's national agricultural strategic objectives for producing new entrants into agriculture or aquaculture (Department of Agriculture, Forestry and Fisheries, 2018, p. 76).

The SAIMI's Skills Audit and Needs Analysis, conducted in 2017 by the Aquaculture Skills Working Group, comprised skills and needs analysis for the aquaculture industry in South Africa. The research group included aquaculture farms and their employees. It should be noted that the majority of respondents were abalone farms (South African International Maritime Institute, 2017, p. 9). The report found that the aquaculture sector is characterised by:

- very limited transformation, particularly at higher management and supervisor levels;
- a lack of certified vocational training for basic aquaculture farming skills;
- no formal mechanisms of skills and prior learning for farm workers that have relevant experience;
- insufficient agricultural extension officers with aquaculture-specific training (South African International Maritime Institute, 2017, p. 75).

One of the key recommendations arising from the report is the need for aquaculture-specific qualifications, as well as the need for management and supervisory training on topics such as people management, business management, to help mentor junior staff into supervisor and management positions (South African International Maritime Institute, 2017, p. 78). The DFFE's Aquaculture Yearbook 2022 contains up-to-date, relevant information about the sector to inform decision makers, investors and the general public. Since 2006, South Africa's aquaculture sector has shown fairly consistent growth. Although this trend has slowed in recent years, total aquaculture production increased by 1723,99 tons (28%) between 2020 and 2021 (Department of Forestry, Fisheries and the Environment, 2022, p. v). The DFFE attributes the industry's underperformance in 2020 to the Covid-19 pandemic and other long-standing constraints, such as limited skills, limited access to water, and inadequate technology development (Department of Forestry, Fisheries and the Environment, 2022, p. 67).

A review of the literature confirms the need for further analysis of the aquaculture sector, in particular:

- A detailed analysis of the challenges facing the sector and the key blockages towards achieving Operation Phakisa's targets.
- An in-depth review of the skills development landscape for the sector, comprising an analysis of the curriculum and training materials, as well as the infrastructure and equipment available.
- Engagement with institutions to determine current levels of collaboration between institutions.
- Engagement with institutions and industry to explore opportunities for collaboration and the shared use of facilities.
- Engagement with key stakeholders to determine what training institutions need to enable them to produce qualified and skilled aquaculture practitioners to support the sector in achieving the objectives set out by Operation Phakisa, with the understanding that training must be relevant to the climate, area, species and market demand.
- Collaboration between training institutions and the aquaculture industry to ensure training programmes are aligned to and support industry needs.
- Identification of priority institutions with existing facilities that can be 'fast tracked' for aquaculture training.

In addition to the abovementioned reports, the legislation governing aquaculture in South Africa was reviewed, including the National Aquaculture Policy Framework (2013) and the Aquaculture Development Bill to gain an understanding of the legislative context in which the industry exists.

5. Desktop Analysis

The desktop analysis included compiling a database of all universities, TVET colleges and ATIs in South Africa, including their contact details, their websites, the information contained in their prospectus and whether or not they offer aquaculture or aquaculture-related courses.

Following the online research, all institutions were contacted telephonically to verify whether the information online was correct and up to date. A total of 23 Universities, 11 Agricultural Training Institutions (ATIs) and 50 TVET Colleges were contacted.

All institutions were asked the following four questions:

- i. Do you offer aquaculture academic courses or training?
- ii. Do you have aquaculture research infrastructure and technical resources on site?
- iii. Do you have a formal relationship with another institution that has aquaculture research infrastructure and technical resources?
- iv. Are you interested in developing aquaculture capacity and training facilities?

All engagement and responses were captured in a Data Capture Google Sheet. Institutions that confirmed that they offered aquaculture training or courses were asked to complete an initial screening questionnaire (see attached Annexure A).

The results of the desktop analysis and engagement are summarized in the table below.

Table 4: Aquaculture training available at South African Universities

	University	Province	Aquaculture courses or training	Aquaculture Infrastructure	Partnerships	Interest in development	Qualification Type	Qualification	Department	Site Visit
1	Cape Peninsula University of Technology	WC	Yes	No	Yes	Unsure	Diploma	Marine Science (including Marine aquaculture modules). Currently working with DFFE on a project to determine the nutritional value of marine aquaculture species.	Dept of Biodiversity and Conservation. Dept of Oceanography	No
2	Central University of Technology	FS	No	No	No	No		Agricultural courses, but none linked to aquaculture.		No
3	Durban University of Technology	KZN	No	No	No	No				No
4	Nelson Mandela University	EC	No	No	No	No	Bachelors	BSc (Biological Sciences), modules in Zoology 3 - aquatic ecology and applied aquatic science.	Zoology Department.	No

	University	Province	Aquaculture courses or training	Aquaculture Infrastructure	Partnerships	Interest in development	Qualification Type	Qualification	Department	Site Visit
5	North West University	NW	No	No	No	No		Agricultural courses, but none linked to aquaculture.		No
6	Rhodes University	EC	Yes	Yes	Yes	Yes	Bachelors	BSc (module in aquaculture for Ichthyology majors).	Ichthyology & Fisheries Science (DIFS).	Yes
							Masters PhD	Research Masters and PhD available.	Ichthyology & Fisheries Science (DIFS).	
7	Stellenbosch University	WC	Yes	Yes	Yes	Yes	Bachelors	BSc Agric (major in Aquaculture) BSc Genetics (includes aquaculture component).	Animal Science (Faculty AgriScience) Genetics.	Yes
							Masters PhD	Research Masters and PhD available.	Welgevallen Experimental Farm.	
							Certificate course (NQF 5)	Certificate course in Aquaculture Production Management.	Animal Science (Faculty AgriScience).	
							PG Diploma	Post-graduate Diploma courses in Aquaculture and Aquaponics.	Research conducted at Welgevallen, DFFE Sea Point or at	

	University	Province	Aquaculture courses or training	Aquaculture Infrastructure	Partnerships	Interest in development	Qualification Type	Qualification	Department	Site Visit
									industry partners (abalone farms).	
8	Tshwane University of Technology	GP	No	No	No	No				No
9	University of Cape Town	WC	Yes	Yes	Yes	Yes	Bachelors	BSc (Marine Resources 3, includes Principles of Marine Aquaculture component).	Dept. of Biological Sciences.	Yes
							Masters PhD	Research Masters and PhD available.	Research conducted at UCT facility DFFE Sea Point or at industry partners (abalone farms).	
10	University of Fort Hare	EC	Yes	Yes	Yes	Yes	Bachelors	BSc Zoology (includes module in aquaculture).	Zoology & Entomology.	Yes
							Masters PhD	Research Masters and PhD available.	Research conducted at industry	

	University	Province	Aquaculture courses or training	Aquaculture Infrastructure	Partnerships	Interest in development	Qualification Type	Qualification	Department	Site Visit
									partners (Kingfish, WCA).	
11	University of Johannesburg	GP	No	No	No	No	Short courses	Teaching and training courses in agroecology, aquaponics, aquaculture, hydroponics, water-energy and food nexus, cannabis and agri-enterprises.	Centre for Ecological Intelligence (CEI).	No
			No	No	No	No	Masters and Research	MSc in Aquatic Health Research in aquatic toxicology and physiology.	Faculty of Science, Zoology.	No
12	University of KwaZulu-Natal	KZN	Yes	Yes	Yes	Yes	Bachelors	Module that forms part of Applied Marine Biology.	School of Life Sciences.	Yes
							Masters PhD	Research under Dr Andre Vosloo.	School of Life Sciences.	
13	University of Limpopo	LP	Yes	Yes	Yes	Yes	BSc Hons, Masters, PhD	Post-graduate programmes in aquaculture.	SAES Aquaculture Research Unit.	Yes
14	University of	MP	Yes	Yes	Yes	Yes	BSc Hons	Module within BSc Hons programme.	Faculty of Agriculture and Natural	Yes

	University	Province	Aquaculture courses or training	Aquaculture Infrastructure	Partnerships	Interest in development	Qualification Type	Qualification	Department	Site Visit
	Mpumalanga								Science, School of Biology and Environmental Sciences.	
							Masters PhD	Research hatchery at Rivers of Life.	Rivers of Life Aquatic Health Services Programme.	
15	University of Pretoria	GP	No	No	No	No				No
16	University of South Africa	Online	No	No	No	No				No
17	University of the Free State	FS	No	No	No	No				No
18	University of Venda	LP	No	No	No	Yes			Work with 'four community household projects' where infrastructure has been installed by 'Deep Blue Aquatic Systems'.	No
19	University of the	WC	No	No	Yes	No	Bachelors	Marine Biodiversity (module Benthic in	Dept of Biodiversity and	No

	University	Province	Aquaculture courses or training	Aquaculture Infrastructure	Partnerships	Interest in development	Qualification Type	Qualification	Department	Site Visit
	Western Cape							Integrated aquaculture).	Conservation Biology.	
20	University of Witwatersrand	GP	No response	No response	No response	No response	Bachelors	BSc Hons Animal, Plant & Environmental Sciences (research projects include aquatic ecology).	Faculty of Science.	No
21	University of Zululand	KZN	Yes	Yes	Yes	Yes	Bachelors	BSc (aquaculture components).	Department of Zoology.	Yes
							Masters PhD	Operational aquaculture facility for research (freshwater fishery research).	Department of Zoology.	
22	Vaal University of Technology	GP	No response	No response	No response	No response				No
23	Walter Sisulu University	EC	Yes	Yes	Yes	Yes	Bachelors	Aquaculture modules incorporated under Economic Biology (Zoology 3) and in Freshwater Biology (BSc Hons). Research facilities also present.	Department of Biological and Environmental Sciences.	Yes

Table 5: Aquaculture training available at South African Agricultural Training Institutions

	Agricultural Training Institutions	Province	Aquaculture courses or training	Aquaculture Infrastructure	Partnerships	Interest in development	Qualification	Comment	Recommended for Site Visit
1	Cedara Agricultural Training Institute	KZN	No	No	No	n/a			No
2	Elsenburg Agricultural Training Institute	WC	No	No	No	No		Freshwater aquaculture unit closed due to lack of demand.	No
3	Fort Cox Agriculture and Forestry Training Institute	EC	Yes	No	Informal	Yes	Agriculture (Animal Production) module in Aquaculture (AQ221).	Informal relationship with surrounding farmers.	No
4	Glen Agricultural Training Institute	FS	Yes	No	Yes	Yes	Diploma in Agriculture.	Research Unit at Gariep.	No
5	Grootfontein Agricultural Development Institute (GADI)	EC	No	No	No	No			No
6	Madzivhandila College of Agriculture	LP	Yes	Yes	Informal	Yes	Agriculture (Animal Production) elective module in	Offer courses for farmers and students (tilapia and carp). They work	Yes

	Agricultural Training Institutions	Province	Aquaculture courses or training	Aquaculture Infrastructure	Partnerships	Interest in development	Qualification	Comment	Recommended for Site Visit
							Aquaculture (ANP241).	with farmers in the area.	
7	Owen Sitole Agricultural Training Institute (OSCA)	KZN	No	No	No	No	Diploma in Agriculture.		No
8	Potchefstroom Agricultural Training Institute	NW	No	No	No	Yes	Diploma in Agriculture.		No
9	Taung Agricultural Training Institute	NW	No	No	No	No	Diploma in Agriculture.		No
10	Tompi Seleka College of Agriculture	LP	Yes	Yes	No	Yes	Agriculture (Animal Production) - elective module in Aquaculture (ANQ311).		Yes
11	Tsolo Agriculture and Rural Development Institute (TARDI)	EC	Yes	Yes	Yes	Yes	Aquaculture modules are incorporated in Diploma Animal Health (Aquaculture production,		Yes

Agricultural Training Institutions	Province	Aquaculture courses or training	Aquaculture Infrastructure	Partnerships	Interest in development	Qualification	Comment	Recommended for Site Visit
						Animal and Fish diseases).		

Table 6: Aquaculture training available at South African TVET Colleges

	TVET College	Aquaculture courses training or	Aquaculture Infrastructure	Partnerships	Interest in development	Site Visit
1	Boland TVET College	No	No	No	No	No
2	Buffalo City TVET College	No	No	No	No	No
3	Capricorn TVET College	No	No	No	No	No
4	Central Johannesburg TVET College	No	No	No	No	No
5	Coastal TVET College	No	No	No	No	No
6	College of Cape Town TVET	No	No	No	No	No
7	Eastcape Midlands TVET College	Assume No	Assume No	Assume No	Assume No	No
8	Ehlanzeni TVET College	No	No	No	No	No
9	Ekurhuleni East TVET College	No	No	No	No	No
10	Ekurhuleni West TVET College	No	No	No	No	No
11	Elangeni TVET College	No	No	No	No	No
12	Esayidi TVET College	No	No	No	No	No
13	False Bay TVET College	No	No	No	Yes	No
14	Flavius Mareka TVET College	No	No	No	No	No
15	Gert Sibande TVET College	No	No	No	No	No

	TVET College	Aquaculture courses training or	Aquaculture Infrastructure	Partnerships	Interest in development	Site Visit
16	Goldfields TVET College	No	No	No	No	No
17	Ikhala TVET College	Assume No	Assume No	Assume No	Assume No	No
18	Ingwe TVET College	No	No	No	No	No
19	King Hintsa TVET College	No	No	No	No	No
20	King Sabata Dalindyebo TVET College	No	No	No	No	No
21	Lephalale TVET College	No	No	No	No	No
22	Letaba TVET College	No	No	No	No	No
23	Lovedale TVET College	No	No	No	Yes	No
24	Majuba TVET College	No	No	No	No	No
25	Maluti TVET College	Assume No	Assume No	Assume No	Assume No	No
26	Mnambithi TVET College	Assume No	Assume No	Assume No	Assume No	No
27	Mopani South TVET College	No	No	No	No	No
28	Motheo TVET College	No	No	No	Yes	No
29	Mthashana TVET College	No	No	No	No	No
30	Nkangala TVET College	Assume No	Assume No	Assume No	Assume No	No
31	Northern Cape Rural TVET College	Assume No	Assume No	Assume No	Assume No	No
32	Northern Cape Urban TVET College	No	No	No	No	No
33	Northlink TVET College	Assume No	Assume No	Assume No	Assume No	No
34	Orbit TVET College	Assume No	Assume No	Assume No	Assume No	No
35	Port Elizabeth TVET College	Assume No	Assume No	Assume No	Assume No	No
36	Sedibeng TVET College	Assume No	Assume No	Assume No	Assume No	No
37	Sekhukhune TVET College	Assume No	Assume No	Assume No	Assume No	No
38	South Cape TVET College	No	No	No	No	No

	TVET College	Aquaculture courses training or	Aquaculture Infrastructure	Partnerships	Interest in development	Site Visit
39	South West Gauteng TVET College	No	No	No	No	No
40	Taletso TVET College	No	No	No	No	No
41	Thekwini TVET College	Assume No	Assume No	Assume No	Assume No	No
42	Tshwane North TVET College	Assume No	Assume No	Assume No	Assume No	No
43	Tshwane South TVET College	Assume No	Assume No	Assume No	Assume No	No
44	Umfolozi TVET College	Assume No	Assume No	Assume No	Assume No	No
45	Umgungundlovu TVET College	No	No	No	No	No
46	Vhembe TVET College	Assume No	Assume No	Assume No	Assume No	No
47	Vuselela TVET College	No	No	No	No	No
48	Waterberg TVET College	Assume No	Assume No	Assume No	Assume No	No
49	West Coast TVET College	No	No	No	No	No
50	Western College for TVET	No	No	No	No	No

Although the scope was restricted to Universities and TVET colleges, it soon became apparent that the DFFE facilities at Sea Point and Gariep Dam play a central role in linking institutions, providing research infrastructure, and facilitating practical training. It was therefore recommended that these facilities be included in the site visits, and that Dohne Agricultural Development Institute be included.

The research team is aware of other national and provincial government-funded aquaculture facilities, such as the Agricultural Research Council, the Northern Cape Department of Agriculture and the Limpopo Department of Agriculture. These facilities were contacted and requested to complete the questionnaire. Further information or responses were not received, and as these facilities fell outside of the scope of work of this project, they were not followed up on.

After reviewing the findings from the desktop analysis, a shortlist was compiled comprising institutions that were actively training aquaculture courses and that had existing infrastructure and equipment.

The following institutions were recommended for site visits:

Table 7: List of Institutions for site visits

Universities	
1	Rhodes University
2	Stellenbosch University
3	University of Cape Town
4	University of Fort Hare
5	University of KwaZulu-Natal
6	University of Limpopo
7	University of Zululand
8	Walter Sisulu University
9	University of Mpumalanga
Agricultural Training Institutes (ATIs)	
10	Madzivhandila College of Agriculture
11	Tompi Seleka College of Agriculture
12	Tsolo Agriculture and Rural Development Institute (TARDI)
Other (DFFE / Provincial Government) facilities	
13	Aquaculture Technology and Demonstration Centre, Gariep
14	Marine Research Aquarium, Sea Point
15	Dohne Agricultural Development Institute

The map below shows the location of each of the institutions identified for site visits.



Figure 5: Locality map of institutions identified for site visits

6. Site Visits

A detailed technical questionnaire was developed to determine the level of academic and technical support for aquaculture at each of the identified institutions/facilities (see attached Annexure B).

The questionnaire included the following aspects:

- Course/module information.
- Water supply facilities.
- Live-holding facilities.
- Laboratory facilities.
- Fish feeding systems.
- Fish health diagnostic tools.
- Aquaponics infrastructure.
- Other technology employed.
- Staff and student support facilities.
- Funding opportunities.
- Collaboration opportunities.

6.1. Site visit summary

The findings from the site visits are summarized below:

6.1.1. Type of Infrastructure

The majority of institutions have brick and mortar aquaculture facilities. Shade cloth and plastic tunnels, as well as exposed infrastructure, are also commonly used.

6.1.2. Focus of Programme

The majority of institutions are focused on freshwater training and research. This is concerning when considered against the market trends, which show the highest economic activity and employment is generated in marine aquaculture. Three universities (Rhodes, UKZN and WSU) offer both marine and freshwater training and research.

Facilities specialising in freshwater species mainly obtain their water from dams, rivers and, in one instance, from a freshwater canal. Many institutions also receive freshwater from municipalities and/or boreholes. Most of the institutions specialising in marine species have seawater transported to the facility on a weekly basis. This can be very costly and limits the systems that can be used. Only one facility, the Marine Research Aquarium in Sea Point, pumps water directly from the ocean. More facilities with direct ocean access are desirable.

The graph below shows the split between freshwater and marine training and research at the institutions visited.

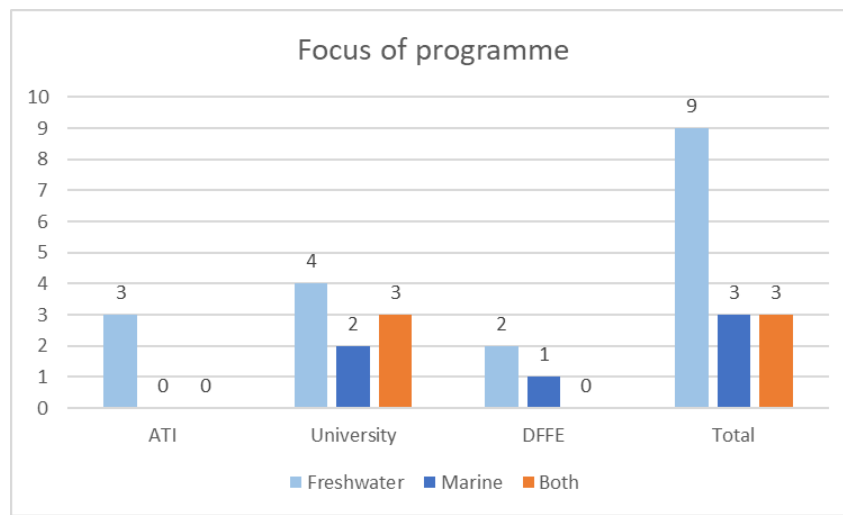


Figure 6: Focus of programme (freshwater or marine) at the institutions visited

6.1.3. Water Filtration

Generally, universities have the ability to filter water to different levels according to the needs of the research being conducted. The ATIs have basic filtration facilities, whereas many, particularly freshwater facilities, do not have any water filtration capacity.

6.1.4. Electricity Supply

Where infrastructure has been vandalised or stolen, institutions do not have any electricity. Although some institutions have back-up generators that are well maintained, many institutions do not have access to back-up generators, or the generators are out of commission. Many aspects of aquaculture depend on a constant electricity supply, and, with South Africa's unreliable electricity supply, back-up electricity is crucial.

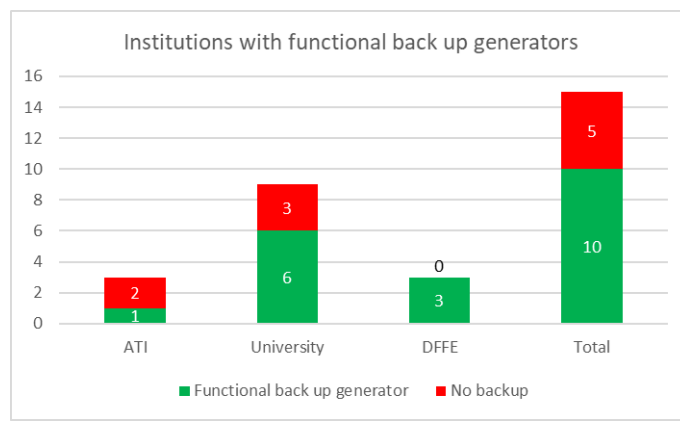


Figure 7: Institutions with functional back-up generators

6.1.5. Feed Storage

Apart from four universities that have operational temperature-controlled feed storage facilities, most institutions store their feed in general storerooms. This is not ideal, and pest infestations and rotten feed were reported.

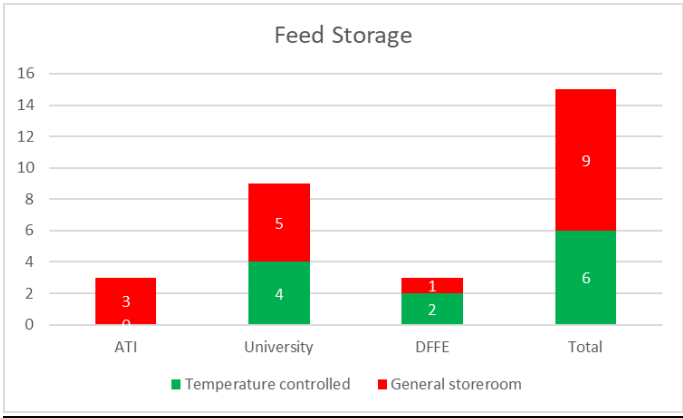


Figure 8: Institutions with temperature-controlled feed storage facilities.

6.1.6. Workshop Facilities

With the exception of a few, most institutions have access to a maintenance workshop in good working order.

6.1.7. Life-support Systems

The majority of the facilities with life-support systems have exclusively Recirculating Aquaculture System (RAS) systems, with a few that are able to provide both RAS and flow-through systems. Although RAS systems allow for training opportunities on a small scale, it is not necessarily the reality in practice. More flexibility and/or the inclusion of flow-through systems would allow for better knowledge and experience.

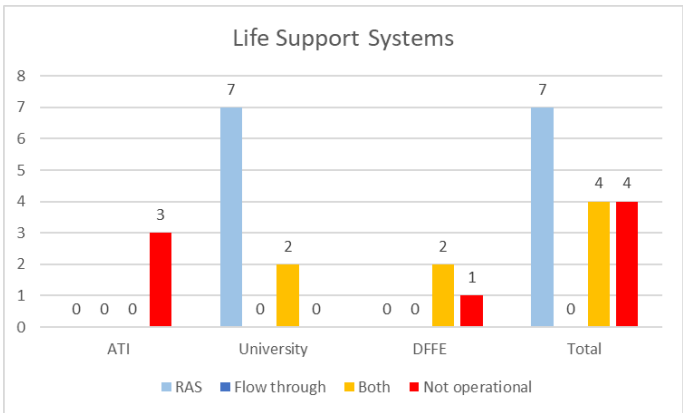


Figure 9: Life-support systems present at the institutions visited

6.1.8. Laboratory Facilities

All the universities have well-equipped laboratories for conducting biological analysis and research. Some universities have specialized laboratories, for example, genomics, physiology, histology, algae, dissection, feed analysis, molecular biology and biotechnology for advanced research and experimentation, which are shared with other departments within the university. The laboratory facilities at ATIs are limited and, in all cases, shared with other (unrelated) departments such as Soil Science.

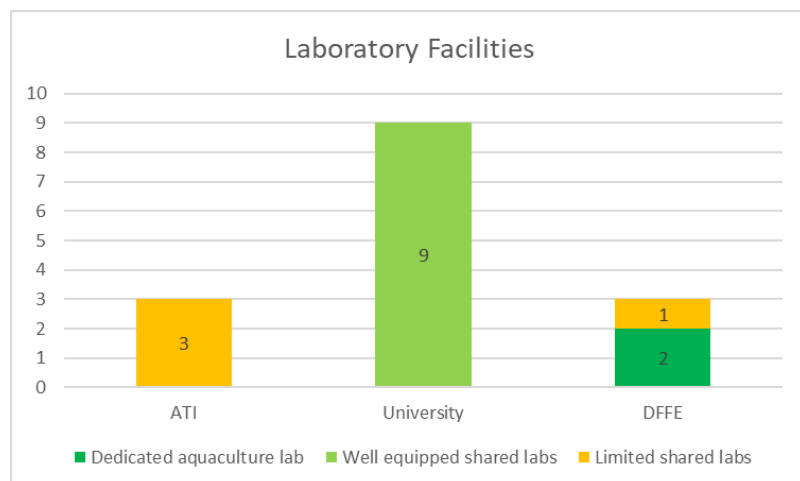


Figure 10: Laboratory facilities at institutions visited

6.1.9. Administrative Support

Administrative support as well as staff and student facilities at universities are available and sufficient. In some instances, however, especially at ATIs, the administrative support and facilities are inadequate and have a negative effect on the quality of education and morale of students and academic personnel.

6.1.10. IT Facilities

All facilities visited share IT facilities with other departments. This is not a major concern as technical support in most institutions is centralised. The ATIs reported insufficient technical and IT support. Reliable IT is important, and facilities with no or insufficient IT support have limited ability to analyse data and conduct adequate data reporting.

6.1.11. Academic Support

Qualified academic personnel are available at all institutions, although several institutions reported challenges with understaffing. A concern is the lack of the timeous filling of vacant positions and the lack of succession planning for retiring personnel. When personnel retire or leave employment, the institutional knowledge that they possess is lost if they do not have the opportunity to train a new placement in their position. Similarly, the continuation of research may be negatively affected if critical positions are left vacant. At one institution, the lack of water safety and swimming skills of lecturers has a negative impact on the quality of training offered.

6.1.12. **Collaboration**

Most institutions collaborate with government institutions, and the universities tend to have widespread collaboration with the private sector, training institutions and government. The ATIs seem to be more isolated and have little to no collaboration with industry. Collaboration with other training institutions and the private sector is very localized and limited. It is important to encourage more collaboration between various training institutions, which can improve the quality, diversity and relevance of the training offered. Collaboration with the private sector can provide valuable practical industry experience and may increase students’ opportunity for employment after completion of studies.

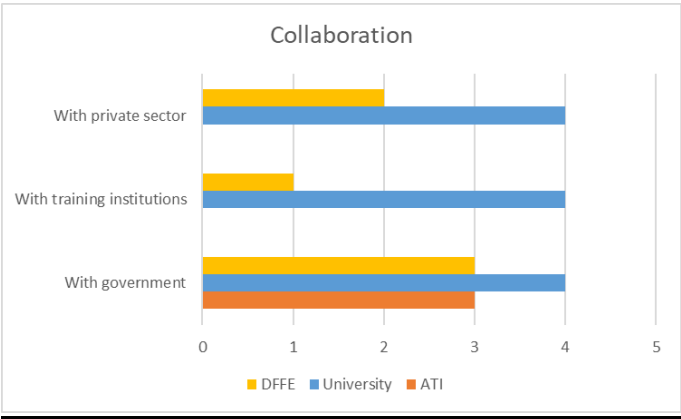


Figure 11: Collaboration with private sector, training institutions and government at institutions visited

6.2. Detailed infrastructure description

This section provides details of infrastructure and facilities at each of the sites visited.

6.2.1. Rhodes University

Table 8: Rhodes University Aquaculture infrastructure & facilities detailed description

CRITERIA	AVAILABLE	COMMENT	Note: Rhodes has another facility in Port Alfred which is currently not operational
Focus of programme		Research – marine and freshwater species.	
Type of structure		Brick building and tunnel structures.	
Water supply	YES	Borehole, rain and municipal freshwater. Truck in sea water from Kowie river mouth.	
Electricity	YES	Eskom and backup generators.	
Water filtration	YES	Filtration can be set up to accommodate student requirements. Coarse filtration, ultrafiltration, UV sterilisation and ozonation possible.	
Feed storage	YES	Temperature controlled storage and has its own feed analysis and development facilities.	
Workshop	YES	Well equipped with technical staff on standby 24/7.	
Life support systems	YES	Primarily 100% RAS with simple biofiltration. Protein skimmers and foam fractionators can also be used. Static and flow through can also be facilitated. Outdoor pond culture facilities also available.	
Laboratory facilities	YES	Multiple laboratory facilities available – genomics, ecophysiology, dissection, water quality, feed analysis, climate change. All well-equipped.	
Flexibility in system setup	YES	Systems can be customised to suit research requirements.	
Replicated tank set up	YES	Systems can be customised to suit research requirements.	
Administrative support	YES	Admin block with staff and student offices.	
IT Facilities	YES	Internet, computers and printing facilities available.	
Academic support	YES	A number of staff permanently employed and associate staff deeply involved. DFFE production scientist on site.	

Rhodes University is a public research university located in Makhanda (Grahamstown) in the Eastern Cape. It is one of four universities in the province and was established in 1904, making Rhodes University the oldest university in the Eastern Cape, and the sixth oldest South African university in continuous operation. Rhodes University's Department of Ichthyology and Fisheries Science (DIFS) offers well-equipped and well-maintained aquaculture facilities, with access to both marine and freshwater training and research facilities. The Department has a close working relationship with the South African Institute of Aquatic Biodiversity (SAIAB), with which resources are commonly shared for mutual benefit and logistical ease, as the facilities are situated adjacent to each other.



Figure 12: Rhodes University Department of Ichthyology and Fisheries Science (DIFS)

6.2.1.1. Focus of programme

DIFS offers a programme that covers a wide variety of fisheries and aquaculture education and research programmes. In terms of aquaculture, research in both marine and freshwater species is available. The aquaculture-relevant research area currently comprises ecophysiology research as well as production optimization through the development and trialling of feeds.

Courses include MSc Fisheries Science, PhD Fisheries Science and BSc Honours students who do a set Honours module in aquaculture. Second-year students have two courses in Applied Ichthyology that are dedicated to aquaculture. Ichthyology 2 and 3 offer fundamentals of research design, fish biology and life history. DIFS also offers short courses for veterinarians and veterinarian students, and SPCA ethics, and has a post-graduate school of about 60 to 70 students at any one time. In terms of freshwater aquaculture-focused research, the opportunities are currently more limited than that of marine research. Species such as Mozambique tilapia, African sharp tooth catfish, and freshwater ornamentals are the key species of freshwater aquaculture research at DIFS.

DIFS staff noted that very few MSc and PhD graduates in aquaculture are not employed in the industry after their degrees. There is an increasing trend towards research and employment using Integrated Aquaculture Systems, such as aquaponics. There is no problem with student enrolment at the facility.

6.2.1.2. Type of structure

There are numerous types of live-holding systems on and off campus, and those at DIFS are housed in various types of structures. The ecophysiology and small trial systems are located within buildings at the department. There are some greenhouse tunnel structures that house freshwater ornamental species as well as a small aquaponics demonstration system. Some tanks are also located outside

under cover, primarily for freshwater species research. Concrete ponds are also available on site but are currently not being used for research purposes.

Plans are underway to rebuild the DIFS fish farm in partnership with SAIAB. The NRF has committed to funding R15 million for a new Aquatic Research Facility. The Aquaculture Research Facility will include a wetland recirculating treatment system, replicated outdoor freshwater space that can be easily set up according to specific research requirements, warm- and cold-water options with a heat exchanger system and a commercial aquaponics demonstration system for teaching.



Figure 13: Various structures at DIFS, including concrete tanks, tunnel structures and laboratory buildings

6.2.1.3. Water supply

The seawater supply for marine research at DIFS is provided by abstracting water from the Kariega estuary at Kenton-on-Sea and transporting water by truck in volumes of 5000 litres at a time. This water is then stored in tanks at DIFS and used where necessary. Freshwater supply is provided from the municipal supply as well as a borehole located on site. Rainwater is also harvested for drinking purposes. Municipal freshwater supply is not consistent.

6.2.1.4. Electricity

Electricity is available throughout the facility. However, DIFS is affected by loadshedding and has a back-up generator available. This back-up generator is situated on site and needs replacement.

6.2.1.5. Water filtration

Seawater that is brought in is not immediately filtered. However, most of the experimental systems are connected to simple filtration systems with a biological filter. There are some systems that are connected to a more technical filtration system that includes a sand filter, drum filter, and protein skimmer. Filtration systems can be set up according to specific research requirements.

6.2.1.6. Feed storage

DIFS has a feed storage room that is temperature controlled using an air-conditioning unit. The feed storage room also includes a chest freezer and a refrigerator. The feed store is not currently being used, apart from the chest freezer, due to the low volumes of feed currently being used at the facility. However, the facility is still functional and needs minimal upgrading. DIFS also have their own small-scale feed production system that includes a drying oven, a grinder, a mixer and an extruder.



Figure 14: DIFS Feed storage and feed manufacturing facilities

6.2.1.7. Workshop

The onsite workshop facility is well equipped to conduct any required maintenance and repairs and has qualified staff that are on standby twenty-four hours a day.

6.2.1.8. Life-support systems

DIFS has a wide variety of life-support systems that can be configured to suit the requirements of the relevant research projects. Most of the systems are designed to be fully recirculating systems but can easily be converted into flow-through or static systems. The systems are mostly intensive systems, apart from the outdoor concrete ponds that function as extensive systems. The life-support systems all include adequate water and air reticulation, oxygen can be provided from cylinders if needed, and filtration systems, both simple and more complex, can be installed. All life-support systems are regularly maintained. When systems have not been in use for an extended period of time, they are fairly easy to service and bring back into operation.



Figure 15: Simple aquaculture research setup

One of the core philosophies at DIFS is that often, simple works better. The Head of Department stressed that it is not necessary to have technologically complex and expensive systems to learn aquaculture or to conduct research. Some of the best research work at DIFS has been conducted in a room with 18 replicated tanks and a simple setup.



Figure 16: Various life-support systems set up for different research projects

6.2.1.9. Laboratory facilities

DIFS has a well-equipped laboratory dedicated to ecophysiology studies where specialised equipment is available, such as respirometers. The ecophysiology facility also has infrastructure to allow for ozone sterilization of water if required. The South African Institute for Aquatic Biodiversity

(SAIAB) is situated next door to DIFS, which allows for natural collaboration and sharing of facilities. SAIAB is equipped with a Genetics Facility and First-Generation Molecular Laboratory, as well as general laboratories.



Figure 17: Laboratory facilities

6.2.1.10. Administrative and academic support

Rhodes has an extensive administrative and academic support structure, which filters through into the various faculties and departments within the University. DIFS has a well-equipped administration block that provides support for both students and staff; IT services are available on campus and basic IT systems are installed at DIFS, such as internet, computer access, printers, scanners, photocopiers, et cetera.

In terms of academic support, DIFS is well resourced with staff within the Department, staff at SAIAB, as well as other academic associates and government representatives. One of the DFFE's Production Scientists is based at DIFS full time. He collaborates with DIFS on numerous projects and assists students when required. One of his core responsibilities is to promote science in schools and to generate awareness about aquaculture and related careers to high school students. He organizes activities through the annual SciFest and collaborates with schools to run science experiments in the Water Quality Testing Laboratory. DIFS funding comes from diverse sources including the NRF, African Union, European Union, private industry and government departments.

6.2.1.11. Other features

A significant grant from the NRF is enabling DIFS and SAIAB to implement significant upgrades in 2024, to create a shared state-of-the-art AquaLabs space, which will include marine and freshwater training and research capacity, an industrial aquaponics facility, and a feed development facility. However, it was strongly presented that DIFS cannot rely on NRF funding alone and that private funding is vital to the continuation of aquaculture research at the facility. It is essential to collaborate with other academic institutions, government and the private sector because the multidisciplinary approach that aquaculture demands needs broad expertise. Industry partnership has become essential, as aquaculture research has the potential to play a critical role in revitalising and innovating the industry.

DIFS has several Memorandum of understandings (MoUs) with the industry, NGOs, government departments and other research institutions and universities, both locally (University of Fort Hare, NMU, Stellenbosch) and internationally (United Kingdom).

Recommendations

The high numbers of students, high pass rates and high levels of employment among DIFS graduates are testament to the quality of resources at DIFS. Rhodes is proactive in terms of sourcing funding and partnering with other institutions from the public and private sectors, both locally and globally. The DFFE has a presence on campus, and it is recommended that this support plays an active role in linking private sector aquaculture farms and educational institutions in order to better support industry needs and assist with unlocking opportunities in the sector.

When the Dohne facility is up and running, there is potential for Rhodes to revive previous MoUs and support Dohne. Rhodes is also well placed to provide support for TVET Colleges in the Eastern Cape, such as Lovedale TVET and Fort Cox TVET, who have an interest in offering aquaculture courses. Rhodes students may benefit from voluntary practical internships at private farms or TVET colleges to provide academic support to such institutions, whilst gaining practical experience.

6.2.2. Stellenbosch University

Table 9: Stellenbosch University Aquaculture infrastructure & facilities detailed description

CRITERIA	AVAILABLE	COMMENT
Focus of programme		Research –freshwater species on site. Work with industry on marine species – no facilities on site for marine studies.
Type of structure		Glass house and tunnel structures. Aquaculture facilities form part of Welgevallen Experimental farm.
Water supply	YES	Borehole water, Eersterivier river water and municipal freshwater.
Electricity	YES	Eskom and backup generators.
Water filtration	YES	Filtration can be set up to accommodate student requirements. Coarse filtration (sand filter).
Feed storage	YES	Temperature controlled storage.
Workshop	YES	Well equipped with technical staff on standby 24/7.
Life support systems	YES	100% RAS. Simple biofiltration.
Laboratory facilities	YES	Multiple laboratory facilities available as part of the University. Wet and dry lab facilities available on the farm.
Flexibility in system setup	YES	Systems can be customised to suit research requirements.
Replicated tank set up	YES	Systems can be customised to suit research requirements.
Administrative support	YES	Admin block with staff and student offices.
IT Facilities	YES	Internet, computers and printing facilities available.
Academic support	YES	A number of staff permanently employed.

Stellenbosch University is a public research university situated in the historic town of Stellenbosch in the Western Cape. Stellenbosch University is one of the oldest universities in South Africa and was the first university in South Africa to offer an aquaculture degree programme, first offering aquaculture as a specialised discipline in 1989. Due to decreasing student numbers, it is no longer economically viable to offer a dedicated undergraduate programme, so aquaculture has been incorporated as a module in the Animal Sciences (BSc Agric) degree. The focus has shifted to developing well-rounded students with a variety of skills and knowledge. The Stellenbosch University Aquaculture Unit, the University's aquaculture research facility, is located on Welgevallen Experimental Farm.



Figure 18: Stellenbosch University Aquaculture Unit, Welgevallen Farm

6.2.2.1. Focus of programme

While Stellenbosch University (SU) does not offer an aquaculture-specific degree programme or courses, a research facility has been developed as part of the Animal Sciences Department within the Faculty of AgriSciences. The focus of research is freshwater species, primarily Mozambique tilapia and African sharp tooth catfish, but includes Nile tilapia, common carp, ornamental fish, algae and pangasius. Some marine research occurs off site where experiments are conducted at private sector facilities (mostly abalone farms). The marine research focuses primarily on mussel and abalone production, particularly the formulation of abalone feeds.



Figure 19: Freshwater research at Stellenbosch University

6.2.2.2. Type of structure

The research facilities at Welgevallen Experimental Farm are located within a greenhouse structure. There are glass, plastic and tunnel-type greenhouse structures on site. The existing structures are in functional condition and the glass greenhouse was being utilized at the time of the site visit. The laboratories are located in buildings adjacent to the greenhouse structures. Currently there is insufficient repetition for research and, as a result, the space is being upgraded. It is anticipated that the cost of upgrading the facility to ensure that the minimum required number of replicas can be accommodated will cost approximately R1.5 million. The first phase of the upgrade was privately funded by Dryden Aqua.



Figure 20: Greenhouse structures at Stellenbosch University



Figure 21: Pump room and glass greenhouse housing replicated tanks for research

6.2.2.3. Water supply

The water supply to the facility is sourced from three primary sources, namely, municipal water supply, abstraction from the nearby Eersterivier, and abstraction from an on-site borehole.

6.2.2.4. Electricity

Electricity is available at the facility. However, the facility is affected by loadshedding and has a back-up generator available. The back-up generator is well maintained and in working order.

6.2.2.5. Water filtration

The main incoming water supply does not undergo any filtration. However, coarse filtration is available in the form of sand filters. A simple trickle biological filter is also available for more intensive systems. Filtration systems can be installed to suit the requirements of the specific research project.

6.2.2.6. Feed storage

Climate-controlled feed storage is available in the laboratory building. An air-conditioning unit has been installed but is only operated when feed is present. A chest freezer and refrigerator are also available.

6.2.2.7. Workshop

The Welgevallen Experimental Farm has a well-equipped workshop that serves as a shared service for all the departments operating within the facility, including the aquaculture division. Maintenance staff are available twenty-four hours a day for emergencies. Staff from the aquaculture division are also on stand-by, particularly when animals are in the system.

6.2.2.8. Life-support system

The Aquaculture Research Unit is primarily designed to be an intensive, recirculating system. However, the system can be modified to either a flow-through or static system, depending on the research requirements. The aquaponics facilities that are part of the Aquaculture Unit are managed as semi-intensive recirculating systems.



Figure 22: Aquaponics demonstration system at Stellenbosch University (top left and right) and life-support systems (bottom left and right)

6.2.2.9. Administrative and academic support

Well-equipped administrative services are available on campus at SU. The Aquaculture Unit has access to a shared administration block at the Welgevallen Experimental Farm that has resources with lecture facilities, boardroom facilities, ablutions and a kitchen. The Aquaculture Unit has its own administration facilities that include staff and student offices, lecture facilities and laboratories, and storage space. Academic support is offered by a number of permanently employed academic staff. However, collaboration with and access to academic resources through other educational, government and private sector institutions is available.

Basic IT services are also available at the Aquaculture Unit to staff and students such as internet and printing facilities. More advanced IT support services are available on campus.



Figure 23: Student facilities and laboratory

6.2.2.10. Other features

The Aquaculture Unit also offers a variety of short courses and has facilitated courses for farmworkers where the basics of aquaculture and life-support systems are presented. Over time, the number of students enrolling for the aquaculture-related modules, courses and workshops has steadily declined. The Aquaculture Unit has indicated that they would be very supportive of further collaboration with other academic institutions, government institutions and private enterprises.

Recommendations

Stellenbosch has expressed interest in partnering with institutions that do not have adequate facilities for training. Currently, SU is the only university that offers certificate courses in Production and Management, as well as various short courses and workshops for skills and development at different levels. The Western Cape produces over 80% of South Africa's total aquaculture production volume (6382,9 tons in 2021) and is home to 79% of our marine aquaculture farms, and 13 % of our freshwater aquaculture farms, thus presenting a significant opportunity for further education and training at a vocational level (Department of Forestry, Fisheries and the Environment, 2022, p. 6). There is an opportunity for the University to expand its short-course offerings to cater for the workforce on the abalone farms, or to provide on-farm training to farm workers.

6.2.3. University of Cape Town

Table 10: University of Cape Town Aquaculture infrastructure & facilities detailed description

CRITERIA	AVAILABLE	COMMENT
Focus of programme		Marine species.
Type of structure		Inside campus building.
Water supply	YES	Sea water brought in from DFFE Sea Point facility.
Electricity	YES	Eskom and backup generators.
Water filtration	YES	Not a standard installation but can be included as part of the system design if needed. Filtration takes place at DFFE facility when water is collected.
Feed storage	YES	Temperature controlled storage.
Workshop	YES	Well equipped with technical staff on standby 24/7.
Life support systems	YES	100% RAS. Simple biofiltration.
Laboratory facilities	YES	Multiple laboratory facilities available as part of the University as a whole – genomics, physiology, histology, algae lab, dissection, water quality, feed analysis. All well-equipped. But no dedicated aquaculture laboratory facilities.
Flexibility in system setup	YES	Systems can be customised to suit research requirements.
Replicated tank set up	YES	Systems can be customised to suit research requirements.
Administrative support	YES	Admin block with staff and student offices.
IT Facilities	YES	Internet, computers and printing facilities available.
Academic support	YES	A number of staff permanently employed and associate staff deeply involved.

The University of Cape Town (UCT) is a public research university in Cape Town, established in 1829 as the South African College. It was granted full university status in 1918, making it one of the oldest universities in South Africa and the oldest university in Sub-Saharan Africa in continuous operation. The UCT is organized in 57 departments across six faculties offering bachelor's (NQF 7) to doctoral degrees (NQF 10). It is home to 30,000 students and encompasses six campuses in the Capetonian suburbs of Rondebosch, Hiddingh, Observatory, Mowbray, and the Waterfront. It is the only African member of the Global University Leaders Forum (GULF) within the World Economic Forum, which is made up of 26 of the world's top universities.

6.2.3.1. Focus of programme

Historically, UCT has had a strong focus on marine research. An Integrated Aquaculture module is available in the Department of Biological Sciences Honours coursework and in the Masters in Applied Ocean Sciences academic programmes. Academic courses cater mostly for post-graduate level aimed at marine aquaculture and a third-year course called Marine Resources (Marine Biology at undergraduate and Honours level). At Honours level there is a one-week compulsory aquaculture module.

The facility at UCT can accommodate any species required by students, provided that their ethics clearance and required permitting has been approved. Previous species that have been studied at the UCT facility include rock lobster, shy sharks, sea stars (starfish), alien crabs, urchins, and many fish species.

6.2.3.2. Type of structure

Aquaculture-related research occurs within the department building. There are no tunnels or outdoor pond structures that form part of the available infrastructure. The facilities and systems within the experimental facilities at UCT are entirely flexible and can be easily modified to suit the specific requirements of research projects.

6.2.3.3. Water supply

Seawater is supplied by the Marine Research Aquarium, managed by the Department of Forestry, Fisheries and the Environment (DFFE). Seawater is brought in from the Sea Point facility via 2000 litre tanks and used where necessary. Since no freshwater aquaculture research takes place at UCT, the municipal freshwater supply is purely for domestic use.

6.2.3.4. Electricity

Electricity is available on campus. In the event of loadshedding, back-up generators are available and are well maintained and functioning. Inverter systems were being installed at the time of the site visits to supplement the electricity supplied from the generators.

6.2.3.5. Water filtration

Water sources from Sea Point are already pre-filtered through the Marine Research Aquarium's own filtration systems. No additional filtration is applied to incoming seawater once it arrives at the UCT facility. However, the experimental systems are connected to a simple biological filtration system and recirculated. Further filtration can be applied to suit the requirements of individual research projects.



Figure 24: Simple trickle biofiltration systems that are used for the experimental systems

6.2.3.6. Feed storage

Both formulated and wet feeds are required by researchers at the UCT facility, so climate-controlled feed storage facilities are made available. A cold room is dedicated to this purpose. A chest freezer and fridges are also available for the storage of feed.

6.2.3.7. Workshop

A well-equipped workshop is available within the department that is primarily dedicated to repair and maintenance of marine research facilities. Trained staff are available twenty-four hours a day to handle emergencies.

6.2.3.8. Life-support system

Life-support systems within the UCT facility are designed to be intensive systems that are connected to a simple recirculating system. Adequate water and air reticulation systems are installed, and oxygen can be provided from an oxygen cylinder if required. The life-support systems can be modified to suit the specific requirements of research projects.

6.2.3.9. Laboratory facilities

The UCT has an extensive laboratory-support system. The cross-cutting nature of aquaculture-related research allows access to a variety of laboratory services, such as genetics, palaeontology, histology, biomedical research, microbiology and general laboratory access.



Figure 25: Laboratories including palaeontology, histology, biomedical, microbiology and algae labs

6.2.3.10. Administrative and academic support

Well-appointed administrative and academic support services are provided by UCT. The Marine Research Facility has staff and student offices, ablutions, and a small kitchen that staff and post-graduate students can access. IT support services are available with internet throughout campus. The Marine Science Department has facilities for printing, scanning, photocopying, et cetera. Academic support is well resourced through academic staff appointed by UCT, as well as academic resources made available through government and private sector channels.

6.2.3.11. Other features

The UCT has a wealth of shared facilities between various departments, which makes the assessment of aquaculture-specific facilities difficult. Owing to the diverse nature of aquaculture research, numerous departments within UCT have some level of involvement in aquaculture development. The engineering department at UCT also incorporates aquaculture-related topics into their research portfolio.

The UCT facility has strong connections with the DFFE and industry. There is significant collaborative research with the DFFE Aquaculture Innovation and Technology Development directorate at the Marine Research Aquarium in Sea Point, where there is the necessary infrastructure and access to seawater, as well as laboratory facilities for aquaculture research and capacity development. Students may conduct their research experiments at the DFFE facility or at UCT, depending on the nature of the research and the specialization of the supervisor required.

Recommendations

The UCT has significant infrastructure available and a number of partnerships and MoUs in place. The University focuses on specialist academic research and skills development at a tertiary education level. There is little scope or the resources to include vocational-level training programmes. Students have access to the Sea Point Marine Research Aquarium for specific research projects, as well as a wide variety of well-equipped laboratories that are part of the broader UCT Science Faculty.

6.2.4. University of Fort Hare

Table 11: University of Fort Hare Aquaculture infrastructure & facilities detailed description

CRITERIA	AVAILABLE	COMMENT
Focus of programme		No aquaculture specific training, but an aquaculture module is incorporated into BSc. Fort Hare Aquaculture Research Unit for MSc and PhD research is set up at Kingfish Enterprises (East London IDZ).
Type of structure		University buildings (laboratory).
Water supply	OFFSITE	Sea water supplied at Kingfish Enterprises.
Electricity	YES	Backup generator available at Kingfish Enterprises with an automatic change-over.
Water filtration	OFFSITE	UV Filtration system, biological filtration (installed by UFH), Course filtration and ozonation installed by Kingfish Enterprises .
Feed storage	OFFSITE	Supplied by Kingfish Enterprises.
Workshop	OFFSITE	Supplied by Kingfish Enterprises.
Life support systems	OFFSITE	RAS system at Kingfish Enterprises; flow through, static and a RAS system installed by UFH.
Laboratory facilities	YES	Limited shared facilities with Kingfish Enterprises but well-equipped lab at Alice Campus.
Flexibility in system setup	OFFSITE	Systems installed by UFH at Kingfish Enterprises can be modified to suit research needs.
Replicated tank set up	OFFSITE	Enough tanks available to meet minimum statistical requirements.
Administrative support	YES	Support provided by University staff (Alice campus).
IT Facilities	YES	IT labs at Alice campus.
Academic support	YES	Academic staff at Alice campus.

The University of Fort Hare (UFH) is a public university in Alice, Eastern Cape. It was a key institution of higher education from 1916 to 1959 when it offered a western-style academic education to students from across Sub-Saharan Africa. Fort Hare alumni were part of many subsequent independence movements and governments of newly independent African countries, and it is now part of South Africa's post-apartheid public higher education system. It is the alma mater of well-known figures in South African history including Nelson Mandela, Desmond Tutu, Robert Sobukwe and Oliver Tambo. Within the Zoology and Entomology Department, the Fort Hare Aquaculture Research Unit (FHARU) was established to provide support to students who wish to pursue further studies in aquaculture-specific research.

6.2.4.1. Focus of programme

Aquaculture research at UFH is encompassed within the modules presented by the Department of Zoology and Entomology with specific aquaculture focus at a post-graduate level through the FHARU. The FHARU focuses predominantly on marine aquaculture species, including dusky kob, yellowtail kingfish, abalone, amphipods and copepods. Mullet is a species that has recently been included within the FHARU's species portfolio.

6.2.4.2. Type of structure

The main campus for UFH is located in Alice in the Eastern Cape. While the Alice campus does not have dedicated aquaculture facilities, it has a number of well-equipped laboratories to support aquaculture research. Aquaculture research through UFH is primarily conducted at the private-sector

facilities of Kingfish Enterprises. These facilities are well equipped for practical, on-farm experimentation. Research activities at the abalone farms take place either in outdoor tanks and ponds, or hatchery and settlement experiments which take place inside the hatchery building. The private-sector facility for fish and other invertebrate research takes place in a structure that is a combination of tunnel structures and buildings.

The UFH has an Aquaculture Research Unit that is permanently based at Kingfish Enterprises in the East London IDZ, Eastern Cape. An MoU entered into between UFH and Kingfish Enterprises allows UFH to utilize the resources to facilitate aquaculture research.



Figure 26: The land-based aquaculture facility, Kingfish Enterprises, in the East London IDZ (left) and one of the experimental setups available to students (right)

6.2.4.3. Water supply

No marine studies take place on the Alice campus owing to the difficulties and practicalities around obtaining seawater. At the private-sector facilities, seawater is abstracted directly from the sea from wells, using pumps. Freshwater supply is sourced from the municipal water supply.

6.2.4.4. Electricity

Electricity is available at the Alice campus as well as the private-sector facilities. However, these facilities are affected by loadshedding, and back-up generators are available at the private-sector facilities. These back-up generators are functioning and are well maintained.

6.2.4.5. Water filtration

Coarse filtration of incoming seawater is provided by Kingfish Enterprises. The farm's experimental systems that have been installed have further filtration infrastructure installed by UFH that allow for finer filtration to take place. The UV sterilization systems, ultra-filtration systems, biological filters and protein skimmers have all been installed by UFH.

6.2.4.6. Feed storage

Feed storage facilities are available at Kingfish Enterprises. These facilities are not temperature controlled, but chest freezers and fridges are made available to students, if needed.

6.2.4.7. Workshop

A general workshop facility is available at the Alice Campus that services the University as a whole. The workshop facilities at Kingfish Enterprises are well equipped with trained staff. Technical and maintenance support at the private-sector facilities is available twenty-four hours a day.

6.2.4.8. Life-support system

No life-support systems are available at the Alice campus. However, the life-support systems at Kingfish Enterprises allow intensive recirculating systems, semi-intensive flow-through systems and static systems to be utilized. Well-appointed water and air reticulation is available at the private-sector institution, as is the supply of oxygen and ozone.



Figure 27: Various experimental setups available to students through the Fort Hare Aquaculture Research Unit located at Kingfish Enterprises

6.2.4.9. Laboratory facilities

Well-equipped laboratory facilities are available at the Alice campus. Small laboratories have been set up at the private-sector facilities, alongside their own laboratory setups. These laboratory setups include a benchtop laminar flow hood, stereomicroscope with a digital camera, and required chemical reagents needed for various research projects.



Figure 28: Some examples of the laboratory facilities located at the Fort Hare University's Alice campus

6.2.4.10. Administrative and academic support

Administrative support infrastructure is available at the Alice campus. An administration building is available that provides staff and student offices with access to the internet, printers, scanners and photocopiers. These facilities are also available on site at the private-sector facilities but are more closely monitored for use.

Academic support is limited with only one key person within the faculty at UFH driving the Aquaculture Research Unit. Private-sector facilities have been vital in providing both technical and academic support to students.

6.2.4.11. Other features

Working alongside private-sector facilities has been instrumental in facilitating aquaculture research at UFH. Students from UFH have presented their research to international audiences with positive feedback from industry experts.

Recommendations

UFH are fortunate to be able to utilize the infrastructure at Kingfish Enterprises and Wild Coast Abalone. The university receives government support through the NRF and other internationally driven programmes. The UFH focuses on the development of scientific skills rather than vocational skills and does not have adequate facilities or resources to consider including vocational training in their academic portfolio. There is an opportunity for UFH to partner with Dohne for freshwater aquaculture practical training, should this be required in the future.

6.2.5. University of KwaZulu-Natal

Table 12: University of Kwa-Zulu Natal Aquaculture infrastructure & facilities detailed description

CRITERIA	AVAILABLE	COMMENT
Focus of programme		Freshwater (zebra fish) and marine.
Type of structure		Tunnels, brick buildings and insulated/environmental control rooms.
Water supply	YES	Sea water transported up in 1m3 mini-bulk containers.
Electricity	YES	3 phase. - departmental back up electricity available.
Water filtration	YES	Filtered seawater obtained from uShaka Marine works. Freshwater deionised and demineralised.
Feed storage	YES	No dedicated feed store, but have alternative options for small-scale feed storage.
Workshop	YES	Maritime workshop and general workshop.
Life support systems	YES	Partial flowthrough RAS / replacement as needed.
Laboratory facilities	YES	Well-equipped laboratories for biological studies, microbiology and liquid robotics.
Flexibility in system setup	YES	System can be customised to suit research requirements.
Replicated tank set up	YES	Tank replicates can be set up to suit research requirements.
Administrative support	YES	Offices for staff and students.
IT Facilities	YES	Well established on campus.
Academic support	YES	Academic staff on campus and associate staff available.

The University of KwaZulu-Natal (UKZN) is recognised as one of South Africa's top research-focused universities and is considered to be one of the largest universities in Sub-Saharan Africa. The UKZN has been placed third among 16 universities in South Africa and 369th among 2000 Higher Education Institutes (HEI) across the world by the world body, University Ranking by Academic Performance (URAP). Aquaculture modules are presented at UKZN as part of the Applied Marine Biology module within the Marine Biology Programme.

6.2.5.1. Focus of programme

The UKZN has both freshwater and marine research facilities. In terms of freshwater research, the zebrafish unit was developed as a bio-medical research unit. The focus of the research conducted at the zebrafish research unit is related to toxicology and the effect of antiretroviral chemicals in wastewater on embryonic development.

The marine species that the programme focuses on include abalone, shrimp, and various indigenous fish species. Although small-scale trials are conducted on campus, final testing and validation is always done in collaboration with aquaculture facilities, with trials under operational conditions. The University has conducted farm-based trials at a number of private-sector facilities in both the abalone and finfish sectors. The UKZN has also supported, and has been supported by, the National Research Aquarium, uShaka Marine World, and the Two Oceans Aquarium with applied research.



Figure 29: Zebrafish research unit facility

6.2.5.2. Type of structure

The UKZN has a variety of structures in which aquaculture research takes place. Systems are located within buildings, tunnel structures, glass-panelled greenhouse structures and environmental control rooms.



Figure 30: UKZN's Glasshouse research facility for marine and freshwater studies (left) and the inside of the tunnel structure available for research purposes (right).

6.2.5.3. Water supply

Seawater supply is sourced from uShaka Marine World and is transported to campus in 1m³ mini-bulk containers. Freshwater supply is sourced from the municipal supply and then deionized.

6.2.5.4. Electricity

The UKZN campus has electricity, and in the event of loadshedding, they have a back-up generator that is functioning and maintained.



Figure 31: UKZN's Back-up generator

6.2.5.5. Water filtration

Freshwater is filtered and deionized. It is then remineralised to match the water quality requirements needed for zebrafish husbandry.

Seawater sourced from uShaka Marine World is treated by uShaka's filtration systems, which includes sand filtration and treatment with ozone. Basic filtration systems are incorporated into the experimental systems in the form of biological filters and sand filters.

6.2.5.6. Feed storage

No dedicated feed storage facilities are available. However, alternative feed storage options are available within the laboratory facilities. These include air-conditioned rooms, freezers and refrigerators.

6.2.5.7. Workshop

UKZN has both a well-equipped maritime workshop and a general workshop. Workshop staff are well trained to undertake repairs and maintenance of the facilities.

6.2.5.8. Life-support system

The life-support systems for the zebrafish unit are designed as partial flow-through systems but can be adapted to be static or flow-through. The unit has a holding system to hold the zebrafish and then utilizes a standard modular live-holding system for research activities. The system has an incubator, pH-dosing machine and water reservoir to maintain water quality. The modular system can be expanded with add-ons as required. Research is done on the embryonic phase of development in the incubator.

The marine aquarium facilities are also designed as modular partial flow-through systems with simple biological filtration of return water. Water and air reticulation infrastructure is available, and oxygen can be provided if required using an oxygen cylinder.

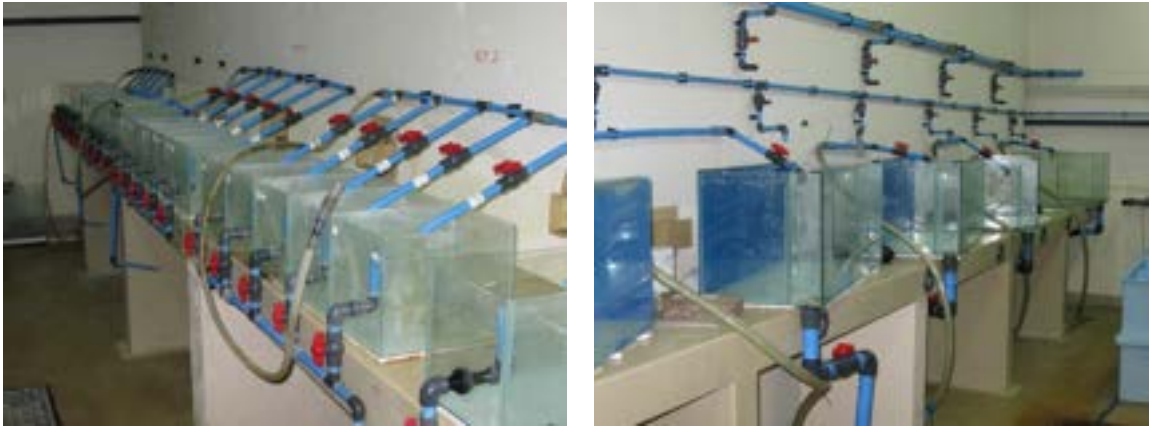


Figure 32: Examples of the small-scale experimental systems at UKZN

6.2.5.9. Laboratory facilities

The UKZN has well-equipped laboratory facilities that cater for a wide variety of analyses. The laboratories are equipped to undertake water quality testing, algae production, microbiological studies, histological studies and cryogenic studies. A Biosecurity Level 3 Biological Laboratory (Bio Lab) is also available to undertake research on infectious diseases and pathogens. This Level 3 Bio Lab is audited annually and has retained its status as a Level 3 Bio Lab.



Figure 33: Examples of some of the laboratory facilities and equipment available at UKZN

6.2.5.10. Administrative and academic support

The UKZN has well-appointed administrative support services for staff and students. Administration buildings are located on campus that have offices for staff and students and provide IT support in the form of computer access and internet. The administration facility also has meeting rooms and a 'Max-Hub' for student support and interaction.

In terms of academic support, there are a number of academic staff and post-graduate students that provide support to students. There are several small laboratories within the Marine Science Faculty and larger general laboratories for practical sessions.



Figure 34: One of the student laboratories (left) and the Max-Hub student support centre (right)

6.2.5.11. Other features

The Marine Science Department has a diving storeroom that includes a shower and bathroom. Boating facilities are also available in the form of the following:

- 1 x 9 m semi-rigid duck with 2 x 100 hp outboard motors.
- 1 x 4 m semi-rigid with 40 hp Yamaha.
- 1 x 3.5 estuarine boat (tin).
- 3 x Toyota bakkies: 1 x 4x4 fully rigged, and 1 x LWB standard bakkie.



Figure 35: UKZN's boating equipment

The School of Life Sciences has developed a concept document for the establishment of an aquaculture hub to integrate research and development within a functioning production system which is aimed at developing and supporting aquaculture in the KwaZulu-Natal Province. The UKZN is also starting research around liquid robotics in the marine environment, and the University has been able to secure funding for this research.

Recommendations

It is recommended that UKZN aligns with an industry partner (e.g., feed, prawns, ornamentals, corals) in order to focus their work and drive their research programme. There are five trout farms in KZN which account for around 30% of the country's freshwater production; however, there is no focus on driving trout-related research or training. The marine-focused training and research at UKZN does not appear to align with industry needs, and the university is located far from the marine aquaculture market.

6.2.6. University of Limpopo

Table 13: University of Limpopo Aquaculture infrastructure & facilities detailed description

CRITERIA	AVAILABLE	COMMENT
Focus of programme		Freshwater - tilapia, catfish, phytoplankton & ecosystems.
Type of structure		Greenhouse - polycarbonate sheeting.
Water supply	YES	Municipal water supply.
Electricity	YES	3 phase - departmental back up electricity available.
Water filtration	YES	Sand filtration.
Feed storage	YES	Not temperature controlled.
Workshop	YES	Includes a technical store.
Life support systems	YES	Intensive RAS.
Laboratory facilities	YES	Well equipped.
Flexibility in system setup	YES	System can be customised to suit research requirements.
Replicated tank set up	YES	Tank replicates can be set up to suit research requirements.
Administrative support	YES	Admin offices. Cubicles for students, labs and lecture rooms.
IT Facilities	YES	On-campus IT support.
Academic support	YES	4 members of staff available to provide academic support.

The University of Limpopo is a public university in the Limpopo Province. It was formed on 1 January 2005, by the merger of the University of the North and the Medical University of South Africa (MEDUNSA). Aquaculture-related research is undertaken within the Faculty of Science and Agriculture, within the School of Agricultural and Environmental Sciences.

The University of Limpopo's Rivers of Life facility offers fisheries and aquaculture training facilities.

6.2.6.1. Focus of programme

Within the University of Limpopo's School of Agricultural and Environmental Science, the Rivers of Life facility offers fisheries and aquaculture training facilities. Courses offered include fish nutrition, fish biology, fish diseases, fish genetics and water quality. The primary species of focus are freshwater species – Mozambique tilapia and African sharp tooth catfish.

6.2.6.2. Type of structure

The aquaculture research facility is located within a greenhouse structure with polycarbonate sheet roofing. Smaller experimental systems are also located within the Rivers of Life facility. New tunnel facilities have been provided in which students are able to run experiments. A cascading pond system is also present; however, it is broken and non-functional.



Figure 36: New tunnel structures (top left and right, and middle left), ornamental facility (middle right) and old tunnel with earth pond simulation (bottom row)

6.2.6.3. Water supply

Water supply is sourced from the municipal water supply that feeds onto campus.

6.2.6.4. Electricity

Electricity is provided on campus. However, the university is subject to loadshedding. A back-up generator is located on site but is non-functional and needs to be replaced. Requests to repair the generator have been submitted but have not been approved.



Figure 37: The generator storeroom (left) and the diesel storage tank for the generator (right)

The electrical box for the new tunnel system is out in an open field without a door or cover, which poses a risk to the reliability of the electrical supply due to exposure to the elements.



Figure 38: The electrical box for the new tunnel system

6.2.6.5. Water filtration

Each system is set up with an appropriate water filtration system. A new tunnel for student research has four lines of concrete tanks and each system has its own filtration system. Each sump has two sand filters (the filter medium in these sand filters is presently being changed to biomedica to prevent blocking).



Figure 39: Water filtration systems showing sand filtration infrastructure

The Ornamental Tunnel Filtration system includes a 5000-litre sump tank and two standard swimming pool sand filters.



Figure 40: Filtration system for the ornamental facility with sand filters (left) and a trickle biological filter (right)

6.2.6.6. Feed storage

Feed storage facilities are available but are not temperature controlled. The feed storage facilities are currently not being utilized.

6.2.6.7. Workshop

A technical storeroom is available on site and is fairly well equipped.



Figure 41: Technical manager's office workshop

6.2.6.8. Life-support system

The university has four phytoplankton Culture Ponds and 10 x Aquadam tanks for plankton culture. These systems are designed to be static systems. They are currently unused because academic projects are research-specific, and these systems are not always required.



Figure 42: Unused phytoplankton culture tanks

The new tunnel for student research includes four lines of concrete tanks made from brick and plaster; each system has its own filtration system, is temperature controlled, has a UV filter and its own heat pump. The system turnover rates vary depending on pressure and requirements for the specific research project.



Figure 43: Heat pump systems installed on the new tunnel (left) and the new tank systems installed for the new tunnel (right)

A broken cascading pond system is also present consisting of 10 x 2 ponds running in series down the hill. The ponds are 5 m x 5 m x 70 cm deep. The system sump is 40 m x 8 m.



Figure 44: Cascading pond system

The original tilapia tunnel is currently being converted to an aquaponics system, and the tilapia tanks are in the process of being removed, together with 16 glass-fibre tanks (1 m x 0.8 m x 0.6 m), four round tanks of 2500 litres each, and tilapia trial tanks (2 x 10 round conical tanks of 50 litres each). The three water heaters that form part of the tilapia system are not working and the three non-functional electrical panels need to be removed from the tunnel.



Figure 45: Various experimental tanks systems in the old tunnel and the experimental hydroponics system (bottom)

The existing plastic tunnel provides an earth pond simulation system, which includes five tanks of 6 m x 6 m x 0.8 m deep. These are static ponds used for tilapia culture.



Figure 46: Earth pond simulations for tilapia culture

There is also an outside research system that includes ten round static tanks of 5 m³ each for trials, as well as static 'Mesocosm' tanks with different substrates for various trials.



Figure 47: Static mesocosm tanks

An ornamental tunnel that has its own hatchery and static and recirculating systems is also available.



Figure 48: Ornamental tunnel (left) with hatchery infrastructure inside (right)

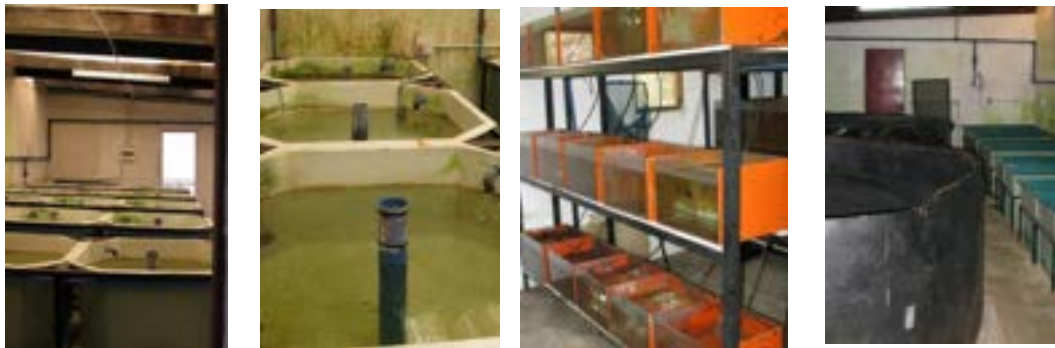


Figure 49: Hatchery systems and experimental systems in the ornamental tunnel

6.2.6.9. Laboratory facilities

Well-equipped laboratory facilities are available on campus that allow for water quality, molecular, cell culture, biochemical and general laboratory studies. The equipment is fairly old, but most of it is in working condition.



Figure 50: Laboratory facilities available to students

6.2.6.10. **Administrative and academic support**

General administration facilities are located on campus but are non-functional. However, staff and student offices are available and are partially functional. There is IT support on campus that includes limited computer access and internet availability. Student accommodation is also available on campus and has good security, which has resulted in minimal disturbance to campus activities due to student unrest.



Figure 51: Student residence (left) and additional staff and student accommodation on site (right)

In terms of academic support, there are four academic staff who are available to support aquaculture studies. There is also a DFFE production scientist based at the university to support research on aquaculture in the province. No undergraduate academic courses are available, and the focus of the Unit's students is at post-graduate level.

6.2.6.11. Other features

The university provides on-campus veterinary support to the Rivers of Life facility. Quarantine facilities and PPE are available for new animals being introduced into the system. The NSPCA conducts bi-annual inspections to ensure that animal health standards are being met.

Recommendations

The location of the University of Limpopo makes it an interesting option for developing vocational-level training. The university is located in relative proximity to two ATIs – Madzivhandila College of Agriculture and Tompi Seleka College of Agriculture. Both lack resources and would benefit from partnership with a university. The variety of systems present at the University of Limpopo would provide a good all-round opportunity for trainees to get practical hands-on experience. It could also be developed as an aquaculture demonstration facility for the province to spark investment interest in supporting local and community aquaculture projects.

The main constraint with the University of Limpopo's research programme is the current focus on catfish and Mozambique tilapia – species which have very low market value. It is recommended that the department explores new opportunities with greater market opportunities such as a freshwater prawn or marron crayfish.

Repairing the back-up generator is a priority, given the current unstable electricity supply. The facility is under-utilized at this stage, and there are some challenges in acquiring resources, particularly in terms of qualified staff.

6.2.7. University of Zululand

Table 14: University of Zululand Aquaculture infrastructure & facilities detailed description

The University of Zululand (UniZulu) is the only comprehensive tertiary educational institution north of the Tugela River in KwaZulu-Natal. Its new status is in accordance with South Africa's National Plan for Higher Education aimed at eradicating inequity and costly duplication. As a result, UniZulu offers career-focused programmes as well as a limited number of relevant university degree courses that have been structured with potential employees and employers in mind.

CRITERIA	AVAILABLE	COMMENT
Focus of programme		Freshwater - sharptooth catfish and Mozambique tilapia.
Type of structure		Concrete structure and glassfibre.
Water supply	YES	Municipal water supply to the farm.
Electricity	YES	Three phase electricity. Backup generator for the department building only. Generator needs to be repaired.
Water filtration	YES	A multiple bed gravel bed biofilter.
Feed storage	NO	Feed store non-functional. Feed stored inside main building on pallets.
Workshop	YES	
Life support systems	YES	Semi-intensive RAS.
Laboratory facilities	YES	Students have access to the General lab that can accommodate a variety of laboratory needs.
Flexibility in system setup	YES	System can be customised to suit research requirements.
Replicated tank set up	YES	Tank replicates can be set up to suit research requirements.
Administrative support	YES	Limited administrative support as it is a rural university.
IT Facilities	YES	IT support on campus.
Academic support	YES	Limited academic support.

6.2.7.1. Focus of programme

The University of Zululand has a freshwater aquaculture unit that focuses on research. The focus species include Mozambique tilapia and African sharptooth catfish. There is no undergraduate programme offered but the facility supports post-graduate research projects. The University has indicated that there is interest from local communities for the University to offer aquaculture training courses to local farmers.

6.2.7.2. Type of structure

The University has both outdoor pond facilities as well as a hatchery that is housed within a concrete and glass-fibre structure. The fish hatchery building is currently in a state of disrepair owing to students having broken the glass windows. As a result, windows are now made from plastic.



Figure 52: Outdoor raceway structures (left), outdoor production ponds and fibreglass tanks (middle) and the on-site fish hatchery building (right).

6.2.7.3. Water supply

The water supply for the facility is sourced from the municipal water supply.

6.2.7.4. Electricity

Electricity is supplied to the facility. However, there is no back-up generator available to the aquaculture research facility, only to the department building. The existing generator needs to be repaired; electricity is switched on intermittently.

6.2.7.5. Water filtration

Water that is recirculated through the pond systems is circulated through a multiple deep-gravel bed biofilter on the hill above the facility. A UV filtration system is available for the nursery system, but it is not clear to whether it is still functional.



Figure 53: Biofilter inlet (left), main biofiltration channel (middle) and wastewater channel (right)

6.2.7.6. Feed storage

The feed storage area is a 5 m x 5 m prefabricated building that is currently non-functional. As a result, feed is stored on pallets inside the main building. There are also functioning freezers and refrigerators.



Figure 54: Feed storage facility (left) that is temperature controlled with chillers (right)

6.2.7.7. Workshop

Workshop facilities are available as part of the Zoology Department and are in a functional state. Maintenance personnel are available to assist with technical issues.

6.2.7.8. Life-support system

The facility was designed and built many years ago and is designed to function as a semi-intensive recirculating system. The live-holding tanks include the following:

- 1 x rectangular production tank that measures 20 m long x 6m wide x 1.5 m deep.
- 1 x raceway that measures 12 m long x 1.5 m wide x 0.8 m deep.
- 3 x round concrete tanks that are each 3 m in diameter and 1.2 m deep.
- 5 x round glass-fibre tanks that 1.5 m in diameter and 0.8 m deep.
- 3 x white glass-fibre nursery tanks.
- 4 x upweller cylinders.
- 1 x 5000 litre rearing tank.

No oxygen or carbon dioxide is available for the life-support systems or laboratory facilities.



Figure 55: Outdoor production pond (left), upweller cylinders (middle), small indoor experimental tanks (right)



Figure 56: Outdoor round fibreglass tanks (left), outdoor round concrete tanks (middle) and outdoor raceway (right)

6.2.7.9. Laboratory facilities

Limited laboratory infrastructure and equipment is available on site. There are two main laboratory research areas: one of 10 m x 4 m, other 6 m x 4 m. There are also four non-functional temperature-controlled rooms that are 4 m x 4 m in size with UV filters for water treatment.

In terms of laboratory equipment, working scales, and Hanna and Hach Instruments for water quality analysis are available. Undergraduate students do practical work in the general laboratory.



Figure 57: Examples of laboratory facilities and equipment available

6.2.7.10. Administrative and academic support

Administrative support is available on campus in the form of administrative offices, printing facilities and photocopying. The IT facilities are available at the university's main campus in the form of computer access and internet availability.

Staff and student offices are available on site and the facility manager lives on site. There is also limited student accommodation on site for post-graduate students.

6.2.7.11. Other features

The University of Zululand has expressed an interest in facilitating short training courses for students and local communities for tilapia farming. The nearby Makathini Flats project is currently dysfunctional and there are no staff available to conduct training.

Recommendations

The infrastructure at the University of Zululand is underutilized and there is a lack of interest from staff and students due to limited funding for relevant research. The university staff have expressed little interest in continuing with aquaculture research. As with UKZN, the location of the university

makes it unsuitable for developing the infrastructure further or offering vocational training, unless the university partners with industry players such as the trout or ornamentals farms in KZN.

6.2.8. Walter Sisulu University

Table 15: Walter Sisulu University Aquaculture infrastructure & facilities detailed description

CRITERIA	AVAILABLE	COMMENT
Focus of programme		Freshwater (Mozambique tilapia) and newly renovated Marine facility.
Type of structure		Freshwater structure is small-scale and portable. Marine facility in a brick building.
Water supply	YES	Freshwater is from municipal supply. Seawater trucked in from Coffee Bay.
Electricity	YES	Single phase supply. There is a backup generator for the marine lab but not the freshwater lab.
Water filtration	YES	Coarse biofiltration - Koi mat and moving bed biofilter.
Feed storage	YES	Cold rooms available but not functional.
Workshop	YES	There are workshop facilities for the whole university.
Life support systems	YES	Intensive RAS for both freshwater and marine.
Laboratory facilities	YES	Fairly well equipped but needs renovation.
Flexibility in system setup	YES	Systems are fairly flexible.
Replicated tank set up	YES	Space is very limited for replication.
Administrative support	YES	Administration facilities are disorganised.
IT Facilities	YES	Wifi, data cards and laptops provided to students by university.
Academic support	YES	Currently two staff members, one of whom is due to retire at the end of this year.

Walter Sisulu University (WSU) is a university of technology and science located in Mthatha, East London (Buffalo City), Butterworth and Komani (Queenstown) in the Eastern Cape, South Africa. It came into existence on 1 July 2005 as a result of a merger between Border Technikon, Eastern Cape Technikon and the University of Transkei. As one of six comprehensive universities in South Africa, WSU is a developmental university, focusing on urban renewal and rural development by responding to the socio-economic needs of community, commerce and industry through science, technology and innovation.

6.2.8.1. Focus of programme

Aquaculture education is briefly covered within the Economic Biology module (Zoology 3rd year) and in Freshwater Biology at BSc Honours level. These two modules are presented within the Department of Biological and Environmental Sciences. The WSU has both marine and freshwater research facilities with a focus on dusky kob, bivalves and seaweeds within the marine research facilities, and Mozambique tilapia comprising freshwater research.

In January 2024, Walter Sisulu University, in collaboration with the Department of Science and Innovation (DSI) and the National Research Foundation-South African Institute for Aquatic Biodiversity (NRF-SAIAB) launched a Joint Marine Laboratory at WSU's Mthatha campus, aiming to address food insecurity and bolster marine science research in the institution.

6.2.8.2. Type of structure

All research activities take place within the department building. No separate tunnel, pond or greenhouse structures form part of the available infrastructure. A new marine research facility has recently been commissioned. However, the freshwater facility needs upgrading. Temperature control rooms are also available; however, they are currently non-functional.



Figure 58: New student laboratory facilities as part of the Marine Research Laboratory

6.2.8.3. Water supply

Seawater is sourced from Coffee Bay but is very expensive (approximately R90 000 per 20-ton water truckload from Coffee Bay). The use of artificial seawater is being considered. Freshwater supply is sourced from the municipal water supply that services the university.

6.2.8.4. Electricity

Electricity is available to the marine and freshwater research units, although the freshwater unit's electricity supply needs to be upgraded. The marine research facility has a back-up generator that is in working order and is maintained. However, there is no back-up electricity supply available to the freshwater research unit.



Figure 59: Back-up generator for the marine research facility (left) and the electrical panel with the automatic changeover switch (right)

6.2.8.5. Water filtration

The marine research facility has coarse filtration in the form of a 3 m³ tank with a moving bed biofiltration system and a koi mat. Sand filtration systems are also available, which provide both coarse and medium filtration. If required, UV sterilization is available. Coarse filtration is also provided in the freshwater research facility.



Figure 60: Filtration systems, including sand filtration (top left), tickle biological filter (top middle), UV sterilization unit (top right), biomedica in the biological filter (bottom right), and more biological filter and biomedica (bottom)

6.2.8.6. Feed Storage

Temperature-controlled feed storage facilities are available for both the marine and freshwater research facilities. A chest freezer and refrigerator are also available.



Figure 61: Temperature-controlled feed store (left) and chest freezer (right)

6.2.8.7. Workshop

A centralized workshop facility for the university as a whole is available, with trained technicians. There is also a workshop available in the marine biology laboratory, while the freshwater workshop needs to be expanded and renovated.

6.2.8.8. Life-support system

The new marine research facility is designed to support an intensive recirculating system. However, the system can be modified to a static or flow-through system. The marine research facility comprises 14 experimental fibreglass tanks with viewing windows that range in size from 300 litres – 500 litres. The system includes pump controllers, UV sterilization, aeration infrastructure and supply, overhead electrical supply and floor drains. The facility also has four black, circular nursery tanks that are approximately 2500 litres each.



Figure 62: New systems installed as part of the marine research facility with fibreglass tanks (top row), pump controllers and monitoring sensors (bottom left) and round PVC-lined tanks (bottom right)

Within the freshwater research facility, the system is designed to support an intensive recirculating system. There are many small independent glass tanks for experimental purposes, as well as three circular portable tanks. The portable circular tanks are 3 m³ in volume and are used to study freshwater ecology. Water heaters are available to manage water temperature in the tanks.



Figure 63: Portable tanks for the freshwater research facility (left and middle) and small glass experimental tanks (right)

6.2.8.9. **Laboratory facilities**

Laboratory facilities are shared between the marine and freshwater research facilities, and some sections of the laboratory facilities have recently been upgraded. However, the original laboratory facilities for the freshwater research facility require upgrading. The existing laboratory facilities include histological preparation facilities, water quality monitoring apparatus and reagents, cell and microbiological culture facilities, algae culture facilities, and cryogenic storage facilities. Environmental control rooms are also available where experiments can be undertaken under controlled environmental conditions.



Figure 64: Examples of laboratory facilities and equipment available to students



Figure 65: More examples of laboratory facilities as well as a temperature-control room and dissection microscope (bottom right)

6.2.8.10. Administrative and academic support

Administrative support is available to the aquaculture research facility; however, the centralized administrative support systems are disorganized. Revenue generated from publications produced by the aquaculture research programme goes back into the research account.

Staff and student office facilities are available with IT support provided in terms of access to computers, internet, printing facilities, scanning and photocopying facilities. On campus, student accommodation facilities are very limited and are subject to bursary allocation. Students who were not able to obtain bursaries for student accommodation have been permitted to stay on campus where they sleep and cook in the laboratories.



Figure 66: One of the staff offices on campus

In terms of academic support, two staff members are available for aquaculture research and training support. However, one staff member retired at the end of 2023. Formal agreements between other research institutions are in place but, owing to the distance from these institutions, logistics become complicated and difficult to organize. Support for the marine research facility primarily comes from WSU main campus, SAIAB and other academic institutions. There is very limited academic and institutional support for freshwater research.

6.2.8.11. Other features

Since 2023, WSU has been partnering with the Tsolo Agriculture and Rural Development Institute (TARDT) to train the local community in aquaculture and agricultural practices. They have identified communities that require support and training. The WSU has also partnered with the Agricultural Research Council (ARC) and Stellenbosch University, where they send samples for analysis. WSU intends to collaborate further with the ARC with a focus on freshwater aquaculture.

The WSU has expressed an interest in further developing aquaculture research in the province. The research focus area in freshwater aquaculture was initiated in 2023, specifically with the aim of achieving Sustainable Development Goals 1 to 4 (UN Sustainable Development Goals 2030), and as a result, the need to develop research infrastructure has been identified in order to take a step towards achieving these goals.



Figure 67: The UN Sustainable Development Goals that WSU aims to achieve through its aquaculture research programme

Recommendations

Despite the recent upgrades to the facilities, WSU experiences low levels of student interest in aquaculture. The university is well equipped and has a vibrant and enthusiastic staff complement. It is suggested that WSU considers focusing exclusively on freshwater aquaculture training and research at their Mthatha campus, due to the high costs of transporting seawater from Coffee Bay. The University is also in the process of upgrading their Marine Research Facility located in the Dwesa Nature Reserve, which would be more suitable for marine research and where there may be an opportunity to conduct research on cultivating seaweeds that are endemic to the Eastern Cape coastline.

It is recommended that WSU considers actively marketing at career days and at high schools, to promote aquaculture as a career path and to achieve higher student enrolment.

6.2.9. University of Mpumalanga

Table 16: University of Mpumalanga Aquaculture infrastructure & facilities detailed description

CRITERIA	AVAILABLE	COMMENT
Focus of programme		Freshwater - Yellowfish, Redbreast Tilapia, Mozambique Tilapia, Catfish and Marron.
Type of structure		Steel superstructure with a flat concrete floor.
Water supply	YES	Water sourced from Nels canal.
Electricity	YES	Backup generator available.
Water filtration	YES	The proposed facility at ARC will have filtration systems installed for each species. Coarse and UV filtration capabilities.
Feed storage	YES	Not in operation yet.
Workshop	NO	
Life support systems	YES	Intensive RAS.
Laboratory facilities	YES	Well-equipped existing laboratory facilities.
Flexibility in system setup	YES	System set up is flexible to suit the project requirements.
Replicated tank set up	YES	
Administrative support	YES	Large offices and laboratories on campus.
IT Facilities	YES	Have their own person for IT support for the Rivers of Life Programme.
Academic support	YES	Four staff are allocated for academic support to students.

The University of Mpumalanga is based in Mbombela and in Siyabuswa. It was established in 2014, incorporating the infrastructure of three existing institutions: the Lowveld College of Agriculture, the hospitality school at KaNyamazane, and the Siyabuswa Education Campus. It currently offers Bachelor of Education and Bachelor of Agriculture degrees, as well as a Diploma in Hospitality Management.

Aquaculture education and research is presented in a dedicated BSc Hons in Ecology Module – Fish and Fisheries Management, which includes content on aquaculture production and wild fisheries management. This module is facilitated through the School of Biology and Environmental Sciences within the Faculty of Agriculture and Natural Science.

6.2.9.1. Focus of programme

Aquaculture research at the University of Mpumalanga focuses on the production of freshwater species, particularly yellowfish, redbreast tilapia, Mozambique tilapia, African sharp tooth catfish and *Cherax quadricarinatus*. The University has the 'Rivers of Life' programme that aims to undertake comparative growth trials of tilapia in the four main river systems in the province. The programme aims to undertake research to enable the facility to produce fish at a commercial scale where studies will be undertaken to push fish density and growth rates.

6.2.9.2. Type of structure

The University has access to a steel superstructure with a flat concrete floor, which is located on ARC land. The construction of the UMP Rivers of Life Water Resource (Aquaculture) and Fisheries facility is currently under way.



Figure 68: Construction of the new UMP Rivers of Life Water Resource and Fisheries facility

Cage farming facilities are available in the University dam. The University has access to the Department of Agriculture, Rural Development, Land and Environmental Affairs (DARDLEA) facility, which includes a well-structured and maintained tunnel structure.



Figure 69: Cage farming activities in the University's dam.

6.2.9.3. Water supply

Fresh water is supplied to the facility by abstracting water from the Nels River Canal. Water from the University's dams is also available for aquaculture purposes.

6.2.9.4. Electricity

Electricity is available at the facility. Back-up generators are available for the UMP - Rivers of Life Water Resource (Aquaculture) and Fisheries Facility which is under construction but are not currently used during loadshedding. There is a processing facility that also has a back-up generator, but it is also currently not being used during loadshedding.



Figure 70: Back-up generator

Back-up generator power is also available for the abstraction pumps that fill the University's dam from the Nels River Canal.

6.2.9.5. Water filtration

There is currently no incoming water filtration installed, but filtration systems have been planned for the new Rivers of Life Water Resource and Fisheries Facility. It is proposed that separate filtration systems will be installed for each species strain.

6.2.9.6. Feed storage

A feed storage facility has been developed; however, it is not currently operational. It will become operational when the Rivers of Life Water Resources and Fisheries Facility is commissioned.

6.2.9.7. Workshop

No workshop facilities are available for the aquaculture research project. A general workshop facility is located on the main campus that services the entire university.

6.2.9.8. Life-support system

The University's dam is used for extensive cage culture purposes. The dam is used for training, which includes training in farming protocols, swimming training, how to operate a boat, et cetera. The dam is also used for practical purposes for students where fish collecting and sampling techniques are taught. Two larger fish cages are located in the dam and measure 8 m x 8 m x 1.8 m deep. Two smaller fish cages that measure 1.5 m x 1.5 m x 1 m deep are also present.



Figure 71: University's dam used for skills development and training

The UMP – Rivers of Life Water Resource (Aquaculture) and Fisheries Facility is currently being constructed on land owned by the Agricultural Research Council (ARC). Two million rand has been allocated to rebuild the old ARC storeroom. The ARC has funded the fixed assets, and the University has funded the movable assets. Fifteen student offices will move to ARC and the facility will be used to produce clean genetic strains of various indigenous species.

Incoming water will come from the Nels Canal. Wastewater from the systems will flow out onto the irrigation field. Plans are in place for the development of a processing laboratory, wet lab for strip-spawning, temperature-control room, and a hatchery with glass tanks for all species. Movable equipment is already in storage and ready for installation like the glass tanks.

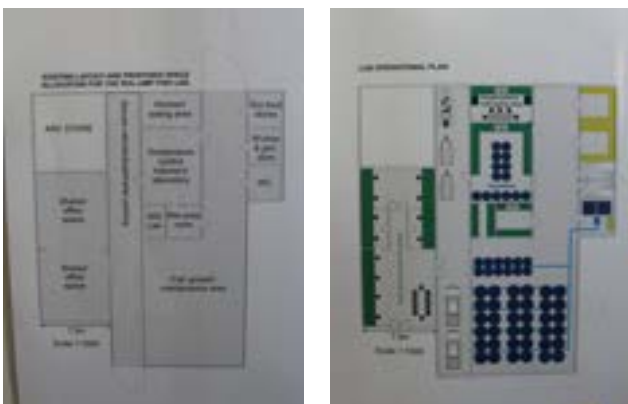


Figure 72: Layout plan for the new Rivers of Life Water Resource and Fisheries Facility



Figure 73: Facilities under construction for the new facility

There is also a mesocosm facility located at the ARC site. Experiments conducted here are on plants, invertebrates, tilapia, cherax and eels in different tanks. Every sump has a different substrate.



Figure 74: Mesocosm facility

The DARDLEA Aquaculture facility is one of six in the province and the University has secure access to this facility for a period of two years. The facility consists of a tunnel structure that supports an intensive recirculating aquaculture system. Heat pumps, filtration systems, including a drum filter, sand filters and a biological filter, and a cold room are part of the facility.

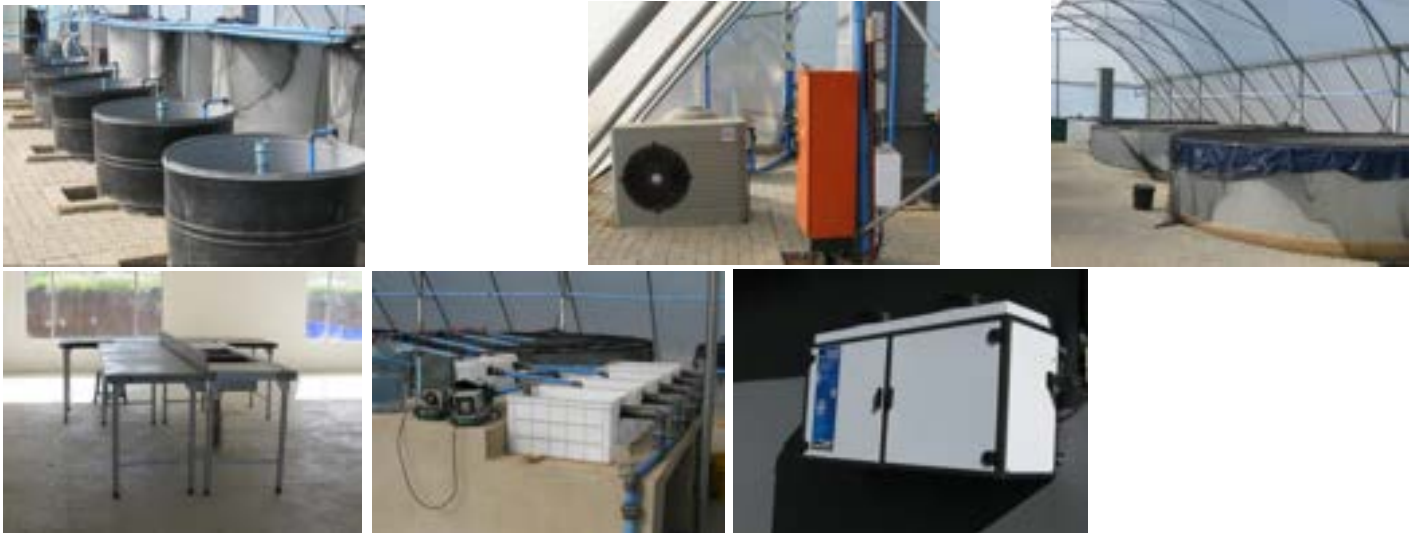


Figure 75: Available infrastructure at the DARDLEA Aquaculture Facility: Individual filtration systems on each tank, heat pumps, production tanks (top), stainless steel processing tables, cascading filtration system and a chiller (bottom)



Figure 76: DARDLEA infrastructure processing facility



Figure 77: DARDLEA facility experimental tanks and UV sterilisation system

An aquaponics greenhouse is also available that is 50 m x 30 m in size. Twenty-four grow-beds are available as part of the aquaponics facility.



Figure 78: Aquaponics facility with grow beds (left) and grow bed containers (centre and right)

6.2.9.9. Laboratory facilities

Well-equipped, shared laboratory facilities are available on campus. Laboratory facilities allow for water quality analysis, cell and microbiological culture, genetic studies, histological studies and biochemical assays, such as spectrophotometry.





Figure 79: Laboratory facilities and available equipment



Figure 80: Examples of some of the available laboratory equipment

6.2.9.10. Administrative and academic support

Well-appointed administration facilities are available with large staff and student offices. Student support facilities are also available on campus, including IT support and residences.



Figure 81: UMPs small dam and aesthetic water feature

In terms of academic support, four staff members are available to provide aquaculture support to students. However, collaboration opportunities between other institutions are growing and the need to retain technical and specialist staff is becoming more apparent.

6.2.9.11. Other features

The University wishes to work with DARDLEA with the primary focus being able to support the development of aquaculture in the province by providing skills and knowledge on broodstock holding requirements; how to grow fish successfully, and to provide the province with genetically superior tilapia. The University also aims to establish linkages between aquaculture and fisheries and indigenous species such as Mozambique and Redbreast tilapia, catfish and yellowfish.

There seems to be a concentrated focus on improving livelihoods in the province through sourcing funding and injecting money into communities. The intention is to use the University's dam for training, particularly for yellowfish gill netting and fyke net sampling trials under various scenarios.

Recommendations

The University of Mpumalanga has focused primarily on Fisheries research. The University is well resourced and capacitated in terms of infrastructure, staff and students. It is recommended that the University explores local aquaculture opportunities such as marron crayfish, in order to allow for a stronger focus on aquaculture development.

6.2.10. Madzivhandila College of Agriculture

Table 17: Madzivhandila College Aquaculture infrastructure & facilities detailed description

CRITERIA	AVAILABLE	COMMENT
Focus of programme		Freshwater - Mozambique tilapia.
Type of structure		Shade cloth cover over a compacted floor.
Water supply	YES	Municipal water supply or water from the Nandoni dam.
Electricity	YES	Backup generator is non-functional.
Water filtration	YES	Course filtration. Tanks are stand alone and not connected to filter systems.
Feed storage	YES	Feed stored in the general store.
Workshop	YES	Workshops also used for training diploma students.
Life support systems	YES	Intensive RAS.
Laboratory facilities	YES	Limited laboratories facilities available. Access to the soil science laboratory can be facilitated.
Flexibility in system setup	NO	Systems are designed as standalone systems.
Replicated tank set up	YES	16 tanks have been installed.
Administrative support	YES	Facilities are inadequate and not in a functional state.
IT Facilities	NO	
Academic support	YES	Only 1 person available on campus and aquaculture coordinators available at a municipal level.

Madzivhandila College of Agriculture was established in 1982 as an affiliated institution of the Department of Agriculture and Forestry of the then Venda government. The College is situated 15 km east of Thohoyandou (next to Nandoni Dam) in the Vhembe District and focuses on agricultural education and training. The main purpose of establishing the College was to train agricultural extension workers for the Department of Agriculture.

In 2005 the colleges shifted from Higher Education to Skills Development as directed by the provincial Department of Agriculture. The shift meant the College started offering short courses and learnership programmes in animal and plant production and conducting participatory research. The main clients now include the surrounding farming community and extension officers.

A semester course in aquaculture is offered by the Department of Animal Production.



Figure 82: Security entrance (left) and main administration building (right)

Focus of programme

The focus of the aquaculture course is centred around the culture of freshwater Mozambique tilapia.



Figure 83: Mozambique tilapia (*Oreochromis mossambicus*)

Type of structure

There are 16 x 2500 litre tanks installed in total at the facility. These tanks consist of a combination of 10 000 litre rainwater tanks that have been cut in half, and a number of other 'Aquadam'-type fish-holding tanks.

The tanks are positioned on a raised, compacted-earth platform with an 85% shade cloth roof structure. At the time of the site visit, three of the 16 holding tanks contained fish. The species was Mozambique tilapia which had been sourced from the local natural watercourses and bred naturally in the holding tanks. They are fed with 3 mm and 5 mm tilapia pellets.

The holding tanks are free-standing with no connected filtration systems or electrical power supply.



Figure 84: Fish holding tanks

Water supply

The water supply to the facility is primarily from the municipal water supply system, but alternatively, water can be sourced directly from the Nandoni Dam.

Electricity

There is no electrical supply to the existing fish tanks or live-holding systems from the electrical supply point. The back-up electrical generator does not work, which is a problem during loadshedding.

Water filtration

There is no water filtration attached to the live-holding systems. The water filtration systems are no longer operational.



Figure 85: Simple water filtration system that is no longer functional

Feed storage

Feed is stored outside for short periods but is held along with other livestock feeds in a general feed storage facility for long-term storage.



Figure 86: Feed and staff shelter

Workshop

Technical workshop facilities are available as part of the general workshop facilities at the College.

Life-support system

There is no life-support systems attached to the existing fish tanks. It is clear that there used to be life-support systems, but these are broken and no longer functioning.

Laboratory facilities

Laboratory facilities are available to the aquaculture operation, but the laboratory is not well provisioned and has limited operating capacity. The laboratory equipment and capacity focus mostly on servicing the agricultural needs of local farmers in the form of animal production and soil sciences, rather than aquaculture.





Figure 87: Laboratory facilities available at the College

Administrative and academic support

Administrative support is in place, but procurement processes tend to be lengthy and affected by systemic corruption. Most of what is delivered as part of the procurement system is not fit for purpose. The facility is well supported academically and for training purposes; staff and student accommodation is available on-site with sufficient staff and student offices and lecture facilities.



Figure 88: Student residence

Other features

The facility is very willing to collaborate with other institutions in order to use its facilities more effectively. Student practical training is done at Dzindi Nature Reserve (government facility) and the University of Limpopo (Turfloop Campus). While the funding from the Limpopo Department of Agriculture for the facility is not adequate, there is potential funding that can be received from AgriSETA.

Recommendations

Madzivhandila will need significant investment to make the facility operational and fit for purpose. It is recommended that MATI partners with universities such as the University of Mpumalanga, as well as industry partners, to share facilities. Although the students are well funded, the limited and derelict facilities do not allow for appropriate training. It is recommended that budget allocations are reconsidered to ensure that sufficient funds are allocated to upgrading and maintaining facilities to enable meaningful training and research activities.

Mpumalanga Province has limited aquaculture activities, with the industry comprising a few trout farms and tilapia farms. It may be possible for the universities and MATI to collaborate in exploring new opportunities such as freshwater eel and marron crayfish in the province.

6.2.11. Tompi Seleka College of Agriculture

Table 18: Tompi Seleka College Aquaculture infrastructure & facilities detailed description

CRITERIA	AVAILABLE	COMMENT
Focus of programme		Freshwater - carp, catfish and Mozambique tilapia.
Type of structure		Buildings and Ponds.
Water supply	YES	Freshwater supplied from Lola Montes Dam via a canal.
Electricity	NO	Electricity supply to buildings on campus but not to unused aquaculture facilities.
Water filtration	NO	Water does need to be treated.
Feed storage	YES	An old garage is used to store feed.
Workshop	YES	A basic workshop.
Life support systems	YES	Extensive flow through.
Laboratory facilities	YES	Some laboratory facilities are present but needs major upgrade.
Flexibility in system setup	NO	Ponds are designed to be flow through systems.
Replicated tank set up	NO	
Administrative support	YES	Administration facilities in a poor state.
IT Facilities	YES	
Academic support	YES	Hesitant to provide practical support as they cannot swim.

Tompi Seleka College of Agriculture (TSCA) is situated about 35 km northeast of Marble Hall and 75 km south of Lebowakgomo along the Oliphants River next to Boshielo Dam (Phetwane Village), Limpopo Province. The facility opened for training in 1960 and has grown and developed considerably since then. There are a total of nine lecture rooms and a new office complex with modern laboratories and research facilities. The college farm is 1,470 hectares in extent.

At the beginning of 2000, the College began offering diploma courses in plant and animal production, and hospitality. Tailor-made short courses in agriculture are also now offered in swine, poultry and vegetable production as well as aquaculture.



Figure 89: Tombi Seleka College of Agriculture, Fishery Department

Focus of programme

The facility offers a three-year Diploma in Agriculture in Animal Production (which includes a six-month aquaculture module). At the moment, 16 students have elected to complete the aquaculture module (a third-year elective module). The six-month aquaculture module includes field trips and fish harvesting practices.

The academic coursework is completed at the College, but practical training of three to four days is spent at the Gariep Aquaculture Technology and Demonstration Centre. Aquaculture development at the facility focuses on the production of sharp tooth catfish and Mozambique tilapia.

Type of structure

The facility consists of a broodstock holding and spawning building with a small hatchery, technical and administrative support buildings and a number of fishponds built to support production.

In the hatchery building there are five 150-litre glass broodstock tanks, eight egg incubation upwelling tubes, concrete working surfaces, and one 1000-litre fish transport tank. The building also holds small workboats for working in the ponds.

A number of fish production ponds were renovated in 2018. There are 15 ponds at the facility in total: three nursery ponds (35 m x 10 m x 1 m) and 12 grow-out ponds, each between 2000 and 4000 m². There is one round concrete tank in the field for holding broodstock.

The construction company that renovated a few of the ponds in 2018 damaged the pond monk tanks and underground water supply pipework. Now only two ponds contain fish and only a total of six ponds are operational. The pond walls are not wide enough to drive a vehicle on, so access is difficult.

Mozambique tilapia breed naturally in the ponds and catfish juveniles enter the ponds from the unscreened canal water supply system. The catfish are predatory, so they prey upon all other species in the pond. The ponds have a sandy bottom, so they continuously lose water and drain down if they are not filled regularly. The ponds need to be lined with a plastic liner or with a clay earth to prevent water loss.



Figure 90: Hatchery building (left), on-site dam for cage farms trials (middle), integrated aquaculture system with chickens and fish (right)



Figure 91: Glass experimental tanks (left), waders (middle) and fishing equipment (right)

Water supply

Incoming water is supplied via a canal from Lola Montes Dam. This water irrigates crops at the facility and then overflows into the fishpond main canal system. The water can be directed into any of the ponds via the canal system.

Each pond has a single monk tank for drainage. Drainage water from one pond can back-flow into another pond if it is not managed carefully. The water distribution pipework at the facility is blocked and leaking in places due to pond renovations that were conducted in 2018.

The water supply to the hatchery is not filtered; it is pumped from one of the ponds to a header tank and then into the hatchery.



Figure 92: Open channels through which incoming water flows towards the ponds (left) and the junction between the ponds and the hatchery's water supply

Electricity

The electricity supply to the farm is intermittent and affected by loadshedding. There is no back-up electrical supply to the fish production facilities. Only the lecture rooms and laboratories have access to back-up electricity.



Figure 93: The state of the electrical boards at the aquaculture facility

Water filtration

The incoming water to the facility is not screened or filtered in any way.

Feed storage

The feed store is in relatively good condition. The feed is kept dry, but it had passed its expiry date.



Figure 94: The feed store (left) with feed bags currently in storage (right)

Workshop

There is a basic workshop staffed by 'handymen' and a workshop storeroom which still has old pond management equipment in it.

Life-support system

The life-support systems in the fish hatchery are no longer operational.



Figure 95: Non-functional life-support systems (left) and the scaffolding structure that once held a water reservoir (right)

Laboratory facilities

Laboratories are available upstairs in the administrative building but with a focus on computer (IT) and soil science in support of the local agriculture industry. The facility previously had equipment to test water quality, but it no longer works. Laboratory equipment presently includes a fume cupboard, drying oven, bench-top pH meters, electrical conductivity, shaker, spectrophotometer, water purifier / de-ionizer, dosing pump for titrations, et cetera, which are used to support small-scale farmers in the area.



Figure 96: Basic laboratory infrastructure and equipment



Figure 97: Laboratory equipment available to researchers

Administrative and academic support

There is one skilled staff member, two technicians and one farm aide dedicated to the aquaculture facility. Farm ablutions are outside the offices and there is office space for a laboratory and a chemical store. Most administrative activities are conducted at the main administrative office at the facility.



Figure 98: Aquaculture operations office building

Other features

The educators of the aquaculture module are unable to swim so they are hesitant to do any work with students in the ponds. They also do not have 'waders' to be able to work in the ponds.

Funding is provided for students, who are generally 100% fully funded (meals, accommodation and tuition) from the National Student Financial Aid Scheme (NSFAS) Agri-SETA, the Department of Agriculture, Land Reform and Rural Development (DALRRD) and the Limpopo Department of Agriculture and Rural Development (LDARD). There is a partially completed fish-processing facility on site. Construction was not completed owing to lack of funds.



Figure 99: Partially completed fish-processing facility

Recommendations

The facilities at TSCA require significant upgrade to be a fully functional aquaculture training facility. Similar to MATI, Tompi Seleka students are well funded but there is insufficient allocation of budget towards maintaining the infrastructure. Much of the infrastructure is under-utilized due to lack of demand.

It is recommended that swimming and water safety is introduced as part of the introduction to aquaculture module. This will enable better utilization of practical training options in ponds.

Collaboration with Universities, such as the University of Limpopo would be beneficial in revitalizing TSCA.

6.2.12. Tsolo Agriculture and Rural Development Institute (TARDI)

Table 19: TARDI Aquaculture infrastructure & facilities detailed description

CRITERIA	AVAILABLE	COMMENT
Focus of programme		Freshwater - catfish and Mozambique tilapia.
Type of structure		An old chapel that can be used as a hatchery and irrigation tunnels.
Water supply	YES	River water and borehole water is abstracted, screened and transferred to a collection pond.
Electricity	YES	Backup generator present and working.
Water filtration	NO	Screening only.
Feed storage	YES	Not temperature controlled.
Workshop	YES	Facilities functional.
Life support systems	YES	Extensive flow through systems.
Laboratory facilities	YES	Veterinary laboratory available and agricultural testing equipment available.
Flexibility in system setup	NO	Ponds are designed to be flowthrough systems.
Replicated tank set up	NO	
Administrative support	YES	
IT Facilities	NO	IT support not at college but provided through the DRDAR.
Academic support	YES	One person available to provide academic support to aquaculture research.

The Tsolo Agriculture and Rural Development Institute (TARDI) (previously the Tsolo College of Agriculture) is situated in the Mhlontlo Local Municipality, a rural municipality with a population of about a 194 000 people that falls inside the OR Tambo District Municipality. The TARDI is located just outside of the town of Tsolo, about 50 km north of Mthatha, in the Eastern Cape.



Figure 100: Main entrance buildings

Focus of programme

While TARDI does not offer dedicated training courses and qualifications in aquaculture, an aquaculture module is offered at the facility in the first year of academics where it is combined with wildlife training. A fish health module is combined with animal diseases in the second year of academics, which forms part of a diploma in the three-year animal health course. The last six months of the third year includes a standalone aquaculture module.

Type of structure

Apart from a few fish production ponds, there is no dedicated operational aquaculture infrastructure at the facility. There are 11 fish culture ponds in total, but they are not operational and are inaccessible in wet weather. There are plans to use an old chapel building and convert it into a fish hatchery to hold broodstock, fish fry and fingerlings. Adjacent to the chapel, there is space to install a RAS aquaponics system.

There is the potential to use the existing training building as a slaughter, chill and processing facility.



Figure 101: The TARDI dam and collection ponds (top left), the old chapel that is earmarked to be a new hatchery (top right), training building to be used as future processing unit (bottom)

Water supply

Incoming water is supplied from the river and is screened for alien species before it enters the primary water collection pond. From there it needs to be pumped into the fish culture ponds.

There is no water supply to the ponds in dry periods when the river is not running, so a borehole would need to be installed to provide a consistent supply of water to the facility.

Effluent water from the facility flows through a series of water treatment dams before it is screened in a collection pond and flows back into the river.

Electricity

Electricity to the facility is supplied by Eskom, and it is affected by loadshedding. Back-up electricity from a generator supplies the whole facility, but it is expensive to operate.

Water filtration

Incoming water to the ponds is screened. There is no further water filtration.

Feed storage

There is no dedicated aquaculture feed storage area at the facility, but feed can be stored in the general feed store. No feed manufacture is conducted, despite having manufacturing equipment available on site.

Workshop

General technical workshop facilities are available on site. The workshop is functional and caters for the maintenance and other general technical requirements of the facility.

Life-support system

There are no life-support systems on site.

Laboratory facilities

Laboratory facilities are available for agricultural testing only. A fully operational veterinary research laboratory could also be made available for testing.



Figure 102: Basic laboratory equipment available to researchers

Administrative and academic support

Administrative and academic support at the facility is good. There is accommodation for workers, lecturers and students at the facility for farmer training. Students are funded and supported by DRDAR, Agri-SETA, HW Seta (@ R100k/annum). There is no IT support at the College, but departmental IT support is available.



Figure 103: Domestic animal veterinary clinic and laboratories (left) and students working with the veterinarian

Other features

Senior staff at the facility are interested in the veterinary sciences and animal health and research aspect of aquaculture. There is a fully equipped government veterinary clinic located at the facility.

TARDI would like to target Mozambique tilapia and catfish; however, the research team noted that there will be problem with temperature control in winter, as ambient water temperatures drop to 4 °C in winter. As a result, fish would take up to 4.5 years to get to market size because the water temperatures in the area are so low.

TARDI has signed many collaborative MoUs with other institutions, including the University of Fort Hare, University of Cape Town, Walter Sisulu University, University of Pretoria, the University of Illinois (USA) and institutions in Germany. TARDI assists local communities as much as possible, in partnership with Walter Sisulu University.

Recommendations

The TARDI facility is functioning optimally as a veterinary clinic. There are environmental constraints to operating an aquaculture training facility at this location. It is not recommended that this ATI pursues developing an aquaculture training facility. It would be a more optimal use of resources and equipment if TARDI and WSU collaborated to provide practical training to enrolled students.

6.2.13. Aquaculture Technology Demonstration Centre (ATDC), Gariep

Table 20: ATDC Aquaculture infrastructure & facilities detailed description

CRITERIA	AVAILABLE	COMMENT
Focus of programme		Freshwater - common carp, sharptooth catfish, yellowfish and goldfish.
Type of structure		RAS in a building, covered ponds for the nursery, open production ponds.
Water supply	YES	Water supplied from Gariep dam via a pipeline to the incoming supply holding dam.
Electricity	YES	Backup generators are available and functional.
Water filtration	YES	Full RAS filtration setup. Sand filters and UV filters can be used to treat dam water.
Feed storage	YES	Three feed store rooms.
Workshop	YES	Well-equipped workshop and team.
Life support systems	YES	Intensive nursery, extensive grow-out. RAS, pond culture and flow through.
Laboratory facilities	YES	Well-equipped genetic laboratory, feed laboratory, parasitology laboratory and general laboratory.
Flexibility in system setup	YES	Land based systems can be modified to suit research requirements.
Replicated tank set up	YES	
Administrative support	YES	Well-equipped and maintained.
IT Facilities	YES	IT Support is sub-contracted out. Wireless Internet is very slow and unreliable. Use the data network and get partial support with a data contract.
Academic support	YES	Nine officials are available to assess research and academic activities.

The Aquaculture Technology Demonstration Centre (ATDC) at Gariep offers training and demonstration for a variety of freshwater fish species, including sharp tooth catfish, common carp and goldfish. Established over 30 years ago as a fish hatchery, it is located in the Xhariep District, just below the Gariep Dam along the Orange River System, from which it receives its water supply.

The ATDC is a collaborative initiative between the Department of Forestry, Fisheries and Environment (DFFE) and the Free State Department of Agriculture and Rural Development. It was established to unlock opportunities in the freshwater aquaculture sector, both regionally and nationally. The Centre plays a key role in contributing towards the sustainable development of the aquaculture and fishery sectors. It provides technical support and capacity development in the form of training. The services provided at the Centre benefit countries of the Southern African Developing Communities (SADC) through training and capacity development. The upgrading of the facility in 2017 was funded by the Chinese Government.



Figure 104: Satellite image of the Gariep Aquaculture Technology Demonstration Centre

Focus of programme

The facility offers different types of training courses, including a five-day course for aspiring aquaculture farmers, government officials and graduates. It also offers three-to-four-month in-service training for students studying animal production, and a two-year internship programme for graduate students. The ATDC currently offers non-accredited training courses which are in the process of being accredited. It also conducts aquaculture lectures at Glen Agricultural College.

The facility currently provides for the following training modules:

- Fish biology and introduction of fish species
- Fish breeding and fry rearing (catfish and common carp)
- Fish diseases and animal health
- Water quality management
- Aquaculture economics
- Fish industry legislative environment
- Fish Agro-processing
- Basic fish feeding and nutrition (under development)
- Aquaculture equipment
- Biosecurity and record keeping
- Fish stock management
- Fish transport
- Aquaculture farming systems
- Aquatic food safety

Some of the officials at the facility are registered as students at other universities, so collaborative research is being conducted between these universities and the ATDC.

SAIMI funded an aquaculture training course for aspiring farmers held in September 2023. They are also planning to fund trainers for aquaculture facilitator, assessor and moderator courses.



Figure 105: The main building the houses administrative officers, lecture rooms (right) and laboratories

Type of structure

There are a number of different farming systems present at the ATDC; these include:

- A Fish Cage Farm which comprises eight experimental fish cages of 1x1 m and four cages of 4 m x 4 m x 2 m deep. The cages are situated in the main incoming water reservoir dam that is fed from the Gariep Dam wall water supply.
- The Pond Farm incorporates a total of 34 ponds approximately 40 m x 25 m x 1,5 m deep. Eight of these ponds are operational, 26 are non-functional.
- The hatchery and nursery room was originally built in 2013 but was upgraded between 2018 and 2020 with the installation of a RAS system with Chinese financial support and the Free State Agriculture Department. The hatchery is a single, small RAS system and there are three independent RAS systems in the nursery; each has 28 tanks and its own in-line water quality monitoring system. The nursery has two catfish systems and one carp production system.
- The nursery ponds are outside, but they are covered by netting / shade cloth and protected from predators. The ponds are seeded with rotifers and algae cultures which are inoculated into the ponds, after which carp fry is introduced.
- There is a small Bumina-type aquaponics system operating at the facility. This is where fruit plants are grown in buckets and fish farmed in the aquaponics tanks. These systems have been built with a protective cage to prevent monkeys raiding the fruit gardens.
- The old hatchery building is due to be renovated when funding is available for a multispecies hatchery (carp, tilapia and yellowfish).
- There are a number of feeds, chemical and equipment stores on the premises.
- There is a fish feed manufacturing area which includes a kitchen and accommodation for staff and trainees. The feed manufacturing equipment was sponsored by the Chinese.



Figure 106: Nursery raceways (top left), one of the production ponds (top right), covered outdoor nursery ponds (middle left), nursery room (middle right), indoor nursery tanks (bottom left) and the aquaponics building (bottom right)

Water supply

The facility is supplied with freshwater via a pipeline from the Gariep Dam into the facility's main water supply dam. The water supply is not affected by water levels in the Gariep Dam itself. The freshwater supply canal coming out of the facility dam feeds into the pond farm and nursery buildings. An alternative water source is available from the municipal supply to the facility.



Figure 107: Incoming water filtration room (top left), main incoming water canal (top right), incoming water canal junction (bottom left) and the incoming reservoir to the fish cages (bottom right)

Electricity

The ATDC has a back-up electricity generator for the administrative office and a second generator for the farm. Both are used during power cuts and loadshedding events. Electricity supply to the pond farm is possible, but the infrastructure needs to be renovated as the electrical cables have been stolen.



Figure 108: The generator for the administration block (left) and the generator for the farm (right)

Water filtration

There is an option to treat the water coming from the main supply dam through two sand filters and one UV filter. The water that circulates through the nursery and hatchery is filtered through drum filters, sand filters and is UV sterilized.



Figure 109: Filtration systems and pumps (top left), the drum filter (top middle), UV sterilisation banks (top right and bottom)

Feed storage

The ATDC has three fish feed storage facilities. Feed is supplied by Specialised Aquatic Feeds, AVI Products and Wild Feeds.



Figure 110: Feed storage facilities with feed currently being stored.

Workshop

The facility has a workshop on site with necessary tools and equipment. Equipment includes a drill, cutter, grinder and staff lockers.



Figure 111: Well-equipped workshop

Life-support system

The ATDC operates different farming systems that include cages, ponds, RAS and aquaponics. Most of the systems are in a good state; however, the ponds would benefit from some renovation. The RAS has independent life-support systems.

Pond water temperature drops to 4 °C in winter where the pond edges become frozen. The main dam water temperature drops down to about 8 °C in the coldest period of winter. Overflow water from the ponds goes back into the main channel. There are only catfish being held on the farm at the moment, but they suffer and die in winter. Only carp can survive the winter.

Otters are a problem in the production ponds where they feed on the fish, and they are difficult to control. Herons and other bird species have been observed feeding on the fish as well.

Staff are at the facility 24/7 in order to monitor operations. There are 24 operational staff at the facility.



Figure 112: Water and air reticulation (top left), RAS pipework canal (top right), heat pumps (bottom left) and main electrical panel (bottom right)

Laboratory facilities

The facility has three laboratories (fish nutrition, molecular and fish diseases) that are used for training and research.

The feed (fish nutrition) laboratory is well provided for with gas chromatography equipment, a monospectrophotometer, incubators, and a small experimental feed extruder with a drying oven to determine feed digestibility and fat content. Additional equipment includes an autoclave and a bag sealer. In the molecular laboratory there is a strong focus on genetic research and associated

equipment. The laboratory has the following equipment: an incubator, centrifuge, PCR machine, -88 °C freezer, fume cupboard and an autoclave.

The parasitology (disease) laboratory is equipped with a microtome, water bath, bacteria and fungi identification machine, compound and dissecting microscopes, a scanning electron microscope (desktop) and other light and compound microscopes.



Figure 113: Feed and nutrition laboratory equipment



Figure 114: Parasitology laboratory (top left), feed production equipment (top right), HPLC facilities (bottom left) and *Artemia* culture laboratory (bottom right)

Administrative and academic support

The ATDC is well supported administratively, although lengthy procurement processes do pose challenges to the operating efficiency of the facility.

The lecture room can hold up to 40 people for a five-day training course, who are in the process of attaining QCTO and SETA accreditation. There is currently no course fee, but fees may be implemented in future. Transport, accommodation and catering are paid for by trainees.

The staff are provided with offices and accommodation on site. The Internet connectivity service is challenging with poor signal available most of the time. Student support and technical facilities are available. However, accommodation facilities are run down.



Figure 115: Staff accommodation (left), student accommodation (middle), lecture facilities (right)

Other features

The ATDC has no industry partners at the moment, but they remain open to entering into MoUs with industry. There are no commercial catfish or carp farms currently in operation. The market price for fish is R15/kg (carp and catfish) if caught from the dam.

Fish produced from the facility aim to support farmers, research and development and training. The ATDC supplies juveniles nationally and to other SADC countries.

Recommendations

The Gariep ATDC offers a variety of systems and has significant infrastructure for freshwater aquaculture training. Although the aquaculture industry in the Free State is very small, the ATDC is centrally located in the middle of the country. It is recommended that the Gariep ATDC is identified as a Centre of Excellence for Freshwater Aquaculture Training and Research, as described in the National Aquaculture Policy Framework 2013.

It is important that the facility does not focus solely on catfish and carp but aligns to industry trends and requirements in order to enable meaningful contribution to research and industry development.

6.2.14. Dohne Agricultural Development Institute

Table 21: Donhe Aquaculture infrastructure & facilities detailed description

CRITERIA	AVAILABLE	COMMENT
Focus of programme		Freshwater - catfish, mozambique tilapia, trout
Type of structure		Tunnel structure
Water supply	YES	Municipal water supply
Electricity	YES	Backup generator available and functioning
Water filtration	NO	Filtration will be planned
Feed storage	NO	Feed storage could be be factored into the planning and design of the facility
Workshop	YES	Well-equipped workshop and staff
Life support systems	NO	No systems currently in place. Intensive RAS/partial flow through being planned
Laboratory facilities	YES	Soil science laboratory and some veterinary laboratory support within the Institute
Flexibility in system setup	NO	Flexibility in system setup could be factored into the design and planning of the facility
Replicated tank set up	NO	Replicated tank setup could be factored into the design and planning of the facility
Administrative support	YES	Well-equipped administration facilities
IT Facilities	YES	Well-equipped facilities
Academic support	YES	Three staff are available to facilitate aquaculture research and development

The Dohne Agricultural Development Institute is a government-operated research institute located in Stutterheim in the Eastern Cape. It is supported by the Eastern Cape Department of Rural Development and Agrarian Reform (DRDAR). Dohne focuses on directly supporting industry and surrounding farmers. While research interns form part of the staff assemblage, no students from tertiary education facilities are supported on site.

Focus of programme

The Dohne Agricultural Development Institute has traditionally focused on facilitating research for the production of cattle, sheep and pigs, as well as a limited number of crops for production purposes. Only recently has the Institute expressed an interest in developing an aquaculture research unit in response to an increase in demand for aquaculture support from surrounding farmers.

While no programme currently exists, the plan is to focus research efforts on commercially available freshwater species. These species will include Mozambique tilapia, African sharptooth catfish, mullet, and rainbow trout.

Type of structure

A well-built tunnel has been allocated to the upcoming aquaculture research unit. The tunnel structure is in good condition with state-of-the-art automated climate control mechanisms in place. This tunnel was originally used for crop research but is to be utilized for aquaculture research.



Figure 116: The tunnel structures earmarked for the Aquaculture Research Unit

Water supply

At this stage, it is anticipated that water will be sourced from the on-site borehole. However, water quality test results have indicated that high calcium levels may be a problem for running aquaculture systems. This will need to be factored into the planning and design of the facility. There are also two dams located on the property that could potentially serve as a water supply source for the unit.



Figure 117: Water storage reservoir

Electricity

The Institution has electricity. In the event of loadshedding an on-site generator is available to the aquaculture research unit, which is in a functional state, although it has not been used in a while.



Figure 118: Back-up generator on site

Water filtration

At this stage, no water filtration systems are being planned. A specialist is being consulted for the design and planning of the facility.

Feed storage

Currently there are no feed storage facilities. This will need to be included in the planning and design of the facility.

Workshop

The Institute has a well-equipped workshop with trained staff. The staff in the workshop include fitters and turners, boiler makers, and interns who are working with the experienced staff. While a dedicated workshop is not available for the aquaculture research unit, the existing facilities are sufficiently well resourced to support the unit.

Life-support system

At this stage, there are no life-support systems installed. The project is still in the planning and design stage and a specialist is being consulted to guide the unit around the requirements for aquaculture research systems. It is anticipated that the system will be designed as a recirculating system with the option to modify the system to support the species and research requirements. An option to utilize the two on-site dams for cage farming is also being considered.



Figure 119: The two on-site dams that are being considered for cage farming

Laboratory facilities

The Institute has shared laboratory facilities, which include a general laboratory that focuses on water quality testing. There is also a soil analysis laboratory and veterinary services on site. However, no laboratory facilities are currently available to undertake studies, such as nutrient analyses, which will form part of the scope of the research activities at the unit. It is assumed that the specialist consultant will include a basic laboratory in the plan and design of the facility.

Administrative and academic support

A well-appointed administration building is located on campus. Staff and interns have access to IT facilities, such as computers and internet, as well as printers, scanners and photocopiers. The

administration building has staff offices, boardroom facilities, a small conference facility, ablutions and a kitchen.

The Dohne Agricultural Development Institute does not function as an academic facility but rather as a research facility to support industry. As a result, no students are present on campus, but the Institute has an internship programme. There is very limited on-site accommodation that is primarily reserved for staff. Transport to and from Stutterheim is readily available for interns.

In terms of academic support, if it is required, educational institutions, such as Rhodes University and Fort Hare University are consulted.

Other features

The Dohne Agricultural Development Institute used to have an MoU in place with Rhodes University, which has expired. The project team has indicated that the future plan will include collaboration with academic institutions, such as Rhodes University, to support the aquaculture research that will be conducted, and to assist students with the provision of research facilities.

Recommendations

Currently this facility is in the process of being established. Once operational, it will be important for Dohne to focus on collaboration with universities, ATIs and TVET colleges to provide facilities required for practical training and to collaborate with training institutions to offer short courses in aquaculture and aquaponics.

Dohne has the potential to provide support to local farmers and communities. It is currently not a training institute, but rather a government-funded research and support facility that services surrounding farmers.

6.2.15. Marine Research Aquarium, Sea Point

Table 22: Marine Research Aquarium Aquaculture infrastructure & facilities detailed description

CRITERIA	AVAILABLE	COMMENT
Focus of programme		Marine - spotted grunter, kob, sea urchins, macro algae, micro algae, macrophytes.
Type of structure		Building.
Water supply	YES	Seawater abstracted directly from gulley in front of facility.
Electricity	YES	Backup generators available and functioning.
Water filtration	YES	Full RAS filtration system, UV filtration, ultrafiltration if required.
Feed storage	YES	Temperature controlled storeroom.
Workshop	YES	Well equipped with capable team.
Life support systems	YES	Intensive RAS, flow through, partial flow through.
Laboratory facilities	YES	Well-equipped algae lab, genetics lab and general lab.
Flexibility in system setup	YES	Systems can be modified to accommodate research project needs.
Replicated tank set up	YES	Multiple replicate tank set ups available.
Administrative support	YES	Well-equipped offices and administrative support - procurement process can be a problem.
IT Facilities	YES	Well-equipped IT facilities, particularly for genomics.
Academic support	YES	A number of staff permanently employed and associate staff deeply involved. Many staff co-supervise students at UCT, Stellenbosch etc.

The Sea Point Marine Research Aquarium is a marine research aquarium that, over time, has focused increasingly on aquaculture research and technology development. It is located on the Sea Point Promenade in Cape Town.



Figure 120: Sea Point Marine Research Aquarium in Sea Point, Cape Town

Focus of programme

The Sea Point Aquarium focuses on research on marine species. Currently, the species that are being researched at the facility include spotted grunter, dusky kob, sea urchins, kelp, microalgae and macroalgae. The Aquarium has undertaken a wide variety of research, which includes genetic studies, animal health studies and the enhancement of production efficiency of aquaculture species through optimization of spawning protocols, feeding protocols and environmental and rearing

An analysis of aquaculture infrastructure available for training, research and skills development

conditions. The Aquarium has started addressing the issues around food security through research on the nutritional value of aquaculture species.

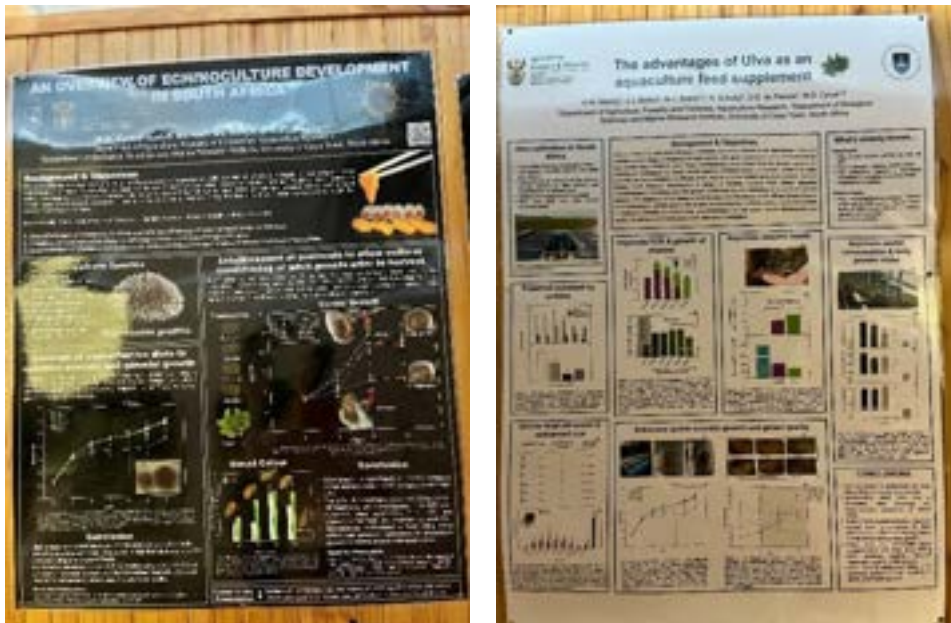


Figure 121: Examples of the research conducted through the Sea Point facility

Type of structure

The facility consists of a three-level building in which several purpose-built facilities are available. These include wet and dry laboratories, temperature-controlled laboratories, a phytoplankton culture laboratory, an auditorium and a number of open-plan research areas.



Figure 122: Multi-level building in which aquaculture research activities take place

Water supply

The Sea Point Aquarium has its own seawater abstraction infrastructure located on site. The location of the facility allows for seawater to be abstracted from the kelp beds directly in front of the facility. However, the abstraction pipe has been constructed directly into the gully and not through the sandy substrate, which allows for organic matter, such as small animals and sediment to easily enter the facility.

Electricity

The Aquarium has back-up generators on site for use during loadshedding. These generators are in working order and are regularly maintained. Solar power is currently being explored as an option to supplement the electricity supply and to provide back-up power when the electricity supply is switched off.



Figure 123: Main electrical panel

Water filtration

The aquarium has well-equipped water filtration systems that include a number of drum filters, a series of sediment filters, sand filters, biological filtration systems, protein skimmers, ultra-filtration systems, UV sterilization and options for ozonation, if required. These filtration systems are regularly maintained and can be modified to suit the requirements of specific research projects.



Figure 124: Filtration systems in place

Feed storage

Climate-controlled feed storage is available and chest freezers and refrigerators are also available if needed. The feed store's climate is controlled through the use of an air-conditioning unit.

Workshop

A well-appointed workshop facility is available at the Aquarium and is dedicated to supporting research activities. Workshop staff are well trained and experienced in maintenance and repairs of aquaculture production systems. Procurement processes are a challenge in sourcing tools, parts and new equipment.

Life-support system

The life-support systems at the Research Aquarium are well resourced and can be modified to suit the needs of specific research requirements. An extensive network of water and air reticulation infrastructure is readily available. Oxygen can be supplied to the systems, if needed, using oxygen cylinders. The life-support systems are primarily designed as recirculating systems but can be converted to flow-through or static systems if required.



Figure 125: Various tank setups and life-support systems available to students

Laboratory facilities

The Research Aquarium has well-appointed laboratory facilities that include wet and dry laboratories, a general laboratory, an algae laboratory and a genetics laboratory. Students receive laboratory safety training before working in the facilities, which helps minimize the risk of accident in the laboratories and provides practical training to students around working in a laboratory environment.

The procurement of chemicals and other laboratory supplies can be a challenge. However, arrangements can be made with collaborating institutions to assist with the supply of laboratory requirements.



Figure 126: Algae laboratory (top left), sterile wet lab (top right), general laboratory (middle), autoclave (bottom left) and the kelp hatchery laboratory (bottom right)

Administrative and academic support

Well-resourced administrative and academic support is available at the Research Aquarium. Offices are available to staff and students; IT facilities, in terms of computers and internet, are made available. Other administrative support, such as printers, scanners, and photocopiers are available to staff and students.

The extensive collaborative effort between the Research Aquarium and academic institutions, including Rhodes University, UCT, UWC and CPUT to name a few, allows for strong academic support to students. However, one of the challenges faced by the facility is the lack of succession potential for the replacement of key academic staff. Several key positions within the DFFE to support aquaculture research and development have not been filled, and a number of current key staff are due to retire in the near future.

Other features

The Sea Point Research Aquarium has a wide collaborative network with South African institutions as well as international institutions. This enables the facility to support of diverse range of aquaculture-specific research projects that benefit the aquaculture industry itself as well as community development on South Africa.

Recommendations

The Sea Point Marine Research Aquarium is very well equipped with extensive infrastructure and technology to accommodate a variety of marine-focused research. It provides academic and infrastructure support to numerous universities, such as Rhodes, UCT, Stellenbosch and the Cape Town University of Technology.

The greatest challenges for the facility are bureaucratic issues, which have resulted in numerous vacancies and limited succession planning. Institutional knowledge is at risk of being lost as key individuals retire. The Sea Point facility plays a critical role in marine research in the country, and it is important that its body of research and knowledge is safeguarded.

6.3. Table of infrastructure

The table below sets out the status of the infrastructure that is available at each institution.

Well maintained and fully operational
Functional
Poorly maintained, requires repair
None present on site
Accessed offsite at another institution

					Universities						ATIs			Government		
Ar	Technical specification	Rhodes	Stellen- bosch	UCT	UFH	UKZN	Limpopo	Zululand	WSU	Mpuma- langa	MATI	TSCA	TARDI	Gariep	Sea Point	Dohne
Water	Freshwater															
	Marine															
Type of facility	Hatchery															
	Research															
	Training & Demonstration															
Infrastructure	Water															
	Water filtration															
	Electricity															
	Backup power / generator															
	Temperature control															
	Life Support Systems															
	Replicated tank set up for research															
	Flexibility in tank set up for experimentation															
	Aquaponics facility															
Laboratory equipment	Microscopes															
	Counting slides															
	Water quality monitoring devices															
	Algae laboratory facilities															
	Laminar flow hood															
	Fume hood															
	Autoclave															
	Drying oven															
	Incubator															
	Tissue staining reagents/ equipment															
	Cleaning stations															
	Cold storage facilities															
Feed	Feed storage facilities															
	Feed manufacturing equipment															
	Feed store climate control															
Support	General administrative support															
	Support for procurement of resources															
	Onsite technical support															
	Practical and lecture facilities															
	Student offices															
	IT support services															
	Student facilities															

7. Skills Gaps and Needs

It is important that changes and improvements to aquaculture training and education take place in response to identified industry and market needs. The Aquaculture Skills Inventory and Needs Analysis (SAIMI, 2017) identified the following skills gaps and needs within the aquaculture industry.

7.1. Adult Education and Training (AET)

This was indicated as a high priority. Many of the training facilities currently available at ATIs and other institutions, such as the Dohne Agricultural Research institute and the ATDC at Gariep can be used for this purpose.

7.2. Supervisory, management, and ‘soft skills’ training

Supervisory and management training were indicated as a high priority. The inclusion of this training should be considered in all aquaculture-related training programmes.

7.3. Aquaculture specific technical skills

Technical skills in aquaculture consist of theoretical and scientific knowledge as well as a practical component. Collaboration between training institutions as well as with the private sector can ensure that both the knowledge and practical skills needed for aquaculture are effectively taught. The reality is that every institution does not have equal financial, academic and infrastructural means to provide efficient training at all levels. Collaboration will make the provision of a rounded education more achievable.

There are two accredited aquaculture-specific qualifications developed in recognition of the need for skills in the aquaculture industry:

- Occupational Certificate: Aquaculture Farm Worker (SAQA ID 104904) – NQF Level 2
 - Intended to provide a foundation in aquaculture practices that will enable trainees to enter into a formal career in the aquaculture industry.
 - Aimed at new entrants, individuals, or employees who are currently employed within the aquaculture industry
- Occupational Certificate: Aquaculture Farmer (SAQA ID 104912) – NQF Level 4
 - Intended to prepare the learner to operate as an Aquaculture Farmer. An Aquaculture Farmer promotes productivity through overseeing activities performed by team members within the aquaculture industry to ensure the attainment of aquaculture production objectives, and economic and environmental sustainability.
 - Aimed at new entrants, individuals, or employees who are currently employed within the aquaculture industry.

The ATDC currently offers non-accredited training and are in the process of getting their training accredited. Many private training institutions, such as Aquaculture Innovations, La Pieus Aqua, David Fincham Aquaculture, et cetera, also provide technical aquaculture training. The challenge for training service providers, as well as Universities, TVET colleges and ATIs is to integrate the

accredited modules into existing training modules to support the aquaculture industry in their respective provinces.

7.4. Aquaculture veterinary courses, qualification, or specialisation

It is recommended that the inclusion of aquaculture-specific training form part of veterinary science degrees.

7.5. Research in feed manufacturing

Training and research programmes should include a focus on the development and research on feed manufacturing for the aquaculture industry. Rhodes University has facilities for research in feed development. The Tsolo Agricultural Research facility can also benefit from the inclusion of a feed development/research focus in their programmes, since they already possess some of the needed infrastructure.

7.6. Interventions specifically directed at building positive relationships with aquaculture farmers

This was indicated as a high priority. Collaboration by the training institutions with aquaculture farmers can assist in alleviating many of the problematic issues highlighted in the current research.

A number of institutions indicated that students do not have a realistic idea of the nature of aquaculture. Collaboration with aquaculture farms in the form of job shadowing and internships may alleviate this problem.

The 2023-2024 AgriSETA Aquaculture Sub-Sector Skills plan highlights the following skills gaps in aquaculture-related occupations. At management level, Aquaculture Farm Managers lack skills in:

- Management and leadership
- Supervision
- Problem-solving
- Planning and organising
- Project management
- Communication

This indicates a need to include management and leadership skills in the curriculum of professionally qualified aquaculturists pursuing a career as aquaculture farm managers. This can typically be included as a compulsory module in the final year of tertiary education. These skills are also invaluable for aquaculture entrepreneurs.

At professional level, veterinarians and agriculture consultants lack skills in:

- Animal and plant disease and pest control
- Communication skills
- Production
- Technical (job-specification)

Although animal and plant disease forms part of many curricula, a more in-depth focus on aquatic diseases is imperative for veterinarians in the aquaculture milieu. Practical experience in the

identification of disease in authentic aquaculture farming setups may assist in more effective disease identification.

Extension services can be a valuable service offered by the government. Qualified and experienced aquaculture extension officers can assist especially small aquaculture farms with disease identification and management as well as sound production methods. An important aspect of their training should include extensive knowledge of aquatic production systems and the skills to effectively translate scientific principles into practice.

At Technician and Associate Professional level, Operation Supervisors, Veterinary Technicians and Veterinary Technologists lack the following skills:

- Aquaculture produce analysis
- Planning and organising
- Advanced computer skills
- Communication skills
- Supervisory

Since data collection and analysis are a critical part of technicians' jobs, advanced computer skills, specifically in the context of data management, should be included as part of their training. At the operational level, planning and organising, supervisory and communication skills are especially important practical skills. There is a need for the training of elementary occupations in aquaculture. AgriSeta has accredited training modules available for aquaculture workers, but this is very limited, and accredited trainers are not readily available. ATIs and TVET colleges can play a valuable role in providing trained workers for aquaculture companies.

8. Recommendations

It is recognized that aquaculture, as an industry, is technology driven, and research and development play a crucial role in innovating techniques for species identification and advancing technology to promote sustainable commercial production. The role of research institutions is therefore critical in the development of the industry, in order to advance innovation and diversification throughout the value chain, and to implement improvements and efficiencies in aquaculture production systems. Research into new species for culture, breeding and genetics, production systems, technology transfer, nutrition, feed development, harvest technology and integrated aquaculture systems is critical to enable a sustainable and commercially viable aquaculture industry. For this level of research, technology and high functioning infrastructure are required.

At the same time, people who are equipped with practical skills and knowledge of animal husbandry, basic production management, and animal health are essential to supply the workforce required on the aquaculture farms. For this level of training, high technology equipment and systems are not essential; however, the training must be practical and relevant.

Following the analysis of the data gathered during the site visits, the research team identified the recommendations below to optimize aquaculture training and education at Universities, ATIs and TVET colleges in South Africa.

1. **Imbalance of infrastructure** – Although there is a significant amount of aquaculture infrastructure at educational institutions across the country, only the infrastructure at universities or DFFE-funded facilities has been maintained and upgraded. All universities visited have adequate infrastructure for training and research and make use of shared university laboratories and /or DFFE research facilities. Equipment and infrastructure have been maintained and are mostly adaptable to cater for the required research projects. Several of the universities (e.g., Rhodes) have plans and funding for significant infrastructural upgrades in the next year.

On the opposite end of the spectrum, there has been no infrastructure maintenance or upgrade at the ATIs (MATI, TSCA, TARDI) for the past few decades. If upgrades have taken place, they have been unsatisfactory or incomplete. This has resulted in an imbalance of aquaculture-related training facilities nationally, with adequate equipment for tertiary-level students, or scientific research, but far fewer facilities available for vocational level training. The lack of funding for the maintenance and updating of crucial infrastructure poses a significant challenge to the sustainability of aquaculture training. Additionally, there is a noticeable lack of security measures at training and research sites, resulting in vandalism and theft.

In order to serve the needs of industry, vocational level training is critical. However, rather than upgrading the infrastructure at all ATIs, it would be preferable to focus on establishing opportunities for collaboration between universities, ATIs, and DFFE- and DARDLEA-funded facilities. It is also important to develop the infrastructure at facilities that are aligned to, and in proximity to industry demands. For example, as the majority of the country's marine aquaculture farms are located in the Western Cape, it would make sense to develop the vocational training

service offerings at Stellenbosch University, rather than UKZN or the University of Zululand. Interestingly, the majority of freshwater aquaculture farms are located in Gauteng, a province that has no universities or ATIs offering aquaculture-related qualifications. In this case, the centrality of the Gariep ATDC facility, despite being inland, is well placed to enable most of the provinces to benefit from the training offered.

2. **Availability of trained staff / teachers** – A critical factor in the success of an institution's operations is the capacity and commitment of its staff. At the ATIs there is a noticeable shortage of adequately trained staff available to assist students with practical training, hindering the overall educational experience. Train-the-trainer or mentorship programmes with universities would be beneficial to these institutions. While the universities seem to be adequately staffed, it is clear that the universities with high success rates and plans for expansion are staffed and led by dynamic lecturers who are passionate about the subject matter. At government-funded institutions, such as the Marine Research Aquarium, the absence of succession planning and timely appointments in vacant positions is identified as a key risk, which could lead to an immeasurable loss of institutional knowledge.
3. **Awareness about aquaculture as a career** – A notable factor is the decline in student enrolment in aquaculture-related studies. Stellenbosch, UFH, UKZN and WSU commented on low student interest in aquaculture as a subject. Aquaculture, by its nature, is multi-disciplinary and requires inputs from a range of scientific dictionaries, including physiology, genetics, biotechnology, ecology, nutrition, economics, engineering, et cetera. Few of the universities had a specific aquaculture-dedicated department; in most cases, the aquaculture unit was housed with zoology, life sciences or fisheries.

It is recommended that that more effort is put into educating matriculants and prospective students about the nature of aquaculture work and the career development opportunities. It must be noted that this should go hand-in-hand with industry partnership and development, to ensure meaningful opportunities exist for employment post-qualification.

4. **Collaboration and cooperation are crucial** – It is clear that the most successful institutions benefit substantially from cooperation and collaboration with each other and with industry partners. In order to attract funding and receive student bursaries, educational institutions need to generate relevant and meaningful research that has market value and is useful to industry. It is in the interests of both educational institutions and private aquaculture facilities to engage in potential opportunities and development in order to strengthen and grow the industry and stimulate post- graduation job opportunities.
5. **Development of a national database** – A central database containing training and research facilities as well as private industry partners willing and able to collaborate may assist in making collaboration easier.
6. **National aquaculture development strategy** – The lack of a national strategy for the aquaculture sector that focuses on the creation of economically viable and self-sustainable

initiatives, poses a significant barrier to the overall growth and success of the aquaculture industry.

The upliftment and upgrading of aquaculture training facilities cannot take place in a vacuum without a clear guiding strategy and vision. In recent years, the aquaculture industry in South Africa has suffered under increasing electricity costs, infrastructural challenges, relatively low national demand for aquaculture products and the knock-on economic effects of the Covid-19 pandemic. As a result, employment in the industry has declined and private sector companies are concerned about the viability of the emergent aquaculture industry.

Given the global trend towards increased consumption of farmed fish, there is undoubtedly opportunity for the growth of our aquaculture industry. However, the specific species and type of aquaculture should be carefully considered and explored. Most freshwater training facilities focus on tilapia, catfish, and carp, as these are hardy and relatively easy species to rear. However, outside the realm of the university, they have no real value. With a local market value of R15/kg, catfish costs more to produce than its market value. There should be focus on developing expertise in niche and currently under-supplied aquatic species with market opportunity, such as prawns, freshwater eel, rock lobster, sea urchin, mullet and seaweed.

There are numerous intergovernmental, and public-private aquaculture forums, including the National Aquaculture Intergovernmental Forum, the National Aquaculture Research Forum, the Marine Aquaculture Working Group, the Aquaculture Value Chain Round Table and the Aquaculture Skills Expert Group. It is recommended that, within these existing groups, the viability and justification of identified aquaculture opportunities are assessed. 'Aquaculture Development Programmes' could be identified, designed and implemented, aligned to the research capacity at ATIs, universities, other government-funded institutions, and industry role-players in order to unlock and realize these opportunities. Skills development and training should be aligned, and aquaculture skills (from post-graduate to vocational) developed as part of the programme, making these skills practical and applicable in that specific field of expertise. In this way, aquaculture development resources are aligned, and skills are developed in support of establishing a sustainable aquaculture industry.

In conclusion, this study has highlighted the need for collaboration between government, industry, and educational institutions in revitalizing the aquaculture sector. The analysis of infrastructure at educational institutions demonstrates that extensive infrastructure exists, but there is a lack of alignment to economically viable or social development initiatives that exist in the real world (e.g., focus on catfish and tilapia, which have limited commercial viability in South Africa). The strategy to uplift and develop educational institutions cannot take place in isolation from broader social, economic and market realities.

Market trends suggest that significant opportunity exists, both nationally and internationally, for the aquaculture industry, and these need to be unlocked through research and feasibility assessments. Thereafter, skills and development programmes at all levels can be developed and implemented

aligned to industry demands, including the development and upgrading of specific infrastructure at educational institutions to support required aquaculture qualifications.

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10. Annexures

Annexure A - Initial screening questionnaire

Annexure B - Detailed technical questionnaire

Annexure C – High-level overview presentation

Annexure D – Contact list of all universities, TVET colleges and ATIs contacted.



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