KELP VALUE CHAIN ANALYSIS, MARKET ASSESSMENT AND ROADMAP FOR DEVELOPMENT OF KELP FARMING IN SOUTH AFRICA

Final Report (30 Nov 2023)

Compiled by:

Advance Africa Management Services

On behalf of:

Bivalve Shellfish Farmers' Association of South Africa (BSASA)

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ACRONYMS AND ABBREVIATIONS

ASC	Aquaculture Steward Council
ADZs	Aquaculture Development Zones
BSASA	Bivalve Shellfish Farmers' Association of South Africa
CSIR	Council for Scientific and Industrial Research
DEFF	Department of Environment, Forestry and Fisheries (now DFFE)
DAFF	Department of Agriculture, Forestry and Fisheries (now DFFE)
DFFE	Department of Forestry, Fisheries and the Environment
DW	Dry weight
EMPr	Environmental Management Programme
FAO	Food and Agriculture Organization of the United Nations
FCDO	Foreign Commonwealth and Development Office
FW	Fresh weight
GDP	Gross domestic product
HS	Harmonised System
IMTA	Integrated multi-trophic aquaculture
KFP	South African Kelp Farming Project
MSY	Maximum Sustainable Yield
R&D	Research and Development
SARS	South African Revenue Service
SMMEs	Small-, medium- and micro-enterprises
SWOT	Strengths, Weaknesses, Opportunities and Threats
TNPA	Transnet National Ports Authority
UN SDGs	United Nations Sustainable Development Goals
UK	United Kingdom
USD	United States Dollar
ZAR	South African Rand
ZSCI	Zanzibar Seaweed Cluster Initiative

EXECUTIVE SUMMARY

- The South African Kelp Farming Project (KFP), implemented by the Bivalve Shellfish Farmers' Association of South Africa (BSASA), supported by the Department of Forestry, Fisheries and the Environment (DFFE) and funded by the United Kingdom (UK) via the UK Foreign Commonwealth and Development Office (FCDO) was commissioned (December 2021) in recognition of the opportunity to develop a financially and environmentally sustainable kelp farming industry in South Africa.
- The pre-feasibility study undertaken in Phase 1 of the KFP (concluded in March 2023) demonstrated a positive potential for kelp farming in South Africa. Phase 2 (ongoing) aims to further investigate the technical and economic feasibility of commercial kelp farming in South Africa.
- As part of Phase 2 of the KFP, a more detailed Market Assessment and Value Chain Analysis was conducted (this study) to build on the preliminary market and value chain information contained in the market overview of the pre-feasibility study.
- This report maps and establishes the current market value for kelp in South Africa and identifies key gaps and inefficiencies within the value chain.
- Data for the study were collected through a combination of stakeholder engagements (in-person, virtual, telephonic, online correspondence, questionnaire) and literature reviews.
- The total biomass of kelp used in South Africa is now approximately 24 245 tonnes fresh weight (FW) per annum, which indicates that the sector has grown in the last 5 years.
- Over 12 719 tonnes of beach-cast kelp (FW equivalent) was collected, while 11 525 tonnes of fresh kelp was harvested.
- Most of the beach-cast kelp (95%) was dried and milled (2 019 tonnes after drying and milling) and exported for alginate extraction.
- Of the fresh kelp, around 50% (5 766 tonnes FW) was used as abalone (*Haliotis midae*) feed while 45% (5 194 tonnes fresh, plus 101 tonnes dried and milled) was processed locally to produce high-value biostimulants, and liquid fertilisers for local and export markets. Approximately 60 tonnes was used as an additive in the making of formulated abalone feed.
- The total market value for kelp (pre-value-addition) was approximately ZAR 56.5 million.
- The wholesale market value for biostimulants and liquid fertilisers was approximately ZAR 317 million. Overall, around 64% was exported with a value of ZAR 233 million.
- The entire value chain was estimated to be worth ZAR 357 million.
- The kelp industry provides approximately 350 direct jobs. Roughly 47% are held by women and 38% by youth (35 years or younger).
- Several value chain gaps and inefficiencies were identified in the South African kelp industry. These include the lack of a local (Western Cape) food-grade processing facility, the paucity of supply to the niche restaurant market, an industry-wide supply inconsistency and difficulty with accessing raw product, a constrained and inefficient concession license system, as well as the lack of a kelp farming industry, which may constrain the supply of kelp to niche markets.
- Several market opportunities for farmed kelp were identified, including biostimulants, animal feeds, nutraceuticals and cosmeceuticals, bioplastics and fabrics, the restaurant and local food market trade, and the exploration of multiproduct development.
- An overview of development needs for each market opportunity and product is provided.

- A key consideration is the need for value-addition/processing of farmed kelp to ensure the economic viability of the operation.
- The Kelp Value Chain Roadmap describes practical project components that should be implemented to unlock opportunities for parties interested in kelp farming in South Africa.
- The roadmap is premised on the successful development of kelp farming technologies. If the technologies provide reliable and commercially useful proof-of-concept, then the five roadmap strategies can be implemented. These include a Developmental/Regulatory Strategy, an R&D Strategy, a Product-Market Strategy, a Commercialisation Strategy and a Community Participation Strategy.
- The data presented in this report along with the identified value chain inefficiencies, market opportunities and roadmap establish a baseline that should be understood before embarking on or investing in kelp farming. Failing to grasp these insights puts kelp farming investors at risk of pursuing a production-driven venture instead of one driven by the market.

1. INTRODUCTION

The South African Kelp Farming Project (KFP) was commissioned in recognition of the opportunity to develop a financially and environmentally sustainable kelp farming industry in South Africa. The Bivalve Shellfish Farmers' Association of South Africa (BSASA) is the implementing organisation for the Project, which is funded by the United Kingdom (UK) via the UK Foreign Commonwealth and Development Office (FCDO) and supported by the South African Department of Forestry, Fisheries and the Environment (DFFE).

In Phase 1 of the FCDO-BSASA South African Kelp Farming Project, implemented from December 2021 to March 2022, a pre-feasibility study demonstrated positive potential for kelp farming in South Africa. This conclusion was reached because of the limitations of kelp availability in the market. Phase 2 of the Project aims to further investigate the technical and economic feasibility of establishing commercial kelp farming in South Africa. The objectives of Phase 2 include the further refinement of kelp hatchery technology, sea-based grow-out trials in Saldanha Bay, assessments of kelp quality for food safety and certification, assessment of environmental/ecological benefits and risks, exploring value chain and employment opportunities, initiating further stakeholder engagements, and ultimately concluding on the financial and commercial feasibility of kelp farming in South Africa.

Two primary components of a full feasibility study include a comprehensive assessment and understanding of the market for kelp and a detailed value chain analysis. Drawing on the high-level recommendations and findings of the pre-feasibility study, this report establishes the market potential of kelp. A properly validated understanding of these components will dictate every aspect of value chain development, from production scale to grow-out size and quality, processing requirements, and the need for certification of production and processing facilities. These factors, in turn, are key parameters that affect the technical and economic viability of an aquaculture investment and should therefore be understood from the outset of the feasibility study.

Therefore, in the context of the objectives of Phase 2 of the KFP, the BSASA appointed Advance Africa Management Services (Advance Africa) to conduct an in-depth Kelp Value Chain Analysis and Market Assessment, to build on the preliminary market and value chain data that was presented in the market overview in the Phase 1 pre-feasibility study.

2. CONTEXT

2.1. Kelp in South Africa

Kelp refers to the brown seaweeds (Phaeophyceae) within the order Laminariales. Four kelp species are native to South Africa: *Ecklonia maxima* (sea bamboo), *E. radiata* (spiny kelp, leather kelp or golden kelp), *Macrocystis pyrifera* (bladder kelp or giant kelp) and *Laminaria pallida* (split fan kelp) (Figure 1). Of these species, *E. maxima* and *L. pallida* occur along South Africa's west coast in the cold, nutrient-rich Benguela upwelling region, while *M. pyrifera* has been found in a number of small areas between

Soetwater and Jacobsbaai (Fleischman *et al.,* 2020). The smaller *E. radiata* is distributed sporadically across South Africa's southern and eastern coasts (Rothman *et al.,* 2017; Bolton, 2022; CSIR, 2022).

South African kelp forests dominate the nearshore subtidal zone in the southern Benguela. These forests span roughly 1 000 km of the coast providing a range of social, ecological, and economic services (Rothman, 2015). Kelp forests in South Africa support commercially important fisheries (e.g., West Coast rock lobster (*Jasus lalandii*), abalone (*Haliotis midae*), and various linefish species) and support a developing ecotourism sector. Blamey and Bolton (2018) valued South Africa's kelp forest ecosystems at ZAR 5.8 billion per year, of which ZAR 3.9 billion contributes to South Africa's gross domestic product (GDP). Ecotourism contributes roughly 40% of this, followed by recreational fishing (28%), and commercial and illegal fishing (15-16% each).

Figure 1: South African kelp species. Ecklonia maxima (top left) and Ecklonia radiata (top right) (Anderson et al., 2016); and Macrocystis pyrifera (bottom left) and Laminaria pallida (bottom right) (Maneveldt and Frans, 2001).

2.2. Global kelp production and use

Globally, kelp species are commercially important primarily for the extraction of alginates. Alginates are used as thickening agents in food production, pharmaceuticals, and textile printing, as stabilisers in battery ionisation, and to form calcium alginates which are used in food and fibre industries. Kelp is also used as a source of iodine, potash and other salts, acetone, and kelp char as well as in food products, supplements and research (World Bank Group, 2023). Most of the world's kelp production consists of

sugar kelp/kombu (*Saccharina latissima*), and a smaller portion comprises wakame (*Undaria pinnatifida*), primarily used for food and some feed purposes. Previously, substantial quantities of sugar kelp were used in alginate production in China, but there has been a shift towards its utilisation as food and as feed in aquaculture (Cottier-Cook *et al.,* 2021).

Production of kelp comprises both wild harvesting and aquaculture. Wild harvesting methods include hand cutting and gathering, trawling and dredging, or mechanical cutting, and the collection of washed-up or beach-cast kelp. Generally, wild harvesting of kelp is less costly than farming, however, wild kelp resources cannot satisfy the growing demand for the commodity. Moreover, in most regions of the world, wild harvest concessions are limited to ensure environmental sustainability (World Bank Group, 2023). As a result, the future growth of kelp (and other seaweed) value chains globally will rely heavily on the expansion of the aquaculture industry (World Bank Group, 2023).

Kelp is typically farmed on suspended or horizontal ropes which are attached to buoys or rafts. Global brown seaweed production, including kelp, has increased at a rate of 3.2% per annum, from 9.25 million tonnes in 2000 to 18.34 million tonnes in 2021. This increase has been a result of increased aquaculture production. Brown seaweed farming takes place mainly in East Asia, with China being the biggest contributor (85%). On the other hand, wild-harvest production has remained relatively stable over this period at around 677 000 tonnes, contributing less than 5% to total production in 2021 (Figure 2) (FAO, 2023a, b).

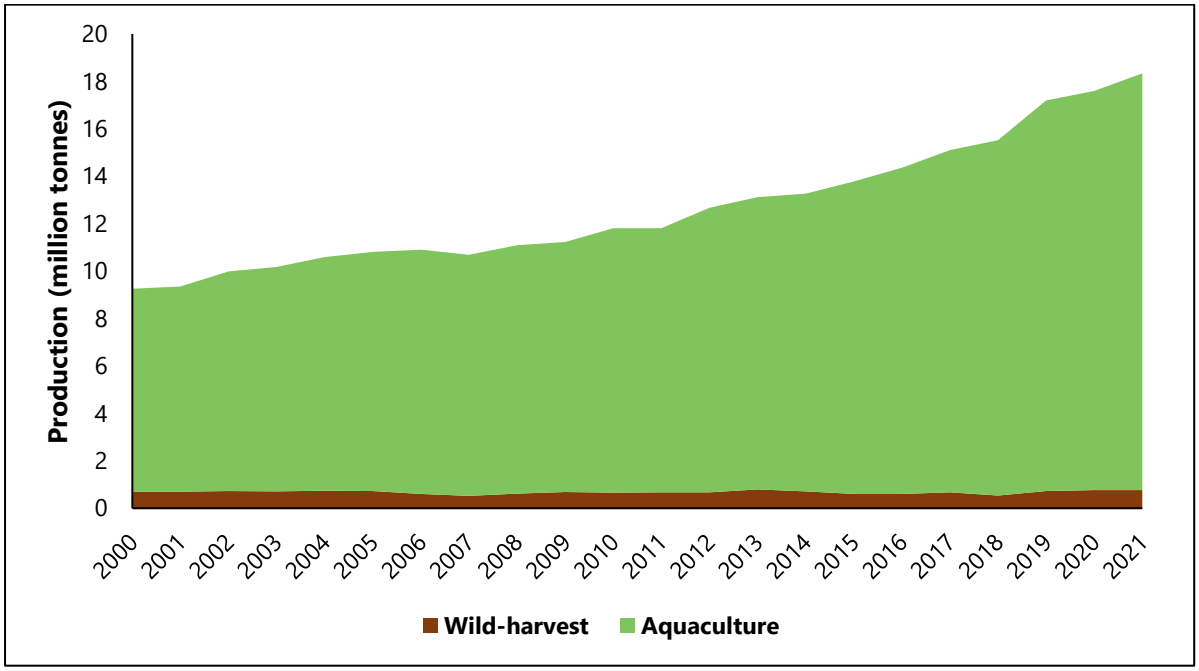

Figure 2: Global brown seaweed wild-harvest and aquaculture production, 2000-2021 (FAO, 2023a, b).

2.3. South African kelp production and use

South Africa's seaweed industry began in the mid-1900s when red seaweeds (*Gracilaria*), collected in Saldanha Bay and St Helena Bay, were dried and exported for agar extraction. The collection of beach-

cast kelp in these bays followed, which was also dried and exported for the extraction of alginate (Anderson *et al.,* 1989). Inter-annual yields varied considerably, ranging from none in some years to a maximum of 2 000 tonnes in 1967 (Anderson *et al.,* 1989).

The harvesting of fresh kelp began in the 1980s for the production of biostimulants and in the late 1990s increased with the establishment of abalone farms. Prior to this, harvests were mostly from collecting beach-cast kelp. Currently, kelp fronds are harvested, and fresh beach-cast kelp is collected from various concession areas (Figure 3) to supply feed to abalone farms (Troell *et al.,* 2006). There are currently 23 Seaweed Concession Areas of which 13 (areas 5-9, 11-16 and 18-19) have kelp rights (Rothman *et al.,* 2020). According to government reports, kelp harvests have remained fairly stable (5 056 tonnes in 2020 and 5 674 tonnes in 2021) over the past few years and the resource is considered optimally exploited in most areas (DEFF, 2020; Dr Mark Rothman, pers. comm).

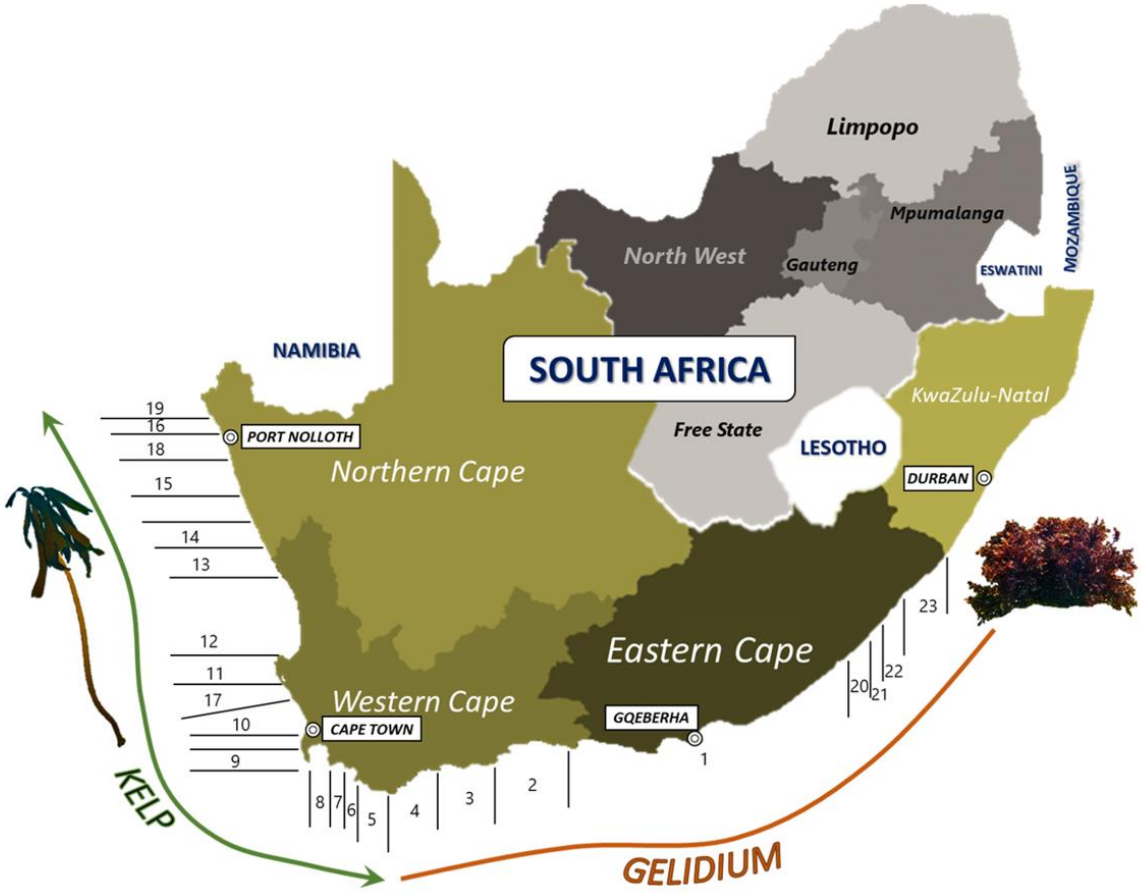

Figure 3: Map of South African Seaweed Concession Areas (adapted from Rothman et al., 2020).

3. AIM AND OBJECTIVES

The overall aim of this study was to obtain a comprehensive understanding of the kelp market, to map the kelp value chain in South Africa, to consider growth opportunities, and to guide the future direction of the kelp farming industry.

The objectives of this assignment were to:

- Provide an overview of the South African kelp value chain activities and actors;
- Identify existing gaps and inefficiencies in the value chain and the reasons for these gaps;
- Understand the current socio-economic impact of the value chain and opportunities for improvement;
- Identify market opportunities;
- Provide recommendations for value chain development; and
- Develop a concise roadmap for kelp farming and value chain expansion and strengthening in South Africa.

4. METHODOLOGY

4.1. Stakeholder Engagement

4.1.1. Stakeholder mapping

During Phase 1 of the KFP, a stakeholder mapping exercise was conducted, in which over 180 kelp value chain actors, including seaweed concessionaires and representatives, kelp processors, retailers and restaurants, aqua-farmers, funding and development institutions, research and academic institutions, Government departments and agencies, and members of civil society, were identified (CSIR 2022). We reviewed this stakeholder list to identify those stakeholders that were most relevant to this study and that would be in a position to provide the most accurate and up-to-date information.

Based on our further stakeholder mapping, the database was updated and used as the basis for stakeholder engagements. It should be noted that the original list was substantially reduced as many stakeholders had no direct involvement in the industry and were not able to provide meaningful information for the study. In addition, many of the stakeholders were no longer working in the industry. At this stage of the project, it was more important to identify key stakeholders with direct interest, investment or involvement in the industry as opposed to a larger cohort which would dilute the results of the project going forward.

4.1.2. Questionnaires

A questionnaire was developed in conjunction with the KFP implementation team. The questionnaire was split into three sections to obtain: 1) value chain data, 2) employment data, and 3) general industry information. The value chain data section was designed to obtain quantitative data relating to (a) kelp harvesting, (b) kelp purchasing, (c) unprocessed kelp sales, and (d) kelp processing and sales. The employment data section was designed to derive quantitative industry data, including the number of female and youth employees. The general industry information section comprised open-ended questions, to obtain additional qualitative information and insights regarding the challenges facing the kelp industry in South Africa, and the opportunities for value chain development and improvement.

The questionnaire was distributed to industry stakeholders, including concessionaires, kelp harvesters, abalone farmers, kelp processors and retailers. In addition, an amended version of the questionnaire,

comprising only the general industry information section, was distributed to Government, Research and Academia, Civil Society, and Funding and Development stakeholders.

4.2. Literature Review

In addition to the questionnaire survey, a literature review was carried out to identify any additional value chain actors, document value chain activities and value addition, identify gaps within the value chain, and to assess current challenges and opportunities for value chain development. Literature that was reviewed included the pre-feasibility study for kelp farming in South Africa (CSIR, 2022), the KFP Stakeholder Engagement Workshop Summary Report (BST, 2023), and the Phase 2-Year 1 Project Output Report and Phase 2-Year 2: Quarter 1 and 2 Reports; as well as other reports outlining South Africa's existing kelp harvesting value chain and/or the potential for the development of a farming-based value chain.

4.3. Value Chain Mapping

Using the data and information obtained through the stakeholder engagements and literature review, the South African kelp value chain was mapped using the following approaches:

1) **Value Chain Linkages map** (Figure 5): to visually represent the relationships between value chain actors, and the movement of kelp within the value chain.
2) **Mass Flow Value Chain map** (Figure 6): to illustrate the flow of kelp through the value chain, with indications of mass and price at critical intervals.

Based on the maps and key insights gained, we identified inefficiencies in the value chain and opportunities for improvement. Thereafter, we evaluated the socio-economic impact of the existing kelp value chain, in terms of employment and potential revenues at different nodes and identified high-potential employment drivers across the value chain.

Based on the inefficiencies in the value chain, we identified and described realistic market opportunities with high potential for success in the South African context. Thereafter, we provide recommendations for value chain development. Finally, we prepared a concise Roadmap for Kelp Value Chain Expansion and Strengthening in South Africa. The Kelp Value Chain Roadmap is structured around practical, concrete project components that should be implemented to unlock opportunities for parties interested in entering the kelp farming industry in South Africa.

5. PART 1: SOUTH AFRICAN KELP VALUE CHAIN

5.1. Kelp Value Chain Overview

Questionnaires were returned by key stakeholders throughout the industry and value chain (Table 1). In some cases, multiple stakeholders within an organisation provided information. It must be noted that there was a general reluctance to provide sensitive industry information from value-added processors. Given the confidential nature of the processing price information in the questionnaire, limited responses were received on these specific data points. This was as to be expected. In these cases, we engaged with the stakeholders verbally and obtained as much relevant information as they were willing to share, while maintaining their privacy.

Table 1: List of questionnaire respondents and their role in the value chain.

Stakeholder	**Market Segment**
Viking Aquaculture (Pty) Ltd	Abalone and oyster farm; seaweed concessionaire
ABAGOLD	Abalone farm
Aqunion Romansbaai Farm	Abalone farm
Doring Bay Abalone	Abalone farm
HIK Abalone	Abalone farm
Jacobsbaai Sea Products	Abalone farm
Blue Sapphire Pearls	Abalone pearl farm
Abalone Farmers Association of South Africa (AFASA)	Aquaculture Industry Association
Bivalve Shellfish Farmers' Association of South Africa (BSASA)	Aquaculture Industry Association
Afrique Petfoods (AFGRI)	Aquafeed Manufacturer
Marifeed	Aquafeed Manufacturer
Specialised Aquatic Feeds (SAF)	Aquafeed Manufacturer
Seas The Opportunity	Commercial/market developers
The Seaweed Alliance	Development; Research
OceanHub Africa	Entrepreneurial Support Organisation; Funding and Development
Food Consultant	Entrepreneurial Support; Development
Department of Forestry, Fisheries and Environment (DFFE); Fisheries Management	Government
Operation Phakisa: Oceans Economy; DFFE	Government
Khoi Kelp	Khoi Local Indigenous Tribe
Saldanha Bay Municipality	Local government
Blue Ocean Mussels	Mussel farm
Imbaza Mussels (Pty) Ltd	Mussel farm
Pluto Mussels and Trading	Mussel farm
Requa Enterprises	Mussel farm
Simunye Mussels Ltd	Mussel farm

Ulwazi Kukutya Pty Ltd	Mussel farm
Kelp Blue	Namibian kelp farm and processor
Adelaide Ruiters Mining and Exploration (Pty) Ltd	Phosphate Mining Company
DFFE: Aquaculture Research and Development	Project Team
Kelp Farming Project	Project Team
WC Department of Economic Development and Tourism (DEDAT)	Provincial government
Phyconomy	Research/Academia
Rhodes University, Department of Biochemistry	Research/Academia
Rhodes University, Department of Ichthyology and Fisheries Science	Research/Academia
Stellenbosch University	Research/Academia
University of Cape Town	Research/Academia
University of the Western Cape	Research/Academia
The Saldanha Bay Water Quality Forum Trust (SBWQFT)	Research; NGO
Biosolutiones Technicas (BST)	Research; Development
Paternoster Oyster Company	Research; Oyster farm
Woolworths	Retailer
Aukotowa Fisheries Primary Co-operative Ltd	Seaweed concessionaire
Buffeljagsbaai Marine Co (Pty) Ltd	Seaweed concessionaire
Taurus Cape Kelp	Seaweed concessionaire
Pearly Beach Fisheries	Seaweed concessionaire and processor
Kelp Products Pty Ltd (Kelpak)	Seaweed concessionaire; Seaweed processor
Afrikelp	Seaweed processor
CMD Industries	Seaweed processor
JLL Trading	Seaweed processor
KelpX (Pty) Ltd	Seaweed processor
Organics Atlantic	Seaweed processor
SeaBamboo Development	Seaweed processor
Viridis Marine	Seaweed processor
Spencer & Owen (Pty) Ltd, T/A RAWKELP	Seaweed processor; wholesaler

5.1.1. Kelp harvesting and collection

In South Africa, kelp is harvested either by cutting kelp fronds/blades from boats or whole kelp plants by diving or collecting beach-cast kelp (fresh and dry). In some cases, kelp harvesting involves cutting the entire 'head' of the kelp, rather than just the fronds or blades which kills the kelp plant. Harvesting only the secondary blades allows the kelp to regrow (Bolton, 2022). Although no quantitative data were available, most of this production is comprised of *E. maxima* with smaller volumes of *L. pallida* (Bolton, 2022; CSIR, 2022; DAFF, 2013; FAO, 2023a).

The "Policy on the Allocation and Management of Commercial Fishing Rights in the Seaweed Fishery: 2015" outlines seaweed harvesting rights in South Africa. Permits are required to harvest, transport and

export kelp, and kelp harvest is controlled by way of a Maximum Sustainable Yield (MSY) set by the DFFE. Kelp in South Africa may only be harvested and collected by concessionaires, within a designated concession area (including beach-cast kelp areas), or for personal consumption using a recreational fishing permit. Annually, concessionaires must apply for a permit to harvest kelp.

There are 23 concession areas in South Africa for commercial seaweed harvesting, of which 13 carry kelp harvesting rights and three are assigned to small-scale harvesting (Rothman *et al.,* 2020; Dr Mark Rothman, pers. comm). While most concessionaires harvest fresh kelp from the inshore areas, some concessionaires do not have the capacity for this work and allow other companies to collect on their behalf. The harvesters then get paid by the concessionaires based on the volume harvested, typically at ZAR 1.8/kg.

Previous reports have indicated that the total market for kelp in South Africa is around 7 000 – 10 000 tonnes per annum (CSIR, 2022). This is likely based on fresh weight (FW) destined for fresh abalone feed and biostimulant products. However, results from this project suggest that the total kelp biomass used in the industry equates to roughly 24 245 tonnes. This shows that demand and production has increased in comparison to previous government figures (Rothman *et al.,* 2020). Dry kelp can weigh between six and 10 times less than fresh kelp and, as a result, may be skewing total production biomass values. For this study, we used the industry standard FW/dry weight (DW) ratio of 6.3:1. Using this ratio, we estimated that over 12 719 tonnes of beach-cast kelp (FW equivalent) was collected in the last year. The amount of beach-cast collected kelp is considerably higher than previous records. This is likely due to issues in the monitoring and reporting process as there is no limit on the amount of beach-cast kelp that is allowed to be collected by concessionaires. Our results suggest that 11 525 tonnes of fresh kelp is harvested, while 2 019 tonnes of dried and milled kelp (mostly from beach-cast kelp) is available in the market.

The movement of kelp volume and value along the different value chain segments is shown in Figure 5 and Figure 6. Approximately 52% (2 019 tonnes DW; equivalent to 12 719 tonnes FW) of the kelp is dried, milled and graded and exported for alginate extraction (this includes almost all of the beach-cast kelp that is collected) (Figure 4). Around 24% (5 766 tonnes FW) is used as abalone feed, while 21% (5 194 tonnes fresh wet, plus 101 tonnes DW) is retained and processed locally into high-value biostimulants and liquid fertilisers (Figure 4) for local and export markets. A small amount of around 60 tonnes FW (<1.0% of total annual production) is used locally as an ingredient in formulated abalone feed (Table 2). Other minor seaweed products include compost tea, agricultural/horticultural moisture retention products, jewellery, decor, and cosmetics (CSIR, 2022). The current raw market value and price of the different products of these value chain segments are shown in Table 3.

Table 2: Volumes of different kelp products in South Africa. (FW=Fresh weight; DW=Dry weight).

Product	**Application**	**Volume (tonnes)**
Fresh kelp blades/fronds	Abalone feed	5 766 FW
Whole kelp	Local manufacture of biostimulants and liquid fertilisers	5 194 FW

Fresh kelp blades/fronds	Local manufacture of formulated abalone feed	60 FW
Dried, milled and graded kelp	Local manufacture of formulated abalone feed	16.2 DW (*102 FW equivalent*)
Dried, milled and graded kelp	Local manufacture of biostimulants and liquid fertilisers	101 DW (*636 FW equivalent*)
Dried, milled and graded kelp	Export for extraction of alginates	2 019 DW (*12 719 FW equivalent*)

Figure 4: Left: Dried and milled kelp (Source: Taurus Cape Kelp); Centre: Fresh kelp transported to South African abalone farms; Right: Plant Biostimulant (Source: Kelpak).

The use of fresh and beach-cast kelp is segregated as follows; 50% of fresh kelp is used as abalone feed and 45% is used for the production of biostimulants and liquid fertilisers, whereas the bulk of beach-cast kelp (95%) is dried and milled, and subsequently exported for alginate extraction. In 2018, the kelp market value was estimated to be ZAR 40 million (DEFF, 2020). In this study, we found the total market value for kelp (pre-value-addition) to be around ZAR 56.5 million.

*Table 3: Total raw market value and average sales price of different kelp products in South Africa. (FW=Fresh weight; DW=Dry weight; *=without value addition).*

Product	**Application**	**Sales price range (ZAR/kg)**	**Raw market value (ZAR)***
Fresh kelp blades/fronds	Abalone feed	1.8 – 10.0 (FW)	9.8 million
Whole kelp	Local manufacture of biostimulants and liquid fertiliser	2.5 – 12.0 (FW)	14.3 million
Fresh kelp blades/fronds	Local manufacture of formulated abalone feed	3.0 – 5.0 (FW)	240 000
Dried, milled and graded kelp	Local manufacture of formulated abalone feed	16.8 - 34.0 (DW)	292 800
Dried, milled and graded kelp	Local manufacture of biostimulants and liquid fertiliser	10.0 – 22.0 (DW)	1.6 million
Dried, milled and graded kelp	Export for extraction of alginates	15.0 – 20.0 (DW)	30.2 million
Total raw market value			**56.5 million**

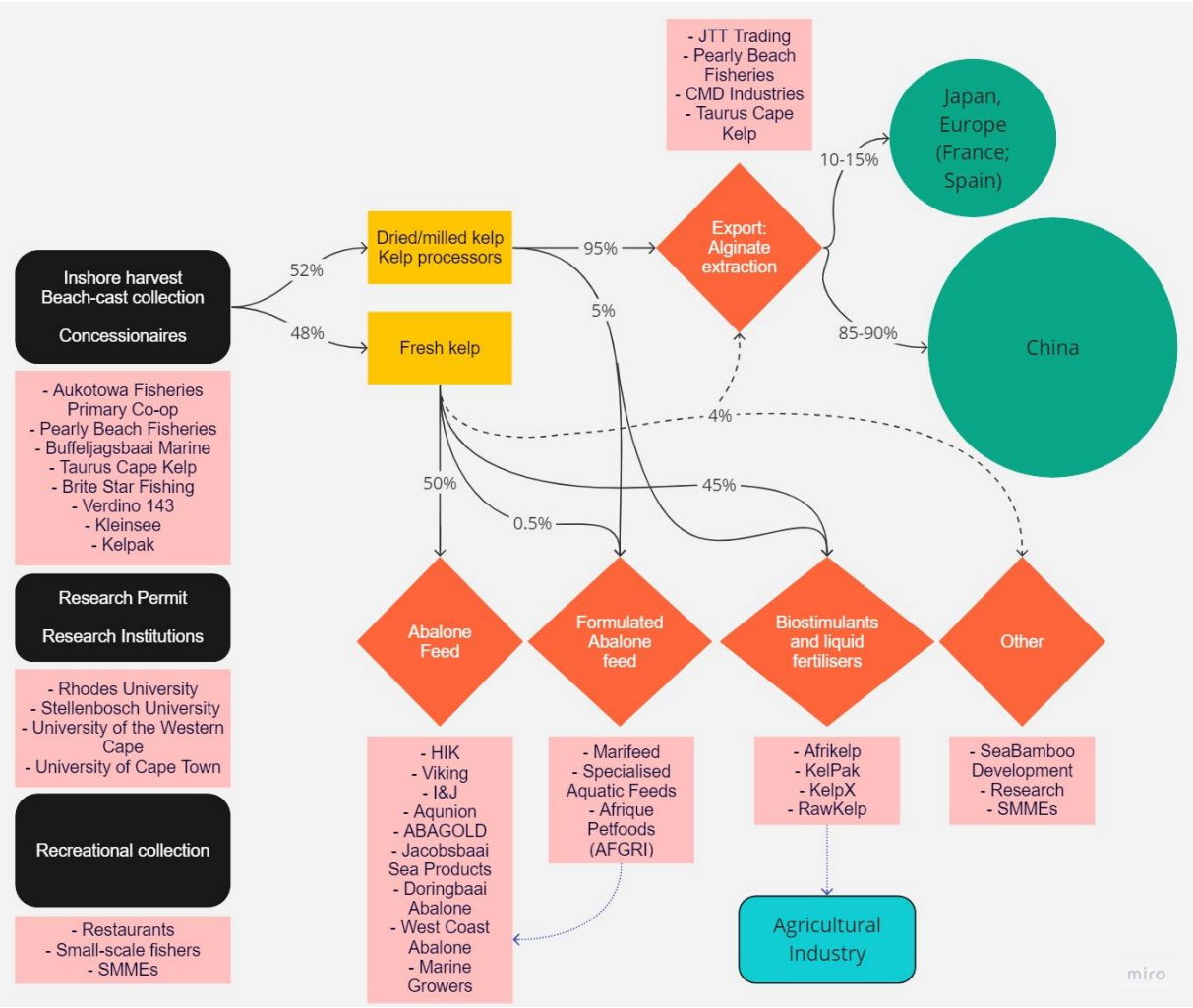

Figure 5: South African kelp Value Chain Linkages map showing the flow of kelp through the different market segments and identification of key value chain actors (solid line = primary markets; dashed line = surplus and secondary markets; blue dotted line = value-added markets).

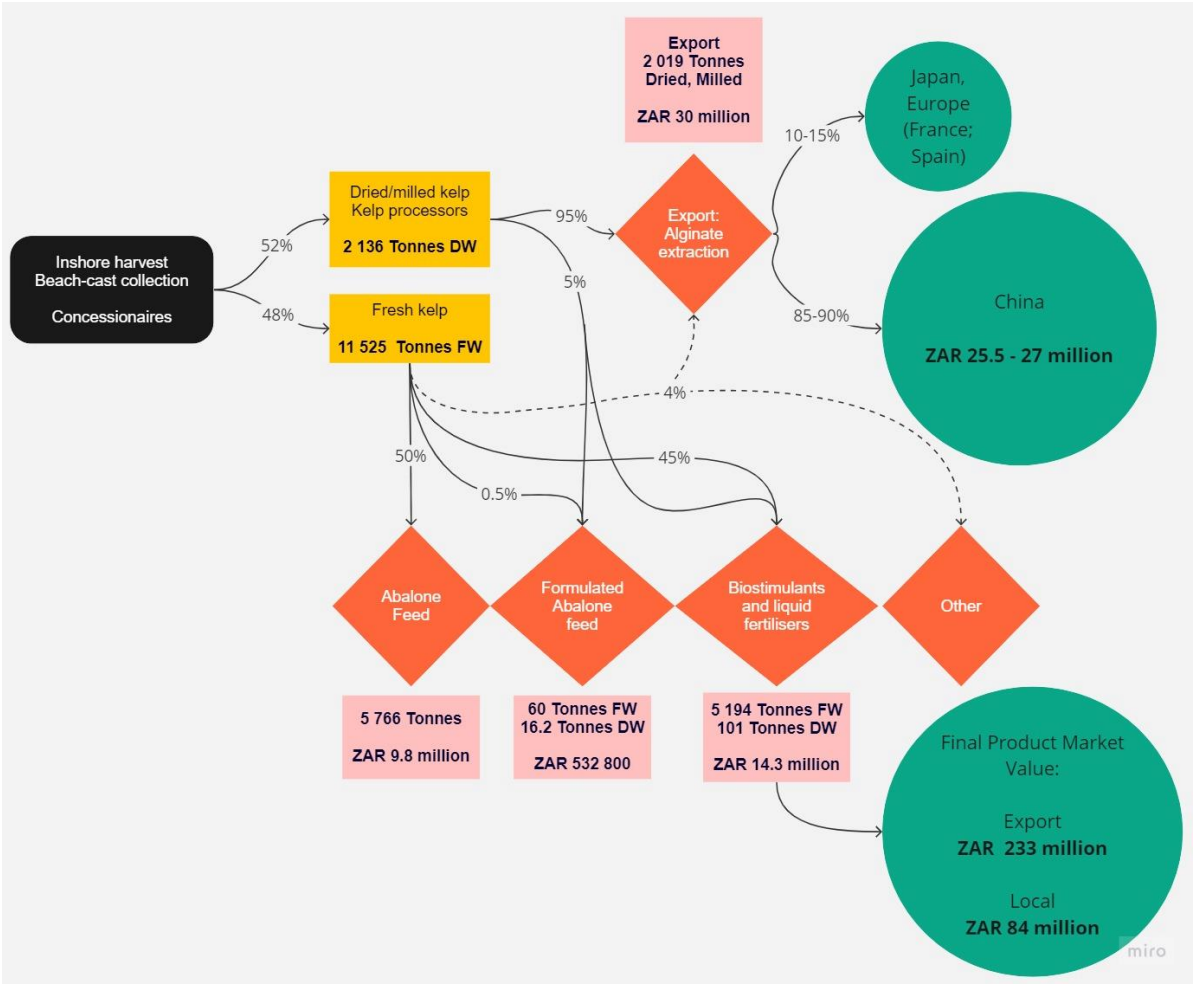

Figure 6: South African kelp Mass Flow Value Chain map illustrating the flow of kelp through the value chain, with indications of mass and price at critical intervals.

5.1.2. Market segments

5.1.2.1. Abalone feed

Figure 7: Kelp forms an important feed component on most abalone farms in South Africa.

Abalone farms purchase around 50% (5 766 tonnes annually) of the fresh harvested kelp (fronds) from concessionaires (Figure 7). These farms typically have exclusive agreements with concessionaires to ensure a relatively consistent and reliable supply of kelp. Some farms purchase larger quantities than others (min = 31 tonnes per annum; max = 2 000 tonnes per annum; mean = 640 tonnes). Quantities purchased depend on farm size and feeding regimens. Some farms use formulated abalone feed as their primary feed in combination with kelp. Kelp is only purchased for abalone feed in the Western and Northern Cape (Figure 7). The abalone farm in the Eastern Cape does not purchase any fresh kelp. Instead, they grow their own seaweed (*Ulva* and *Gracilaria*) because buying and transporting kelp from the Western and Northern Cape does not make financial sense.

The purchase price of kelp depends on the volume procured. For example, farms purchasing between 30 and 350 tonnes pay between ZAR 3.0/kg and 10.0/kg, whereas farms purchasing between 840 and 2 000 tonnes pay between ZAR 1.8/kg and ZAR 2.5/kg. The total market value of kelp as abalone feed is estimated as ZAR 9.8 million.

Abalone farmers prefer using fresh harvested kelp due to its quality, cleanliness and ease of use. However, because of inconsistencies in supply, due to adverse weather, they also have to purchase fresh beach-cast kelp (washed up the previous day/night). Poor weather conditions limit the number of sea days that kelp can be harvested in the inshore areas as it becomes dangerous for small vessels during rough sea conditions. In some cases, farms collect beach-cast kelp on behalf of the concessionaires and then pay a reduced rate. This reduced rate will vary from farm to farm but is indicatively between ZAR 1.8/kg and ZAR 2.0/kg. The volume of beach-cast kelp used for abalone feed is unquantified in this study; however, the available information suggests that it is purchased in small quantities (Rothman *et al.,* 2020).

5.1.2.2. Export of dried and milled kelp for alginate extraction

Figure 8: Dry beach-cast kelp (left) prior to being dried, milled and graded (right) for export.

The largest proportion of the total harvest of kelp in South Africa, when converted to its FW equivalent, is exported in a dried and milled form (Figure 8). Most kelp processors, who dry and mill kelp are also concessionaires or have an exclusive agreement with a concessionaire. Based on engagements with kelp processors of dried and milled product, a weight loss ratio of 6.3 is standard across the industry. Currently, around 12 719 tonnes (52% of total kelp production in South Africa, FW equivalent) is dried and milled and exported to China, Japan and Europe (mainly Spain and France) for hydrocolloid alginate extraction. In total this equates to around 2 019 tonnes DW. Unfortunately, these export data cannot be validated against export trade data as all seaweed (including kelp) is collectively reported as "Seaweeds and other algae", under Harmonised System (HS) codes 121229, 121221 and 121220. According to UN Comtrade, South Africa exported roughly 3 500 tonnes of seaweeds and other algae in 2022 (UN, 2023); however, this cannot be further disaggregated. Likewise, there is no specific harmonised tariff code for kelp (i.e., all grouped as seaweeds and algae) on the South African Revenue Service (SARS) portal.

Moreover, reported seaweed exports do not always match harvested quantities because, in some years, material is stockpiled until prices improve (DAFF, 2013). The international seaweed industry is controlled by a few large international companies that are able to control market prices. Marketing of seaweed is complicated and requires overseas contacts to sell seaweed and to obtain a good price (DEFF, 2020). As a result, returns for South African companies that do not process locally may be marginal, and they often stockpile material while negotiating prices. As such, the high volumes reported in this study could represent the current upper threshold of South Africa's export potential.

Milled kelp is graded into 25mm and 3mm chips, and 800-micron powder. The alginate extracted from the kelp is converted into sodium alginate and used as a thickener, stabiliser, and emulsifier in food products as well as other industries (e.g., pharmaceuticals and textile printing). Most dried and milled kelp processors have export forwarding agents who are responsible for coordinating transport via sea freight. Roughly 85% (1 716 tonnes) is exported to China while the remainder (303 tonnes) is sold to Japan, France and Spain.

Most of the kelp (around 98%) that is dried and milled is beach-cast kelp, although small amounts of fresh kelp are also dried and milled. Some processors import the sodium alginate back to South Africa

for further distribution to other African countries (e.g., Morocco, Nigeria, Ghana, Zambia), while some is sold directly to local food processing companies, such as Freddy Hirsch. The sales price of dried and milled export kelp is between ZAR 15.0/kg and ZAR 20.0/kg. Prices to China are typically around ZAR 15.0/kg due to the higher volumes, while European prices are slightly higher at around ZAR 20.0/kg. The total export market value of dried and milled kelp for alginate extraction is estimated to be ZAR 30.2 million.

While China imports the greatest proportion of South African dried and milled kelp, it would appear that this market is volatile with no consistency nor long-term guarantees. For example, during this study, several concessionaires reported a market crash and as a result were not able to sell to China. Based on our engagements with stakeholders, it seems that the demand for dried kelp in China has declined since the easing of their COVID-19 regulations. During the pandemic, there was a shift in dietary preferences, with fresh foods being consumed less frequently, while demand for processed and ready-to-eat meals surged as the population was required to remain indoors and at home. These processed foods require alginate. Consequently, the demand for kelp increased, leading to higher prices. However, with the gradual return to normality and a shift in consumer habits, the demand for dried kelp has moderated, resulting in lower prices.

5.1.2.3. Biostimulants and liquid fertilisers

Biostimulant (Figure 9) and liquid fertiliser (containing nitrogen, phosphorus and potassium; e.g., Kelpak) manufacturing companies (Figure 10) form an important component of the agricultural industries sector in South Africa. Kelp products are frequently used to enhance root flush and fine root development in order to bolster plant resilience, boost nutrient absorption, promote vegetative growth, and enhance fruit quality (Stirk *et al.,* 2014). Kelp biostimulants and fertilisers are commonly administered in liquid form through irrigation or as a soil drench, although foliar application is also an option. Additionally, they can be combined with beneficial fungi to extend the fungi's lifespan and enhance their effectiveness in the soil.

Figure 9: Biostimulants manufactured in South Africa from kelp (Sources: Kelpak; Afrikelp; RawKelp; KelpX).

Figure 10: Liquid fertilisers manufactured in South Africa from kelp (Source: Kelpak).

Currently, around 5 194 tonnes of fresh kelp and 101 tonnes of dried and milled kelp (45% of fresh kelp) is purchased by South African kelp processing companies to produce biostimulants and liquid fertilisers. While both kelp stipes and fronds are typically used to produce biostimulants, some companies use either stipes or fronds to produce specific products. These processing companies include:

- Kelpak, a producer of biostimulants and liquid fertilisers with distribution locally and internationally to over 70 countries (Kelpak is the only company that is currently producing liquid fertiliser).
- AfriKelp, a producer of liquid biostimulants with distribution locally and internationally to 44 countries (including the USA, Latin America, Europe, Australia, China, India, New Zealand, Egypt, and Morocco).
- KelpX, a biotech manufacturer of natural plant growth promotors both locally and internationally.
- RawKelp, a raw material supplier to manufacturers and blenders of organic fertilisers and biostimulants and supplier of raw material for the manufacture of own brand liquid kelp and kelp paste.

Afrikelp and Kelpak are the most prominent biostimulant manufacturers in South Africa, and collectively use 85% of the raw kelp supply (liquid kelp, fresh kelp, and dried and milled kelp).

The price of kelp used to manufacture biostimulants and liquid fertilisers fluctuates depending on factors such as the volume purchased, availability, demand, and the form of the kelp (fresh or dried and milled). Large-volume purchases of fresh kelp, exceeding 1 000 tonnes, generally command a price of ZAR 2.5/kg, whereas smaller quantities are typically sold in the range of ZAR 5.0/kg to ZAR 12.0/kg. Dried and milled kelp prices range between ZAR 10.0/kg and ZAR 22.0/kg. The fluctuating prices are more relevant for buyers who purchase smaller volumes. The total raw market value of purchased kelp for biostimulants and liquid fertilisers is around ZAR 14.3 million.

Biostimulant and liquid fertiliser processing costs are around ZAR 20.0-25.0/kg. Smaller manufacturers have higher processing costs while larger manufacturers have lower costs, due to economies of scale. The yield, representing the percentage of raw material remaining after processing, typically stands at around 80%, although it can exceed this figure due to the inclusion of water during the liquid extraction

process and differences in processing methods. Similarly, sales prices also vary depending on the product. On average, the wholesale price of biostimulant and liquid fertiliser is around ZAR 70.0/L. Most retailers add a markup on top of these prices. Based on the available data, retail prices of biostimulant and liquid fertiliser vary significantly (between ZAR 90.0/L and ZAR 220.0/L). In addition, some biostimulant manufacturers purchase liquid kelp (kelp extract) directly from processors. However, based on the information that we have received, we estimate the wholesale market value for biostimulants and liquid fertilisers to be around ZAR 317 million.

Some liquid kelp is also sold as a white-label product to larger fertiliser companies to market as their own house brand.

A large proportion of the final products is exported. Some manufacturers export 30% of their product while others export 90%. Overall, 64% of biostimulants and liquid fertilisers are exported with an approximate value of ZAR 233 million.

5.1.2.4. Formulated abalone feed and animal feed additives

Currently, abalone feed manufacturers collectively purchase and use approximately 60 tonnes of fresh kelp and 16.2 tonnes of dried kelp at a cost of approximately ZAR 532 800. These volumes equate to around 0.2% of total annual kelp production. The purchase price for this kelp varies based on volume and whether the kelp is in a fresh or dried and milled form. Fresh kelp prices typically range between ZAR 3.0/kg and ZAR 5.0/kg. In contrast, smaller quantities of dried kelp can command higher prices, varying from ZAR 16.8/kg to ZAR 34/kg.

It should be noted that because most of the annual kelp production is either used as abalone feed (fresh) or is exported (dry), feed manufacturers struggle to access larger quantities domestically. Consequently, feed manufacturers annually import approximately 17 tonnes of raw kelp products from Europe.

It is unclear how much kelp is used in the production of other animal feeds (i.e., pets and livestock). However, from our engagements, there is a market for dried kelp as a supplement in the agricultural feed industry. For example, some dried kelp distributors sell to livestock farmers and feed mixers who use kelp as a supplement in licks (ready-mixed licks provide concentrated protein, energy, minerals, vitamins, and trace minerals for optimum animal production) which promote gut health and overall animal productivity.

5.1.2.5. Research

Research plays a crucial role in identifying new products and uses for kelp and the development of the sector as a whole.

Small, unquantified volumes of kelp are used by research institutions in South Africa including Rhodes University (Biochemistry Department), Stellenbosch University, the University of Cape Town, the University of KwaZulu-Natal, and the University of the Western Cape. These institutions either harvest their own kelp using research permits obtained from the DFFE, or through partnerships with

biostimulant companies (i.e., Afrikelp and KelpX). The biostimulant companies also provide financial support for research aimed at extracting value-added products such as fucoidan, alginates, and phenolic compounds. These extracted substances undergo scrutiny for their biological activity, to explore potential applications in pharmaceuticals and the nutraceutical/food industry. Furthermore, research is being conducted on valorisation pathways, using kelp as a raw material. This includes the development and optimisation of extraction techniques to recover, among others, polysaccharides and biostimulants. Research is also being conducted on kelp as an aquafeed ingredient as well as its potential as a vector to transfer disease between aquaculture systems. This includes research into mitigating the chance of disease transfer when harvested kelp is included as a dietary ingredient in formulated abalone feed.

5.1.2.6. Restaurants and food retail

The restaurant industry has been exploring the integration of kelp into their dishes and menus. However, consistent sourcing of kelp from concessionaires remains a persistent challenge. As a result, it is unclear how much kelp is being used in the restaurant industry. Additionally, many restaurants and small-scale producers using and selling kelp products acquire their kelp from unpermitted sources. Numerous small-scale fishers harvest kelp without commercial permits, relying on recreational fishing permits that explicitly prohibit the sale of kelp. Certain small-scale fishing cooperatives have pursued monthly access to small quantities (one ton) of fresh kelp fronds from concessionaires for various purposes. Unfortunately, concessionaires can only supply larger volumes (> 1 ton) of fresh kelp, which introduces logistical and cost challenges related to maintaining the cold chain, storage, processing, and value addition. Nevertheless, there are opportunities for the development of this niche market, driven by the demand from upscale restaurants for other seaweed products like klipkombers or local nori (*Porphyra capensis*) and sea lettuce (*Ulva* spp*.).* For example, upscale restaurants such as Wolfgat collect and use indigenous coastal ingredients which include a variety of seaweed species, such as *L. pallida* and *E. maxima* (see Wolfgat).

Large corporate food retailers such as Woolworths currently do not sell any products containing South African kelp. At this stage, it seems as if all the seaweed in their current products is imported from Asia and comprises red seaweeds (*Porphrya*).

5.1.2.7. Nutraceuticals and cosmeceuticals

Seaweed is incorporated into dietary supplements for human consumption and sold in health food shops and pharmacies. It is, however, unclear to what extent these seaweed/kelp products use South African kelp and in what volumes. Examples include Vetlomar's Allergy Itch Relief Cream for animals which is made of South African *E. maxima*, and Afrakari's skincare products which are made from a combination of South African kelp species (Figure 11). It appears that Korea is also importing *E. maxima* from a concessionaire for the production of cosmetics. This shift is due to the diminishing supply of *Ecklonia cava* in Korea caused by climate change. Further investigative work is needed to understand this node of the value chain and the opportunities it presents.

Figure 11: Examples of retail kelp products.

5.2. Kelp Value Chain Gaps and Inefficiencies

According to the Phase 1 pre-feasibility study, market opportunities for kelp and kelp-derived products to support increased kelp production are based on expansion of the local market, and meaningful access to export markets. The pre-feasibility study suggested that there was a local market supply shortfall, with an unquantified potential export market for processed products such as biostimulants. Moreover, the study suggested that the local and export markets were projected to grow, given the increasing demand for kelp for abalone feed, biostimulants, and other niche markets (CSIR, 2022). However, to grow the sector, several value chain gaps and inefficiencies must be addressed. We have identified several gaps and inefficiencies in the South African kelp value chain and these are discussed below.

5.2.1. Local food-grade processing facility

There is currently no food-grade processing facility for kelp in the Western Cape. As a result, all kelp products for human consumption must be shipped to Johannesburg, Gauteng. This increases costs substantially for kelp processors and retailers. Given that most kelp is harvested, collected and processed in the Western Cape, a local food-grade processing facility should be developed and established to reduce the cost of transport and as a result, the cost of production. This is crucial if kelp is to be developed into food products.

Animal feed companies have reported the occurrence of heavy metals in kelp and, while this is seasonal, it poses a threat for kelp destined for both animal and human consumption. It should be noted that kelp contains naturally high levels of organic iodine, and organically bound arsenic. This further demonstrates the need for a Western Cape-based food-processing centre.

5.2.2. Niche restaurant market

As discussed in Section 5.1.2.6, there is currently no formal market for kelp in the restaurant sector. In cases where kelp finds its way into restaurants, it is often sourced through recreational harvesting. Although the quantities involved are small and most likely would not pose a significant threat to the kelp resource, the absence of legitimate access to kelp hinders the restaurant industry's efforts to promote seaweed consumption and build greater demand for it.

The introduction of farmed kelp would create an opportunity for restaurants to acquire and utilise kelp legally. Moreover, aquaculture would be able to provide a superior quality product and custom selection of kelp (e.g., frond tips) on a consistent basis. This could help fill the niche market for sought-after seaweed products, which are in demand among South Africa's high-end restaurants. Moreover, digital marketplaces like ABALOBI could play a key role in cold-chain logistics and distribution of kelp.

5.2.3. Small-scale processing

As detailed in Section 5.1.2.6, kelp is a key ingredient in numerous dishes consumed by coastal communities and for use in traditional medicines (van Wyk 2008). However, the absence of commercial permits for kelp product sales restricts the quantity of kelp reaching local markets. The harvesting and processing of kelp could potentially provide an alternative source of income for small-scale fishing communities. Moreover, given that the majority of fresh kelp is not originally earmarked for local food markets, creating avenues for small-scale fishers to distribute kelp within these markets holds significant potential. This becomes especially enticing when considering the option of marketing it as a premium, sustainable product that appeals to high-end restaurants as well as promoting the consumption (as food) and use of seaweed products (soaps, gels etc.) by the public.

5.2.4. Inconsistent supply and access

The supply of kelp to most South African markets is highly inconsistent. For example, when concessionaires cannot harvest kelp (as a result of poor sea conditions, weather or any other reason) then abalone farms have to do without it or have to use washed-up kelp. The supply of kelp is further impacted by increasingly unpredictable weather, which limits the harvest of fresh kelp and subsequently impacts on abalone feed management. For small buyers of fresh kelp (feed producers and processors), inconsistent supply constrains their production volumes while also increasing the cost of fresh kelp due to the increased demand. The cost of kelp fluctuates at different nodes of the value chain and depends on purchase volume, operational scale, agreement with concessionaires, and the reliability of supply. This financial variability has a notable impact on smaller-volume buyers in contrast to their counterparts purchasing larger quantities.

While there are some exclusive sales agreements between concessionaires and buyers, in many cases the raw material is sold to the "highest bidder". Coupled with its high export value, it is difficult for small-scale processors to establish reliable business relations with concessionaires to secure enough dried kelp for the local market. Furthermore, some concessionaires are also kelp processors and therefore control the market from end-to-end and tie up a large portion of the available kelp supply.

The accessibility and supply of kelp can also be significantly constrained by the vast distances between harvest sites, processors, and buyers. Escalating fuel prices and the resultant increase in transport costs adds to the volatility of raw material prices. Implementing enhanced logistics strategies could effectively mitigate these risks. These measures would not only streamline the value chain but also ensure the efficient and cost-effective transportation of kelp. Additionally, if farmed kelp were to be utilised as a raw food product (as abalone feed or for human consumption), there would be a requirement for swift kelp processing to extend its shelf life. This involves rapid food processing techniques such as blanching

and packaging. The Chinese have developed methods for prolonged storage of kelp specifically for its use as aquafeed.

5.2.5. Kelp aquaculture

Given the wild harvest limitations of the South African kelp resource, particularly in the southern part of the west coast where the demand (for fresh harvested kelp) from abalone farms is highest, any expansion of local and/or export kelp markets will depend on successful commercial kelp farming (CSIR, 2022). Although there is currently no commercial farming of kelp in South Africa, the KFP pre-feasibility study concluded that there is potential for sea-based farming of kelp on the west coast of South Africa, specifically in Saldanha Bay which is favourable from both an environmental and market perspective (CSIR, 2022). In Lüderitz (Namibia) kelp farming has been pioneered by Kelp Blue, which successfully operates a 4-hectare pilot kelp farm. Kelp Blue will have access to 6 000 hectares of offshore ocean space. Here, the offshore ocean conditions are ideal for cultivating kelp. These conditions are unlike the coastal conditions of Lüderitz or Saldanha Bay and require significant engineering infrastructure and additional inputs. Kelp Blue has also negotiated a multi-year offtake agreement for biostimulant with a leading European buyer. Kelp Blue is also conducting research and development (R&D) into plastic packaging (bioplastics) and textiles from kelp waste.

Food safety testing is a crucial aspect that kelp farmers will have to prioritise to sell their products. Currently, the burden of food safety tests for mussels and oysters falls on the farmers, incurring substantial costs. If we anticipate that oyster and mussel farmers might venture into kelp farming, or if kelp farming becomes an independent venture, these added testing expenses could strain profits. This situation might discourage small farmers from entering the kelp farming industry. Therefore, it is essential to address questions regarding which tests are necessary, who will conduct them, the associated costs, and whether a collaborative funding model involving both industry and government could be devised. Addressing these concerns is vital for the sustainable growth of the kelp farming sector.

5.3. Socio-economic Impact of the Kelp Value Chain and Opportunities for Improvement

The kelp industry provides approximately 350 direct jobs (DEFF, 2020). Specifically, these are in the harvesting and collection of kelp, processing, value-addition and distribution. This does not include indirect kelp-associated jobs on abalone farms, and in research, government and civil society. Of the approximate 350 direct jobs, our results suggest that roughly 47% are held by women and 38% by young people (35 years or younger).

There is potential to drive employment within the small business and restaurant sector of the value chain, particularly due to the limited access that small businesses, restaurants, and small-scale fishers have to a dependable and steady supply of kelp. Achieving this would require commercial rights to be granted to small-scale communities through the small-scale fishing rights allocation process or streamlining the process for concessionaires to place small-volume orders for kelp with these communities. However, this is unlikely within the current context due to the difficulties with the

permitting and allocation process and because the financial benefit may not outweigh the logistical cost for concessionaires. One way to increase access to kelp product by small-scale operators is by farming kelp. This would ensure the sale of smaller volumes at higher prices and create multiple employment opportunities throughout the value chain (i.e., in marketing, distribution, logistics, cold-chain management, and value addition).

Developing the kelp processing and value-addition components of the value chain can also create additional jobs. South Africa's kelp processing and value-addition markets (i.e., biostimulant and liquid fertiliser and animal feed manufacturing) are highly competitive. However, the World Bank Group's *Global Seaweed: New and Emerging Market Report* (2023) identified these as short-term global opportunities (before 2025). Improved technologies (extraction and processing), a readily available export market and shifting consumer preferences provide an opportunity for growth and expansion in these markets. Additionally, it will be important to explore alternative value-added markets like nutraceuticals, bioplastics, and fabrics. These markets were considered as medium-term opportunities (2024-2028) in the World Bank Group's report.

6. PART 2: MARKET OPPORTUNITIES AND VALUE CHAIN DEVELOPMENT

6.1. Global Markets

The global seaweed market is experiencing significant growth, from 10 million tonnes in 2001 to 36 million tonnes in 2021 (FAO 2023b). This includes both wild-harvested and farmed seaweed, but overwhelmingly farmed. Asia contributes 98% of this production and dominates the market. China and Indonesia are the two largest producers, supplying 56% and 27% of farmed seaweed by volume, respectively. The rest of the world outside Asia, produces less than 2% of the total volume of farmed seaweed (Figure 12) (FAO 2023b; World Bank Group, 2023). This is driven mainly by the traditional importance of seaweed in Asian cuisine and its recent popularity in global cuisines (Rioux *et al.,* 2017).

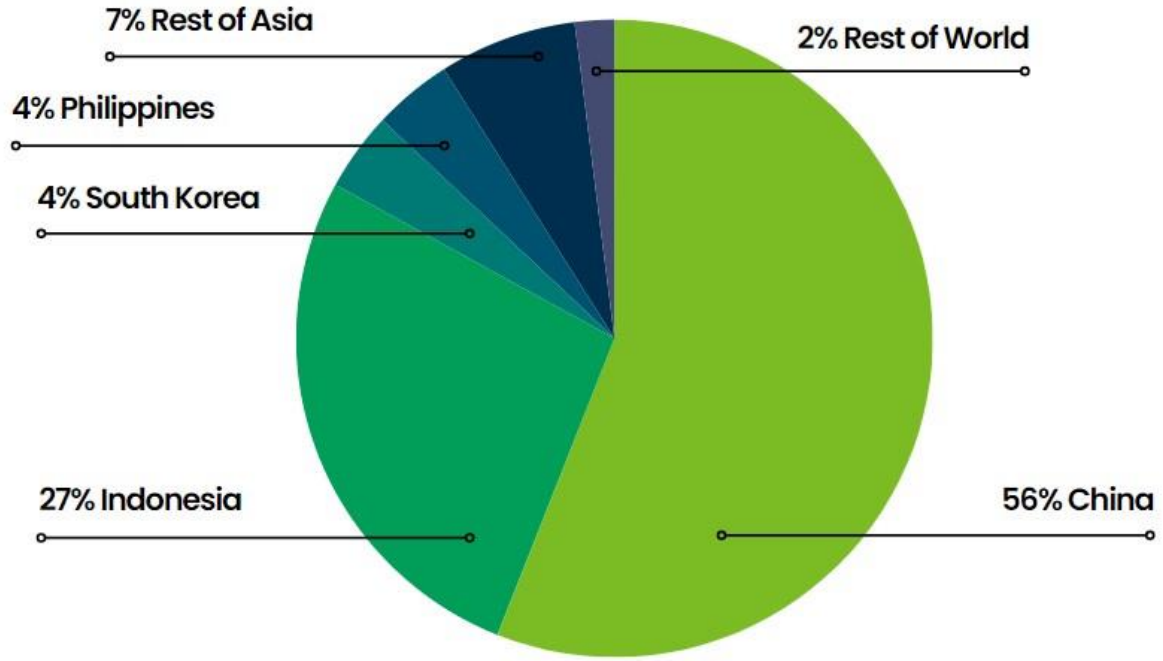

Figure 12: Global seaweed production volumes 1990–2020 in key countries (Adapted from the World Bank Group's Global Seaweed: New and Emerging Market Report (2023)).

Recently, there has been growing interest and investment by the public and private sectors in seaweed farming in North America and Europe. For example, The Unites States Department of Energy has invested USD 55 million in seaweed biofuel research (Dickie, 2023), while The European Union views seaweed farming as a crucial element of its blue economy strategy (European Commission, 2022). As of 2022, around 200 startups in Europe, North America, Australia, and New Zealand were dedicated to seaweed cultivation (Hermans, 2023). Despite the growing interest, the production volumes of farmed seaweed in North America and Europe remain relatively low, amounting to just a few hundred tonnes and showing slow growth. Similarly, Africa and Latin America possess immense potential for seaweed farming due to their extensive coastlines and Exclusive Economic Zones. However, the increase in production volumes in these regions are also slow.

Seaweeds have a versatile composition of carbohydrates, minerals, lipids, proteins, pigments, polyphenols, vitamins, and other nutrients. However, this composition varies based on factors such as species, growth stage, and environmental conditions, making seaweed a valuable raw material for a diversity of applications.

Many seaweeds are nutrient-dense and highly regarded for their unique textures and flavours, and therefore have become a coveted product in the food industry (Cai, 2021). In addition to being directly consumed by humans, seaweeds are used in a diversity of applications. For example, as aquafeeds (abalone and sea urchin) and as food additives; hydrocolloids such as alginate, agar, and carrageenan, prized for their gelling and stabilising properties (Rosenboom *et al.*, 2022). These hydrocolloids, along

with seaweed polysaccharides like fucoidans and laminarin, are used in various sectors due to their bioactive properties (Kraan, 2012).

Global production of brown seaweed, including kelp, has increased at a rate of 3.2% per annum, from 9.25 million tonnes in 2000 to 18.34 million tonnes in 2021. In 2022, farmed brown kelp species from China and South Korea were priced between USD 400 (ZAR 7 500) and USD 500 (ZAR 9 500) per ton FW at farm gate. In the USA, production costs range from USD 300 (ZAR 5 700) to USD 1 000 (ZAR 19 000) per ton FW (Reuters, 2023). South African prices for wild kelp (this study) ranged from ZAR 1 800 to 12 000 per ton FW. While these prices are similar, comparing them is challenging due to diverse contexts associated with market dynamics, consumer demands and input costs (Seaweed Insights, 2023).

6.2. Short-, medium- and long-term market opportunities

According to the recently published *Global Seaweed: New and Emerging Market Report* (World Bank Group, 2023) there are significant market opportunities in the seaweed industry. These were categorised into short-, medium-, and long-term opportunities. In the short-term (before 2025), biostimulants, liquid fertilisers, animal feed additives, pet foods, and methane-reducing additives were identified as promising markets, driven by their competitive value propositions. Medium-term (2024–2028) opportunities included nutraceuticals, alternative proteins, bioplastics, and fabrics, although challenges such as production costs and functionality need to be addressed. In the long term (after 2028), pharmaceuticals and construction materials (such as fibreboard or bioplastic panels for interior design projects), were seen as emerging markets (Table 4).

Table 4: Market opportunities in the seaweed industry (Adapted from the World Bank Group's Global Seaweed: New and Emerging Market Report (2023)).

Short-term (before 2025)	Medium-term (2024-2028)	Long-term (after 2028)
• Biostimulants • Liquid fertilisers • Animal feed additives • Pet foods • Methane-reducing additives	• Nutraceuticals • Alternative proteins • Bioplastics • Fabrics	• Pharmaceuticals • Construction materials

A significant driver for these markets is the growing demand for "green" products. Moreover, ecosystem services offered by kelp farming, include carbon sequestration, biodiversity enhancement, and bioremediation. These services incentivise investment into the industry and further align with consumer demand. Furthermore, the expansion of seaweed farming aligns with several of the United Nations Sustainable Development Goals (UN SDGs). By tapping into these new markets and applications, the seaweed industry can generate value, uplift communities, and contribute significantly to a sustainable future. Globally, blue carbon credits for kelp cultivation are expected by 2025 (World Bank Group, 2023). However, challenges around measuring carbon credits, slow certification, and lack of awareness need attention and this may be an unrealistic expectation globally.

The opportunities for the kelp industry, as identified by stakeholders in the aquaculture value chain development survey (this study), are outlined in the box below.

Opportunities for developing kelp aquaculture and market opportunities in the value chain as identified by stakeholders who participated in this study

Physical and Environmental

- Nutrient-rich west coast waters ideal for growing certain kelp species
- Availability of suitable ocean spaces for small- to medium-scale kelp farming
- Kelp farming as a carbon sink and climate change mitigation strategy
- Kelp farming as an environmentally friendly alternative to wild kelp harvesting
- Utilising natural kelp for food security, carbon sequestration, and alternative livelihoods
- Integrated aquaculture with established mussel farms

Industry Development

- Collaborations with international stakeholders and research institutions to streamline regulations, enhance production, and promote market growth
- Diversification of the South African aquaculture industry through kelp farming
- Increase in global interest and research on kelp products and aquaculture
- Broad-based benefits for lower socio-economic communities
- Job creation potential, especially for unemployed youth and women, contributing to economic growth
- Opportunities in processing, marketing, and distribution due to labour-intensive nature of kelp farming
- South Africa's competitive advantage due to low labour costs
- Development of a skilled workforce through upskilling programs
- Creation of lucrative small-scale farmer support groups and demonstration projects
- Expansion of the kelp industry leading to increased job security
- Potential for funding expansion through low-risk small-scale cultivation projects
- Use of kelp in processed foods, offering a healthier, less expensive alternative nutritional source
- Use of kelp as biomass for fuel and wastewater treatment
- Multiple products derived from kelp (e.g., bioplastics, textiles, abalone feed, fertilisers, animal feed)
- Potential for low-volume/high-value products in pharmaceuticals, nutraceuticals and cosmeceuticals

Markets and Economy

- Attracting international investment, industries, and experts
- South Africa's attractiveness for scientific R&D
- Good working relationships between industry, government and academia
- Integration with existing aquaculture and fisheries sectors in the Western Cape
- Capitalising on carbon capture and nutrient capture to protect South Africa’s kelp forests and enhance the Blue Economy
- Increasing global interest in seaweed and kelp products as an export opportunity
- Unique kelp species in South Africa for innovative uses in medicine, cosmetics, food production, and plastic production
- Diversification into high-value niche markets
- Kelp farming's contribution to carbon sequestration and sustainable practices, offering opportunities for carbon credits

- Involvement of coastal communities through education, job creation, and market access for economic growth and environmental stewardship
- Solid scientific and engineering support ensuring sustainable practices, higher yields, and marketable quality
- Collaboration with government, private entities, and research institutions for enhanced industry development, research, education, and sustainability initiatives
- Secure market access and export opportunities for building confidence and profitability, especially in high-value product segments
- Involvement of coastal communities in kelp production through skills transfer and job creation fostering community-based projects within the value chain
- Undertaking a comprehensive Value Chain Analysis and market Assessment study for informed decision-making and risk mitigation

There is a level of uncertainty whether the farming and selling of fresh kelp in Saldanha Bay is an economically viable approach to industry development. The competition to purchase raw kelp from established concessionaires is intense, and they have lower costs in acquiring raw materials. Farms, in contrast, may incur higher expenses for infrastructure, technology, labour, and other inputs. Hence, it may be essential to integrate the business of kelp farming with processing and value-addition. This strategy will enhance competitiveness, allowing entry into diverse markets and ensuring sustainable growth. However, it may be more complex to establish a processed product in the market and acquire the capital to finance this. Therefore, it may be more viable to focus on producing premium fresh kelp to already established processing and value-addition companies.

On the other hand, farming ensures a stable and reliable supply of kelp, unlike the unpredictable nature of wild kelp harvests. The consistency of supply becomes crucial, especially when demand rises and wild harvests are limited by an MSY. Consequently, kelp farming may have the potential to be highly profitable without the need for extensive processing operations. For instance, a substantial market demand for various products like biostimulants exists, which current processors struggle to meet due to a shortage of raw materials. If farmers can guarantee a consistent supply, processors would likely be willing to pay a higher price.

Both scenarios outlined above must be assessed in a detailed economic feasibility study.

The global demand for seaweed-based products for industrial, agricultural and feed-related applications, as well as seaweed-based food products, is on an upward trajectory (CSIR, 2022; Sande, 2022; World Bank Group, 2023). In addition to the extraction of alginates, potential uses for farmed South African kelp include biosorbents in heavy metal wastewater remediation, biofuels, pharmaceuticals, nutraceuticals and cosmetics, food products, and alcohol for consumption and/or industrial uses (Stirk and van Staden, 2004; CSIR, 2022; BST, 2023; World Bank Group, 2023). Importantly, emerging companies must consider maximising value retention in South Africa. For example, the current model for alginates sees relatively low-value dried and milled kelp exported for processing into higher-value alginates in export markets. This likely results in a significant potential loss in value to South Africa's economy. If raw product were to be a final product, this would need to be directed at niche

markets such as high-end restaurants or would need to be driven by a clear lack of supply and offtake agreements with buyers willing to pay premium prices.

The most significant market opportunities for South African farmed kelp are discussed below.

6.2.1. Biostimulants and liquid fertilisers

In 2022, the global seaweed-based biostimulants market was valued at USD 1 billion (World Bank Group, 2023), and projections suggest an annual growth rate of approximately 10% between 2022 and 2030. As such, the market is expected to reach USD 1.8 billion by 2030. Factors that support these projections include the renewed focus on sustainable farming practices in response to climate change, rising fertiliser prices and seamless integration potential within existing supply chains due to compatible processing requirements. However, several persistent challenges are primarily related to the perceived efficacy of biostimulants and the complexity of their application, necessitating significant efforts in end-user education. While Europe currently dominates the market for biostimulants, strong growth is anticipated in the Asia-Pacific region, particularly in China and India. This is driven by the increasing need for food and a focus on sustainable farming (World Bank Group, 2023). Therefore, the Asia-Pacific region may be a target region for an emerging and expanding kelp-based biostimulant industry.

The biostimulant market in South Africa is highly competitive, and it is important to acknowledge the substantial challenges associated with entering this market. Presently, the kelp-based biostimulant industry is dominated by two major companies, namely Kelpak and Afrikelp, and several smaller producers such as KelpX, RawKelp, and Organics Atlantic. Successful penetration of this market will require substantial capital investment for the development of a distinctive product, capable of competing with established industry leaders, and catering to consumer demands.

Nevertheless, the discovery and availability of new and emerging technologies for manufacturing biostimulants and liquid fertilisers, a readily accessible export market, and evolving consumer preferences create a strategic opportunity for the development of kelp farming in South Africa. For prospective kelp farmers, capitalising on this competitive edge should be considered low risk.

The increasing consumer demand for 'organic,' 'natural,' and ‘environmentally friendly’ products are promising for the biostimulant industry. Additionally, the international export market provides a highly accessible entry point, allowing companies to commence market entry at an earlier stage compared to the current certification and development process which can take as long as five years (addressed in Section 6.4.2.1). Kelp extracts (without additives) are considered a ‘raw ingredient’ and can therefore be exported without waiting for certification/registration. However, the international registration process for biostimulant products can take six months to two years, costing ~ ZAR 100 000. Hence, to produce products that compete in the global market requires substantial capital investment and this may be difficult for new entrants. Depending on the scale and technology requirements, such investments generally range from ZAR 30 million to ZAR 100 million.

6.2.2. Animal feeds

The animal feed industry is competitive, but growth opportunities exist due to technological advancements, research into methane reduction, and changing consumer preferences (World Bank Group, 2023). The global feed additive market was valued at USD 39 billion in 2022, with a projected 3.9% annual growth rate from 2022 to 2030 (World Bank Group, 2023). The seaweed-based (red, brown, and green seaweeds) animal feed additive market is expected to reach USD 1.1 billion in 2030. Key drivers include rising concerns about meat quality and safety, disease outbreaks, animal productivity, and the unique benefits of seaweed-based products, which may include reducing the need for animal antibiotics. Challenges to entering this market include securing sufficient seaweed volumes and demonstrating results through large-scale trials.

In addition to general animal feeds, there are opportunities for kelp as an additive in both aquafeeds and pet food. The production of aquafeeds has traditionally centred around fishmeal and fish oil; however, stagnating production of these ingredients has led to increased aquafeed prices. Moreover, there are growing environmental concerns amongst consumers regarding the use of wild fish to produce farmed fish. Alternative protein sources (most notably soybean meal and extracts) are therefore being used in commercial aquafeed. Seaweed protein extracts have been explored as an alternative protein source in aquafeeds, but are currently not cost-competitive compared to soybean alternatives (World Bank Group, 2023). In South Africa, it is worth noting that the market for formulated abalone feed appears to be saturated. Breaking into this market and competing with existing manufacturers would require substantial R&D into feed formulation and feed conversion, as well as support from abalone farms with established relationships and feed management programs centred around specific formulated feeds. An alternate entry point may be to supply formulated abalone feed manufacturers with a consistent, high-quality source of fresh kelp. However, there will be competition with kelp concessionaires, and it may be difficult to attain competitive prices. Nevertheless, this may be a viable option given the inconsistent supply and increased demand from formulated abalone feed manufacturers.

The pet food industry is driven by the rising demand for sustainable pet products as well as the preference for functional pet foods offering enhanced health benefits. However, challenges such as limited seaweed availability, a highly competitive market, insufficient research supporting health claims, high mineral levels, contamination concerns, and palatability issues need to be addressed. Despite these challenges, stakeholders view this market as potentially more attractive for seaweed producers than livestock feed, especially in regions where seaweed farming costs are high. The market's attractiveness stems from the higher pricing of pet food products due to the increasing integration of domestic animals into households (Graham *et al.,* 2019) and the growing demand for healthier alternatives.

6.2.3. Fresh abalone feed

In terms of the opportunity for expanding the existing local market for kelp, the demand for fresh kelp for abalone farms often exceeds the wild-harvested supply. Therefore, based on supply, the South African abalone farming industry represents a consistent market for farmed fresh kelp fronds within a suitable distance from abalone farms (CSIR, 2022).

6.2.4. Alginate extraction

As shown previously, the bulk of the South African kelp harvest is exported in a dried and milled form for alginate production in China. This has obviously raised the question as to why alginates cannot be extracted locally. To address the question would, in the first instance, require a comprehensive investigation of the alginate extraction business, including the necessary economies of scale and then followed by a detailed economic feasibility study. If the findings suggest that it makes commercial sense, then the next step would be to develop a suitable business plan, which in all likelihood would comprise some form of joint venture between one or more large-scale kelp producers and an established alginate manufacturer.

6.2.5. Nutraceuticals and cosmeceuticals

Nutraceuticals, which are defined as dietary supplements providing food-based nutritional support, lack drug classification and are governed differently from allopathic pharmaceuticals. In 2022, the global nutraceutical market was worth USD 450 billion, with a projected 7.5% growth until 2030. The potential market for seaweed-based nutraceuticals is estimated at USD 3.9 billion by 2030. Drivers include disease prevalence, ageing populations, and health awareness. Challenges include costly trials for quality certification and consistent seaweed supply complexities. For example, a full statistically powered pharmaceutical trial may take more than two years from conception to completion (depending on size and complexity), and cost in excess of USD 1 million (Cobain, 2018). Moreover, the presence of iodine, present in all seaweeds and highest in large brown kelps (Teas *et al.,* 2004), has raised concerns in Europe where seaweed food products occasionally exceed iodine upper thresholds (Aakre *et al.,* 2021). Therefore, careful consideration of iodine levels is crucial when developing seaweed products for human consumption (EFSA Panel on Dietetic Products and Allergies, 2010). Based on the World Bank Group (2023) report the development of this industry is considered a medium-term opportunity (2024-2028) in emerging markets.

Cosmeceuticals (cosmetics) also offer potential market opportunities for kelp. Kelp has bioactive-rich compounds that can positively impact the dermis (deep layer of the skin) against, for example, sun damage and anti-ageing. Entry into these markets carries similar challenges to nutraceuticals.

6.2.6. Bioplastics and fabrics

Bioplastics and fabrics (including biodegradable packaging) have gained significant traction globally and are considered a medium-term opportunity (World Bank Group, 2023). Using seaweed in biodegradable packaging, a well-established concept overseas (such as demonstrated by Notpla's technology), offers a promising opportunity, albeit requiring R&D within the South African context. Collaborative efforts with concessionaires and packaging companies are crucial for successful implementation. Local companies have expressed interest in conducting R&D (e.g., VIRO) to compare kelp-based alternatives with conventional tree-based materials, showcasing a growing domestic market demand.

Despite the potential for bioplastics, challenges persist. A start-up in the seaweed-based plastic industry cited production costs of kelp-based plastics at ZAR 95-115/kg. To compete effectively with other

bioplastics and conventional plastics, costs would need to be reduced to ZAR 35-55/kg (Rydne, 2020). In light of these developments, the South African kelp sector should explore the use of kelp to develop biodegradable packaging and fabrics. Collaborative efforts between industry players, researchers, and manufacturers will be essential to overcome challenges and establish a sustainable presence in these promising markets.

6.2.7. Restaurants and local food markets

The South African market presents a unique opportunity for kelp in restaurants and local food markets due to its significance in coastal communities where it is used in various recipes. Despite challenges in securing a consistent supply from concessionaires and the prevalence of unpermitted harvesting, there is growing interest among restaurants in incorporating kelp into their dishes and menus. Upscale restaurants like Wolfgat are at the forefront of this trend, utilising indigenous coastal ingredients, including various seaweed species like *L. pallida* and *E. maxima*. A consistent supply can only be provided by kelp aquaculture.

However, the absence of a formal market for kelp in the restaurant sector poses obstacles to its widespread adoption and will likely remain a niche market opportunity. In addition, kelp can be unpalatable and therefore requires more innovative culinary methods to promote kelp consumption in restaurants. For example, fermenting could enhance the digestibility and palatability of kelp, making it more appealing for culinary use (Stévant and Rebours, 2021).

Most of the kelp used in restaurants is recreationally harvested, which strictly speaking is illegal. Large corporate food retailers, such as Woolworths, currently import seaweed products from Asia and do not offer South African kelp products. This may provide an opportunity for farmed kelp. Kelp farms could also supply restaurants with a consistent and legal source of kelp. Existing perishable food distribution companies (of which there are many) could facilitate the logistics and distribution of kelp and streamline the supply chain.

As outlined in section 5.2.5, there are currently no existing food safety standards specifically for kelp intended for human consumption. Considering the potential risks associated with contaminants like heavy metals, it will be necessary to establish food safety standards (SABS standards such as FSSC 22000 and ISO 22000) and the associated testing procedures. While these tests can be costly, they are an important component of the development of the sector.

6.2.8. Multi-product development

Emerging trends in biorefinery approaches offer positive market opportunities. Manufacturers are now exploring methods to extract multiple products from a single seaweed biomass. This approach results in the production of various valuable compounds such as alginates, fucoidan, laminarin, and celluloses. A recent study outlines a typical method for generating multiple product streams from seaweeds such as *Alaria esculenta* and *S. latissima* (Birgersson *et al.,* 2022). This method emphasised the use of techniques that safeguard the molecular weights of polysaccharides, especially the alginate.

Within the framework of an integrated multi-product strategy, especially in the context of a kelp biorefinery, it is crucial to focus on generating multiple products from kelp (including energy) to maximise its utility. Concurrently, it is critical to minimise and eliminate waste, promoting eco-friendly practices. However, their success hinges upon the development of robust technologies capable of handling diverse kelp-based processes efficiently. Additionally, a thorough market analysis and development plan are essential, ensuring that the products generated meet market demands and trends, thereby securing the economic viability of the biorefinery (World Bank Group, 2023).

6.3. Integration of coastal communities into the kelp value chain

There are many ways in which coastal communities can be integrated into the kelp value chain. Business opportunities include, amongst others, buying and selling kelp, processing of kelp, transport of kelp and farming of kelp. Kelp farming probably has the highest risk of failure. To ensure the success of community-based kelp farming several crucial issues should be dealt with before farming rights can be considered.

First and foremost, effective farming techniques must be established to ensure simple, sustainable and efficient kelp cultivation methods. This requires extensive research, testing, and innovation to develop methods that are both environmentally responsible and economically viable. This research is currently ongoing under the KFP. Additionally, a compelling business case must be developed that demonstrates the economic feasibility and long-term profitability of kelp farming.

Several fundamentals should be addressed in the business case. It should clearly define and identify suitable locations for farming and also establish where kelp farming would not be a viable proposition for small-scale farmers. Furthermore, the business case must establish the minimum, commercially viable production volumes as well as entry costs and should consider various farming models including out-grower schemes (Felgenhauer and Wolte, 2008). Most importantly, the business case must present a realistic picture of the challenges and benefits of community-based kelp farming and should serve as a catalyst to build trust between the participating parties and members.

Key recommendations for the participation of coastal communities in kelp aquaculture are outlined below.

Education, Training and Capacity Building:

- Establish training programs to educate coastal communities about sustainable kelp farming techniques, emphasising the cultivation of indigenous kelp species in South Africa.
- Collaborate with local educational institutions and training providers to offer courses and workshops on kelp farming to ensure that community members acquire the necessary skills and knowledge.
- Provide funding and resources for community-driven research projects, encouraging innovation and problem-solving tailored to the local environment.
- Promote sustainable farming practices, emphasising environmental conservation and responsible harvesting methods to ensure the long-term health of coastal ecosystems.

- Provide training on eco-friendly farming techniques, including integrated multi-trophic aquaculture (IMTA) specifically on mussel and oyster farms.
- Provide entrepreneurial training and mentorship programs to empower community members to start their kelp-related businesses, such as product manufacturing, eco-tourism, or educational ventures.
- Collaborate and workshop potential value chain opportunities with coastal communities in order to identify opportunities such as developing traditional kelp/seaweed products.

Access to Resources:

- Facilitate access to affordable equipment and infrastructure necessary for kelp farming.
- Collaborate with government agencies and financial/funding institutions to provide financial support and technical assistance to community-based kelp farming projects.

Business model:

- Assess which business model would be most suitable for communities. There are several models each with advantages and disadvantages.
- Small-scale mussel farming may provide the best insights into successful business models for communities to profitably participate in kelp farming.
- Ensure a consistent dialogue is taking place fostering trust between parties.

Regulatory Support:

- Engage with government to contribute to the establishment of clear and enabling regulations for kelp farming as part of the development of the Aquaculture Development Bill,
- Ensure that small-scale farmers and entrepreneurs can navigate the legal requirements efficiently.
- Advocate for supportive policies and incentives, such as tax breaks or grants, to encourage private investment in the kelp industry, creating more opportunities for job creation.

By focusing on education, access to resources, regulatory support, and community empowerment, some geographically suitable coastal communities in South Africa may be effectively integrated into the kelp value chain. This would foster entrepreneurship and job creation, while promoting the sustainable use of kelp and other marine resources.

6.4. Value Chain Development

6.4.1. Challenges and opportunities to value chain development

A strengths, weaknesses, opportunities and threats (SWOT) analysis provides a framework for identifying and analysing the internal strengths and weaknesses, and external opportunities and threats, that can have an impact on the viability of developing the kelp value chain and pursuing market opportunities for farmed kelp. Because wild kelp harvesting is managed on the basis of MSY and is unlikely to increase significantly it should be noted that the kelp value chain can only really grow though farming. Table 5

provides the outcomes of a high-level SWOT analysis for the current kelp industry and value chain and for the development of a kelp farming industry.

Table 5: Strengths, weaknesses, opportunities and threats (SWOT) analysis for the current kelp industry and value chain and for the development of a kelp farming industry.

Strengths	**Weaknesses**
● Established business environment and markets ● Close trade relations with UK/EU/USA enable access to large export markets for biostimulants and liquid fertilisers ● Well-established markets: biostimulants and liquid fertilisers and, export for alginate extraction and abalone feed ● Strong macro-environment: logistics, regulatory environment and agro-processing ● Strong governance over wild harvest ● Strong research focus and capacity	● At-sea cultivation difficult to scale due to exposed coastline ● Obtaining access to sea space outside the Transnet National Ports Authority (TNPA) is difficult ● Lack of food-grade kelp processing facility ● Export of raw dry product for alginate extraction
Opportunities	**Threats**
● Start-ups working on new products for food, feed and fuel markets ● Biostimulant and liquid fertiliser market growing with high returns ● Production of alginate ● IMTA (with mussel farms) ● Kelp forest restoration ● Offshore farming ● Wild stocks largely located in remote locations ● Access to regular, additional fresh kelp outside of the Fisheries Rights Allocation Process ● Blue Carbon credits (subject to further research)	● Climate change could wipe out kelp forests ● Unsustainable wild-harvest practices ● Abalone industry heavily dependent on Chinese market, where government can change import policies overnight

To unlock the full potential of the South African kelp industry, it is imperative to tackle several significant challenges. These include limitations in kelp availability related to volume, consistency, and quality. Promising solutions lie in the development of kelp farming and biorefineries. Biorefineries enable the extraction of multiple products from kelp. Additionally, the establishment of effective regulations is crucial for the industry's progress. Creating a supportive regulatory framework is essential to nurture sectoral growth and facilitate advancements in the kelp industry.

The challenges encountered by the kelp industry, as highlighted by stakeholders in the aquaculture value chain development survey, are outlined in the box below. Addressing these challenges will be critical for the development of the kelp industry.

Challenges facing the development of kelp aquaculture and market opportunities in the kelp value chain as identified by stakeholders who participated in this study

Physical Constraints

- Limited sheltered, low-energy bays along the SA coastline
- Lack of suitable nearshore/sheltered sites for kelp farming (Potential areas for commercial kelp cultivation have been identified in the Saldanha Bay aquaculture development zone (ADZ) and offshore areas along the West Coast)
- Unpredictable weather affecting kelp supply
- Weather dependency and its impact on kelp farming activities
- Kelp farming is untested in SA, impacting cost and retained value

Environmental Factors

- Pollution risks in coastal areas affecting kelp quality
- Environmental challenges like heat plumes and heavy metal footprints
- Climate change affecting kelp quantity and quality
- Impact of industrial development and pollution on the coast
- Competing marine activities necessitating robust marine spatial planning
- Influence of seasonality on production (still being tested).

Economic and Market Challenges

- Competition with wild-harvested products
- Change in price of wild-harvested kelp due to decreased quality
- Lack of established market for cultivated kelp in SA
- High startup costs for infrastructure and hatcheries
- Limited access to seed capital
- Financial implications requiring substantial funding in rural communities
- Limited financial support due to perceived high risk from financial entities
- Challenges in global market penetration for kelp products

Information and Knowledge Gaps

- Lack of awareness and knowledge about kelp among consumers
- Lack of information and expertise for kelp farming
- Limited technical expertise for cultivation
- Lack of knowledge about potential benefits and uses of kelp
- Lack of information on culture techniques for different local species
- Lack of information on likely seasonal production of local kelp species

Regulatory and Policy Issues

- Insufficient regulatory framework for novel kelp products
- Difficulty in obtaining water space
- Monopolies held by concessionaires
- Historical Imbalance and BEE initiatives requiring careful implementation
- Challenges related to community inclusion, rights, and economic involvement
- Limited kelp specific policy support in comparison with global counterparts in the kelp industry

Industry Development and Scalability

- Limited sectorial experience and few actors in the industry
- Difficulties in market development, especially in collaboration with other countries
- Absence of infrastructure for scalable farming and value addition
- Unequal business models impacting emerging farmers' economic viability
- Energy crisis and load shedding affecting processing and refineries

6.4.2. Industry and value chain development

For the kelp industry in South Africa to expand and scale, several value chain gaps need to be addressed. Based on the gaps identified in section 5.2 we provide recommendations to develop the value chain.

6.4.2.1. Organisational and Institutional framework

The first and arguably the most important step towards developing the kelp value chain would be to establish an organisational and institutional architecture that would best support progression along the path to impact/scale. This may best be achieved by the formation of an industry association that overarchingly manages the direction of the kelp industry. Such an association (e.g., South African Kelp Industry Association) would ideally include all value chain actors in the wild kelp sector as well as the nascent farming sector. This concept will be developed further in the roadmap for kelp value chain expansion and strengthening (Part 3).

Such an association could be responsible for driving essential initiatives to progress the development of kelp farming and the kelp industry as a whole and also act as the industry representative to Government to deal with regulatory and governance issues.

6.4.2.2. Local food-grade processing facility

As discussed in Section 5.2.1, the absence of a food-grade processing facility for kelp in the Western Cape limits the expansion of emerging kelp-based companies. However, this provides a business opportunity that should be carefully considered by investors.

The establishment of such a facility can only be undertaken on the back of a thorough feasibility study. Moreover, establishing food safety standards for kelp will form an important component of the development of the sector.

In sum, the existence of a local processing facility would obviate the need to ship kelp to Johannesburg for processing but also facilitate local economic growth, strengthen the kelp value chain, and promote sustainable development in the region.

6.4.2.3. Niche restaurant market

As discussed in Section 5.1.2.6, there is currently no formal market for kelp in the restaurant and local food market sector. Introducing farmed kelp presents a unique opportunity for restaurants to legally purchase and incorporate kelp into their offerings. To establish this component of the value chain, strict adherence to rigorous processing and cold chain practices is imperative.

A crucial aspect involves ensuring that any raw kelp that is destined for fresh use by the restaurant or food industry is transported in cold storage throughout its journey, from the moment of harvest until it reaches the restaurant or food markets in South Africa. For this market to be viable, it is essential to treat kelp as a premium product, both in its transportation and packaging. Furthermore, it is advisable to establish consistent offtake agreements with restaurants and local markets. This consistency is key to avoiding sporadic market presence, which can be both time-consuming and costly. Establishing food safety standards for kelp destined for the restaurant market will be critical for its adoption among premium restaurants.

Although this market will always remain a niche sector, maintaining high offtake volumes and premium pricing could make it a worthwhile venture. Moreover, showcasing aquaculture-produced kelp in high-end restaurants will positively influence public opinion of aquaculture and the consumption of seaweed.

6.4.2.4. Small-scale processing

As detailed in Section 5.1.2.6, kelp is a key ingredient in numerous recipes within coastal communities and is also used in traditional medicine (van Wyk, 2008). Nonetheless, the absence of commercial permits for kelp sales restricts the quantity of kelp reaching local markets. The harvesting and processing of kelp (with legal permits) could create avenues for small-scale fishers to distribute kelp to restaurants, local markets as well as traditional medicine markets. This becomes especially interesting when considering the inclusion of coastal communities into the value chain.

Small-scale, seaweed value chain nodes are economically important in the Western Indian Ocean Region and are well documented (Msuya *et al.,* 2022). In the United Republic of Tanzania, seaweed value addition began in 2006 with the establishment of the Zanzibar Seaweed Cluster Initiative (ZSCI). This initiative primarily focuses on creating value-added products from fresh and dried seaweed, including cosmetics (such as soap, lotions, and shampoo) and various food items (such as juice, jam, crackers, and noodles). Additionally, in 2016, a project by the Food and Agriculture Organization of the United Nations (FAO) encouraged seaweed farmers in Kibuyuni, Kenya to produce seaweed soap and provided training in the production of other seaweed-based products like body cream, jam, juice, and salad. While these products are not specifically made from kelp species, the success, failures and lessons learnt from these entrepreneurial initiatives provide a framework for the development of the small-scale processing of kelp in South Africa.

To develop this node of the value chain, it may be advisable to engage with stakeholders who develop food products (restaurants and food product developers) such as *Weskusmandjie,* who have developed products crafted by women fishers in coastal communities. In addition, kelp should be promoted for home consumption and for use in traditional medicine. Lastly, communities could be encouraged to explore making jewellery and other value-added products (soaps, gels etc.).

6.4.2.5. Inconsistent supply and access

As outlined in Section 5.2.4, the supply of kelp to South African markets is characterised by inconsistency, which is exacerbated by unpredictable weather patterns that limit fresh kelp harvests. To tackle these challenges, implementing improved logistics strategies including optimised transportation

routes and advanced storage solutions is important. These measures can streamline the value chain and also ensure efficient, cost-effective kelp transportation to preserve kelp quality and market value. The potential introduction of farmed kelp into the value chain would overcome the inconsistencies in supply and access, particularly when produced in high volumes.

6.4.2.6. Kelp aquaculture

Given the biomass limitations of the South African wild kelp resource, particularly in the southern part of the west coast where the demand from abalone farms and for biostimulant production is highest, any expansion of local and/or export kelp markets will depend on successful commercial kelp farming (CSIR, 2022). Although kelp is not yet farmed in South Africa, the KFP pre-feasibility study concluded that there is potential for sea-based farming of kelp on the west coast of South Africa, specifically in Saldanha Bay which is favourable from both an environmental and market perspective (CSIR, 2022). Furthermore, the pre-feasibility study estimated that the potential kelp production in 30% of the Saldanha Bay ADZ could equate to 17 680 tonnes per annum FW. This was based on 71 farms producing 250 tonnes in combination with bivalves (IMTA) per annum each. However, the pre-feasibility study concluded that a farming operation of about 4 hectares, using a production system of 250 longlines of 100 m each, with at least two harvests and a minimum of 1000 tonnes production of fresh kelp per year would be financially viable.

Lastly, in order to develop the kelp farming sector it is important to adhere to the fundamentals as discussed in Section 6.4.3 (expanded on in Part 3).

6.4.2.6.1. Integrated multi-trophic aquaculture (IMTA)

The existing bivalve farms in Saldanha Bay provide interesting opportunities for IMTA. These farms have vertical ropes suspended from rafts for mussel cultivation or floating longlines and net bags to produce oysters. There is an opportunity to explore the farming of kelp alongside these rafts or longlines and managing the entire operation as an integrated system. This approach offers several advantages, including the presence of established cultivation infrastructure (rafts and ropes) and trained staff experienced in farming on rafts and longlines and seamanship. Additionally, there is access to harbour processing facilities, providing space for processing both mussels or oysters and kelp. Notably, successful instances of IMTA of sugar kelp *S. latissima*, and blue mussel, *Mytilus edulis*, on the Swedish west coast have been documented (Hargrave *et al.,* 2022), where significant improvements in kelp yields, including blade length and biomass have been recorded. Similar positive outcomes have been observed in studies conducted by Holdt *et al.* (2014) and Mariho *et al.* (2015), examining the effectiveness of mussel and seaweed farming. However, to ensure the success of IMTA in Saldanha Bay, *in situ* trials are required to validate its efficacy.

6.4.3. Developing a business model for kelp farming in South Africa

Starting a kelp farm requires careful planning and a solid financial business model. To attract investments and ensure the farm has a high chance of success, a structured and pragmatic approach is required. The following is a recommended approach:

- Prefeasibility study (alternatively also referred to as a "Scoping Study") which assesses, at a high level, the potential for farming (Completed in Phase 1 of KFP)
- High-level study defining and mapping the value chain and considering product and market opportunities (This study, Phase 2 of KFP).
- Proof-of-concept of farming technology (partially in progress in Phase 2 of KFP). All facets of the farming technology must be proven before a financial feasibility study can be undertaken. This should ideally include a pilot project to establish whether farming is viable under normal farming conditions, to identify and address challenges such as the possible effects of biofouling, optimal growing season, and growth periods.
- A financial feasibility study which considers input variables for production and sales. This includes modelling cost, income and profitability under various scenarios and establishing ranges and sensitivities. The financial feasibility study should include an in-depth market study such that accurate and reliable assumptions (inputs and variables) can be used in the study. It is important to ensure a higher level of certainty where assumptions are minimised (for example, capital infrastructure is based on physical quotations and not on accepted norms or rates). Furthermore, offtake (sales) is based on physical customers providing "in principal offtake agreements" rather than relying on published "market prices". The financial feasibility study should also include an assessment of key risks.
- During the financial feasibility study, it will be necessary to engage with the community that is directly related to the site. This can be complex when several communities are involved. Importantly, the community's expectations must be managed until the feasibility study shows positive results. Thereafter, further integration in the business plan can be explored.
- If the financial feasibility study is positive and a decision has been taken to proceed then the next step is the preparation of a business plan which brings all the pieces together and looks at the specifics of how the business will be developed (i.e., timeframe, funding and the how, who and when). The business plan together with the financial feasibility study are the key instruments with which to raise capital either internally (to convince the Board to invest) or externally in the market.
- The funding requirements, coupled with the community aspects, will start to define suitable funding sources, which may well include a combination of public and private sector investment.
- Capacity building and training commitments will be established during the business plan phase but will only be executed once funding has been secured and the project is underway or in development. Importantly, community expectations need to be managed carefully.
- Market dynamics are often the greatest variable and where too many assumptions can be made, particularly in foreign markets. As part of the feasibility study and business plan the local as well as the international markets have to be explored and assessed in detail. Relying only on published statistics and prices is a fatal flaw. Therefore, in the financial feasibility study stage, sufficient time and money must be invested to ensure a high level of market and price certainty.
- Market development must continue indefinitely when building a national brand. Moreover, this is an expensive exercise, where government support will be critical.

- Policy and regulations are overarching and are assessed at the financial feasibility study stage and are applied in the business plan. It can further evolve over time, but the fundamentals must be correct at the start, otherwise there will be no investment.
- Research and Development must also continue indefinitely to further refine species/genetics, production methodology, packaging etc. It is important that government invests in this through research and development.

Before moving forward with the development of kelp farming in South Africa, it is **strongly** recommended that a detailed financial feasibility study be undertaken, and a comprehensive business plan be developed upon which to assess the commercial opportunity at various scales of operation.

6.5. Recommendations for future research and development

Apart from exploring new products and market opportunities, it is equally important to develop an understanding of ecosystem services resulting from kelp farming (e.g., blue carbon credits and bioremediation). These services have the potential to enhance the economic viability of kelp-based value chains. However, effectively monetising these services necessitates the advancement of certification systems, credit schemes, and rigorous monitoring, reporting, and verification methods. In addition to ecosystem services, the efficacy of IMTA needs to be further investigated to better understand its profitability in comparison to kelp monoculture.

7. PART 3: ROADMAP FOR KELP VALUE CHAIN EXPANSION AND STRENGTHENING IN SOUTH AFRICA

In Parts 1 and 2, we identified value chain inefficiencies and market opportunities with the greatest potential for expansion and broadly outlined project components and interventions by which supply and/or value from these value chains could be increased or enhanced. Based on the market opportunities and potential for aquaculture, our vision for the South African kelp farming industry is "*a strengthened kelp value chain that will lead to the development of an environmentally, socially and financially sustainable kelp farming industry in South Africa*".

7.1. Roadmap Overview

Research on the development of appropriate technologies for kelp farming in Saldanha Bay is currently underway and forms the cornerstone of the sector's development. This is a crucial juncture before the commercialisation phase can commence, and would determine the current feasibility of kelp farming, not only in Saldanha Bay but also in other potential locations.

The commercialisation process must be market-driven. If the opportunities are commercially viable then investors will be attracted, otherwise not. In a developmental context, the private sector should directly lead the commercialisation phase. This does not by any means denigrate the important supportive role that government should play in focusing on R&D, regulatory measures, monitoring, promoting research outcomes, and enabling and facilitating the commercialisation efforts, including the allocation of sites within the ADZs and leases. The private and the public sector play different but equally important roles in successful sector development. One of the cornerstones of successful investment in aquaculture is the presence of a regulatory framework. It provides an important level of investment and operational security.

It is expected that funding sources will dictate who will drive the formative stages of the industry. For example, if funded solely by the DFFE, then the DFFE will be the driver. However, if funded by non-government sources, a service provider should be appointed and assume the responsibility of steering the sector's development.

Government is understandably keen to promote and develop a new aquaculture industry in South Africa. However, the promotion of kelp farming should be approached smartly and with caution in order to avoid raising unrealistic expectations amongst the business community and local coastal communities. The dissemination of information on farming technologies should in the first instance primarily target existing stakeholders within the kelp value chain, as they possess the expertise to utilise the research outcomes effectively. However, while information-sharing exercises must be inclusive, the risks of entering a new sector must be made very clear to all.

Currently, the aquaculture sector in Saldanha Bay is undergoing significant changes, including mergers, acquisitions, and business rescues, leading to a cautious outlook regarding new investments. Considering these circumstances, it is unlikely that entirely new players in aquaculture will venture into

kelp farming from the onset. Instead, the most probable entrants would be existing value chain actors, such as abalone farmers and kelp processors, provided the financial viability aligns with their interests. For established mussel farmers transitioning to kelp farming would unlikely offer significant incentives but if conducted in an integrated manner (i.e., IMTA) may provide benefits like improved water quality around mussel ropes and a secondary income source. At this stage, it is however impossible to predict how commercial kelp farming will unfold in the Bay. It all depends on whether it makes commercial sense.

7.2. Framework for the Roadmap

The roadmap is premised on the successful development of kelp farming technologies. If the technologies provide reliable and commercially useful proof-of-concept, then the five roadmap strategies can be implemented. Each of the five strategies consists of several plans that are, in turn, comprised of specific objectives and project components. The framework of the roadmap comprising the strategies and objectives is shown in Figure 13. At a project component level, the temporal sequence of events are laid out in Table 6. The objectives and rationale for the plans that support the strategies as well as the objectives and project components that underscore the plans are provided and described in detail below.

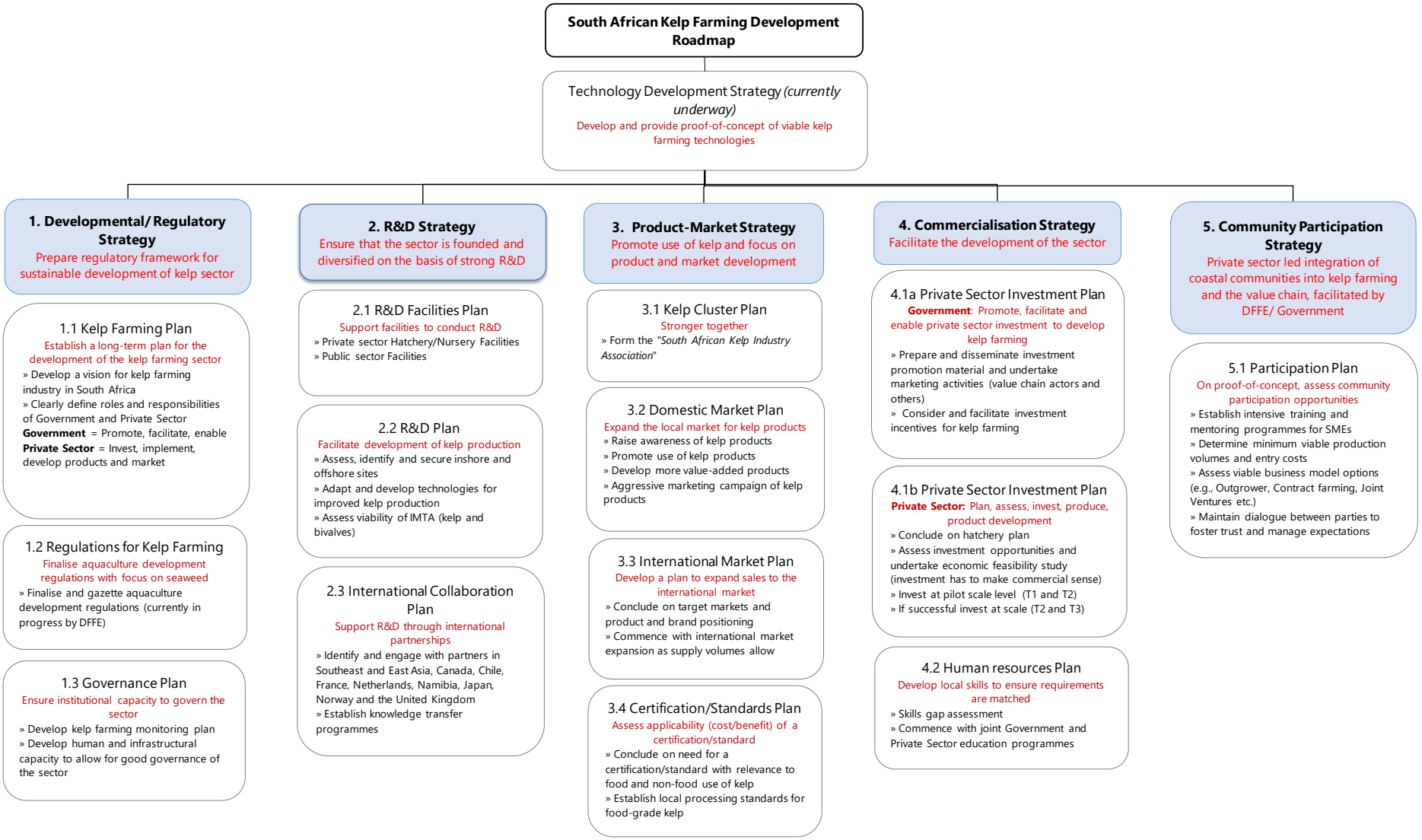

Figure 13: South Africa Kelp Farming Development Roadmap.

Table 6: Sequence of events following completion of the Technology Development Strategy.

Strategy and Plan	Project Component	Commencement year post-completion of Technology Development Strategy
1.1	Draft Kelp Farming Plan	1
1.2	Draft Regulations specific to seaweed in consultation with governing bodies	1
2.1	Support private sector hatcheries to conduct R&D and hatchery trials	1
2.1	Support public sector research facilities to conduct R&D	1
2.1	Conduct technology R&D to improve hatchery and grow-out technology	1
2.2	Conduct site assessments and spatial planning	1
3.1	Draft, review and formalise Articles of Association	1
4.1a	Draft fundraising documentation	1
4.1b	Assess hatchery plan	1
4.1b	Complete economic feasibility study	1
4.2	Identify desired and/or required skills, assess gaps and develop human resources plan to address gaps	1
5.1	Assess opportunities for integration	1
1.2	Review and Gazette Regulations for Aquaculture Act	2
1.3	Establish kelp farming monitoring plan	2
2.2	Conduct technologies and production R&D	2
3.3	Build on the current market assessment to ascertain more specific prices and market entries to understand and identify international market opportunities	2
3.2	Undertake product R&D to establish a basket of goods that match local needs	2-3
4.1b	Evaluate offering investment incentives to early-stage investors	2-3
4.2	Identify best training opportunities and send people for training through knowledge transfer programmes	2-3
4.2	Undertake comprehensive educational programmes aimed at ensuring South Africans are aware of opportunities in kelp farming both at operational and governance level	2-3

5.1	Prepare business case	2-3
2.3	Prepare promotional materials and documentation	3
2.3	Reciprocal knowledge transfer visits and engagement with potential collaborators and funders	3
3.2	Ensure that products are handled safely within the value chain through the development of appropriate standards	3
3.3	Develop a strategy to position the South African kelp farming brand into the target international markets	3
3.4	Develop standards for local processing of food-grade kelp	3
3.2	Commence with sales into the domestic markets	3-4
3.2	Develop a brand that becomes synonymous with quality kelp-farmed product	3-4
3.3	Commence with sales into the international markets	4
3.4	Undertake a needs assessment to conclude on the requirement for certification	5

Technology Development Strategy (*currently underway*)

The development of home-grown or adapted technologies that are appropriate for the species, scale and location of kelp farming projects is an important driver of success in the sector. This strategy should dovetail with ongoing R&D efforts.

Phase 2 of the KFP currently has ongoing hatchery experiments at the Paternoster Oyster Company Hatchery/Nursery facility and at the Sea Point Research Aquarium. Grow-out trials are also ongoing at the Blue Ocean Mussels' grow-out facility in Saldanha Bay. Although two of the three target species are so far growing at the grow-out site, *M. pyrifera* will be harvested in quarter 4 of 2023 with the aim to conduct food safety tests that will inform food safety standards (SABS). Furthermore, monitoring of environmental parameters and assessing the environmental benefits/risks are also ongoing at the grow-out site as decision support for the DFFE's Environmental Management Programme (EMPr).

Key Objectives:

- Develop and provide proof-of-concept of viable kelp farming technologies

Project Components:	**Timeframe:**
• Hatchery trials	• Current/ongoing

• Grow-out trials	• Current/ongoing
• Food safety testing	• Current/ongoing
• Environmental monitoring	• Current/ongoing

1. Developmental/ Regulatory Strategy

Developing responsible kelp farming and sustainable investment, requires a regulatory framework that is in line with the capacity limits of the broader ecosystem. A precautionary approach takes a conservative view on the gradual expansion of capacity under strictly monitored and regulated operations. The basis for regulation in the sector is founded in an approved legislative and regulatory framework that sets phased limits to capacity expansion, gives legal precedence to roles and responsibilities in the field of governance, deals with access rights and sets operational standards. Currently, all aquaculture regulations, including for seaweed, are set out in The Marine Living Resources Act 18 of 1998.

1.1 Kelp Farming Plan

Description:

A Kelp Farming Plan establishes a long-term plan for the development of the kelp farming sector. Moreover, it enables the development of a sustainable kelp farming sector based on sound environmental and economic principles as aligned with the Government's economic and social vision. Furthermore, the plan consolidates legislative, environmental, biological, economic, and social frameworks into a comprehensive plan that sets out the long-term establishment and expansion plan for the sector. The plan describes and quantifies the broad opportunity for kelp farming under a developmental approach that respects the unique nature of the marine environment and its importance in providing livelihoods and food security to a wide spectrum of stakeholders. The plan will also clearly define the roles and responsibilities of the private and public sectors where the government is responsible for promoting, facilitating and enabling, while the private sector is responsible for implementation and investment.

The plan should be developed in line with the Oceans Economy Master Plan and the Aquaculture Development Bill (currently under development) which builds on the aquaculture support and development that took place as part of the Operation Phakisa Aquaculture Programme (2014-2019) and the National Aquaculture Policy Framework.

Key Objectives:

- Provide brief and concise background to the sector
- Summarise sector potential as concluded in the Kelp Farming Plan
- Nominate key developmental objectives
- Describe governance roles and responsibilities
- Identify priority locations for kelp farming development
- Describe kelp species for kelp farming
- Broadly identify domestic and international target markets
- Highlight value chain opportunities
- Develop a vision for kelp farming in South Africa
- Quantify the human resources and skills required for development

- Promote investment and sustainable growth in the kelp farming sector
- Responsibly realise the economic potential of the kelp farming sector
- Responsibly maximise the socio-economic benefits of the kelp farming sector
- Promote kelp farming at the large and small-, medium- and micro-enterprises (SMMEs) scale
- Develop an enabling institutional environment for the development of the kelp farming sector
- Develop appropriate kelp farming technologies through R&D
- Develop the necessary industry support services for the sector
- Build the necessary human capacity for the development of the sector
- Enhance the perception of kelp farming in the country and its many benefits
- Promote kelp farming as an important component of integrated coastal management
- Promote kelp farming as a pivotal component of the Blue Economy
- Develop a kelp farming industry compatible with responsible stewardship of the marine environment and its resources

Project Components:	**Timeframe:**
• Draft Kelp Farming Plan	• T1[1]

1.2 Regulations for Kelp Farming[2]

Description:

Currently, all aquaculture regulations, including for seaweed, are set out in The Marine Living Resources Act 18 of 1998. The Regulations set out governance roles and responsibilities, conditions of access, and prescribes Technical Standards for operators. To farm kelp in Saldanha Bay, environmental authorisation, a marine right and a lease from the Transnet National Ports Authority (TNPA) are required. Specific guidelines for the authorisation requirements for aquaculture in South Africa are available on the DFFE website. It can however be difficult to attain a lease to farm outside of a TNPA area. Therefore, we recommend that farming in the first instance be focussed on the ADZs until the farming technology has been adequately developed at a commercial scale. At that point, the DFFE should focus on identifying and assessing suitable offshore areas outside of TNPA areas.

Key Objectives:

- To ensure aquaculture is developed in a manner consistent with the FAO Ecosystems Approach and in line with global best practice
- To set roles and responsibilities within a governance framework for the sector
- To prescribe fees and levies applicable to operators
- To set out access rights through kelp farming license terms and conditions
- Ensure that the kelp farming sector is developed in line with sustainable environmental limits
- Promote investment into the sector to ensure scale is attained that meets required strategic outcomes
- To ensure that South African citizens enjoy equal opportunities to participate in the sector through small-, medium- and large-scale projects

[1] T1; T = Time, 1 = the year after successful completion of Technology Development Strategy when project component will commence (e.g., T1 = Project components will commence in the first year after completion of Technology Development Strategy).
[2] All issues pertaining to the regulatory framework are dependent on the completion of the Aquaculture Development Bill and the gazetting of the Act. The timeframe presented here is a best estimate, which may or may not be achievable, but importantly it provides a logical sequence of the development of the farming sector.

- To facilitate the production and processing of quality kelp products for domestic and international markets
- To utilise R&D as a means to build the sector using indigenous species

Project Components:	**Timeframe:**
• Draft Regulations specific to seaweed in consultation with governing bodies	• T1
• Review and Gazette Regulations for Aquaculture Act	• T2/3

1.3 Governance Plan

Description:

The responsible development of a kelp farming sector requires good governance and monitoring to be undertaken by well-resourced, qualified, and equipped Government departments.

Key Objectives:

- If required, to restructure departments in the DFFE to accommodate new governance requirements specific to kelp farming
- If required, to resource new units with adequately qualified and equipped kelp farming personnel
- Develop kelp farming monitoring plan

Project Components:	**Timeframe:**
• Establish kelp farming monitoring plan	• T2

2. R&D Strategy

'Ensure that the sector is founded and diversified on the back of strong R&D'

2.1 R&D Facilities Plan

Description:

The need for kelp aquaculture-specific R&D facilities has been recognised, and both private and public sector facilities are currently available where R&D and hatchery trials are ongoing.

Key Objectives:

- Establish fully operational support facilities to conduct R&D

Project Components:	**Timeframe:**
• Support private sector hatcheries to conduct R&D and hatchery trials	• T1
• Support public sector research facilities to conduct R&D	• T1
• Conduct technology R&D to improve hatchery and grow-out technology	• T1

2.2 R&D Plan

Description:

The future development of the South African kelp farming sector is reliant on continued R&D efforts that aim to enhance current kelp farming activities and develop and adapt technologies to diversify

and expand kelp farming production. A concerted effort should be made to involve more postgraduate students in the development of technologies.

The existing bivalve farms in Saldanha Bay provide interesting opportunities for IMTA. These farms have vertical ropes suspended from rafts for mussel cultivation or floating longlines and net bags to produce oysters. There is an opportunity to explore the farming of kelp alongside these rafts or longlines and managing the entire operation as an integrated system. This approach offers several advantages, including the presence of established cultivation infrastructure (rafts and ropes) and trained staff experienced in farming on rafts and longlines. Additionally, there is access to harbour processing facilities, providing space for processing both mussels or oysters and kelp. However, to ensure the success of IMTA in Saldanha Bay, *in situ* trials are imperative to validate its efficacy. If validated, there will be a need for a hatchery to provide existing farmers with a reliable and consistent supply of seed to bring production volumes to an economically feasible and sustainable level. The hatchery could be incorporated into the Paternoster Oyster Company hatchery or be a standalone facility in Saldanha Bay.

Key Objectives:

- Assess, identify and secure inshore and offshore kelp farming sites
- Adapt and develop technologies for improved kelp production
- Assess viability of IMTA (kelp and bivalves) - underway

Project Components:	**Timeframe:**
• Conduct site assessments and spatial planning	• T1
• Conduct technologies and production R&D	• T2

2.3 International Collaboration Plan

Description:

International cooperation and knowledge transfer on R&D is a logical approach to facilitating and funding South African-based R&D. Engagements with possible R&D and funding partners should be actively promoted.

Key Objectives:

- Identify and engage with key partners in Southeast and East Asia, Canada, Chile, France, Netherlands, Namibia, Japan, Norway, and the United Kingdom
- Establish knowledge transfer programmes
- Secure international R&D funding

Project Components:	**Timeframe:**
• Prepare promotional materials and documentation	• T3
• Reciprocal knowledge transfer visits and engagement with potential collaborators and funders	• T3

3. Product-Market Strategy

The global market for kelp products is efficiently traded and fiercely competitive. The development of highly scaled kelp farming production facilities has resulted in increasingly cost-effective production. While kelp farming is nascent in South Africa, significant advances have been made elsewhere and the global market for kelp products is now mature and sophisticated; as such the positioning of new products into domestic and global markets should be carefully considered. Moreover, South Africa's natural strategic advantage in the sector needs to be carefully evaluated.

A strategy that commences with the optimisation of sales into the domestic market with potential expansion into the international markets as volumes allow is proposed. This also includes the promotion of kelp use and a focus on product and market development.

3.1 Kelp Cluster Plan

Description:

Establishing a South African Kelp Industry Association would serve as a crucial step towards fostering unity and collaboration within the sector. Establishing the association must be industry led. Members might include current kelp value chain actors and emerging farmers in future. Through an Association the industry can collectively address challenges, share knowledge, and enhance their overall farming practices and marketing opportunities and drive the development of the sector. One of the significant advantages of such an association is the ability to access markets as a unified entity. By consolidating their resources and products, members can negotiate favourable deals, reach broader audiences, and establish stable market channels. Additionally, the association plays a pivotal role in marketing sector-specific products efficiently. Moreover, the association helps in breaking down the barriers of working in isolation, encouraging information exchange. This collaborative approach will not only strengthen the sector but also ensure the sustainability and prosperity of its members in the long term.

Key Objectives:

- Form a *"South African Kelp Industry Association"*

Project Components:	**Timeframe:**
• Draft, review and formalise Articles of Association	• T1-2

3.2 Domestic Market Plan

Description:

The domestic market for kelp products in South Africa is currently supplied by product from the wild-harvest sector along with negligible imports. Local demand remains strong and the opportunity for kelp farming products is considered present and possibly substantial.

Key Objectives:

- To improve cold chain routes to the primary local markets for kelp farming product
- To raise awareness of and promote the use of kelp farming product in the domestic market through the creation of a South African kelp farming brand
- To develop a range of value-added products that cater to domestic needs
- To improve market infrastructure
- To establish a local standard for the processing and sale of kelp farming product
- Aggressive marketing campaign for kelp products

Project Components:	**Timeframe:**

• Undertake product R&D to establish a basket of goods that match local needs	• T2-3
• Commence with sales into the domestic markets	• T3-4
• Develop a brand that becomes synonymous with quality kelp-farmed product	• T3-4
• Ensure that products are handled safely within the value chain through the development of appropriate standards	• T3

3.3 International Market Plan

Description:

The opportunity to process and produce value-added kelp products (e.g., biostimulants and liquid fertiliser) and supply the nutraceutical, cosmeceutical and pharmaceutical industries offer opportunities for entry into the domestic and international markets. For scale economies to be fully achieved in the kelp farming sector establishing a competitive position in the international marketplace is necessary and products should be developed to accommodate this.

Key Objectives:

- Develop an international expansion plan
- Research market dynamics in product segments relevant to South African kelp
- Position South African kelp farming products into target international markets under a South African brand

Project Components:	**Timeframe:**
• Build on the current market assessment to ascertain more specific prices and market entries to understand and identify international market opportunities	• T2
• Develop a strategy to position the South African kelp farming brand into the target international markets	• T3
• Commence with sales into the international markets	• T4

3.4 Certification Plan

Description:

Develop a plan to assess the applicability (cost/benefit) of attaining certification.

Certification (e.g., Aquaculture Steward Council (ASC) Seaweed Standard) serves as recognition of the efforts invested in a farming operation, ensuring its long-term social and environmental sustainability. Producers who attain this certification gain entry into markets where the emphasis on environmental and social responsibility significantly influences consumer choices. The advantages are multifaceted, encompassing socially responsible and sustainable production, an elevated reputation, safeguarded livelihoods, access to new markets, and the retention of existing ones, along with promotional

opportunities. However, the decision to pursue such certification must be evaluated. Whether the benefits outweigh the costs hinges on market demands; there are instances where seeking a specific certification standard might not be economically viable. It underscores the importance of aligning certification efforts with market requirements to make informed choices. This also hinges on the food or non-food use of the kelp product. Nevertheless, farms should be developed in a manner that would allow for certification later on. This is important for meeting and aligning with climate change mitigation strategies.

Key Objectives:

- Conclude on the need for a certification with relevance to food and non-food use of kelp
- Establish local processing standards for food-grade kelp

Project Components:	**Timeframe:**
• Develop standards for local processing of food-grade kelp	• T3
• Undertake a needs assessment to conclude on the requirement for certification	• T5

4. Commercialisation Strategy

A combination of public and private sector funding is required to establish and expand the kelp farming sector. Public sector funding from multiple sources is necessary to lay the foundations for the sector to attract private sector investment to a well-regulated sector with proven opportunities supported by strong R&D, market intelligence and governance resources. Private sector investment is essential for the scaling of operations to levels that will ultimately achieve forecast benefits in the national context.

4.1a Private Sector Investment Plan

Government role: Promote, facilitate and enable private sector investment to develop kelp farming.

Before attracting private sector investment into kelp farming the foundation of the sector should first be established comprehensively. This requires commercial scale, technological proof-of-concept and early-stage pre-developmental projects that target key regulatory, governance and R&D issues.

Key Objectives:

- To prepare documentation that facilitates fundraising
- To ensure that sector development activities are fully funded
- To consider and facilitate investment incentives for kelp farming
- To enable license application procedures
- To conclude the small-scale fishing rights allocation process

Project Components:	**Timeframe:**
• Draft fundraising documentation	• T1

4.1b Private Sector Investment Plan

Private sector role: Plan, assess, invest, produce, develop products, create employment and partnerships.

For the kelp farming sector to meet developmental objectives in terms of commercial and social benefits, the improvement of food security and contribution to economic development, expansion to scale is critical. This expansion can only be achieved by attracting private-sector investment capital. The market for private sector investment is competitive between countries and sectors and a comprehensive offering should be developed to position South African kelp farming as a competitive and compelling opportunity both locally and internationally.

This investment plan includes investing in the kelp farming value chain and concluding with the establishment of a single hatchery, or multiple hatcheries. Kelp farming in South Africa, while currently nascent, will be constrained by an insufficient supply of seed. An important first step to ensure sustained and consistent production is the development of hatchery facilities to provide farmers with a reliable source of seed. The Paternoster Oyster Company's hatchery where the KFP trials are underway could serve as the first hatchery facility. If the expansion of the industry is to proceed, then additional hatchery facilities may be developed to service the farms, depending on volumes, seed requirements and business models.

In addition to the above, it will be important to undertake an economic feasibility study for kelp farming. This process was discussed in Section 6.4.3. This involves evaluating the financial viability of kelp farming by conducting a comprehensive feasibility study and developing a detailed business plan. This necessitates gathering additional data on factors like growth rate, economic indicators (detailed market prices), labour requirements and costs, and infrastructure requirements and associated cost implications. The FCDO could potentially fund this, or assist in getting other sources of support to facilitate this process.

Key Objectives:

- Conclude on hatchery plan (e.g., a co-op hatchery, independent farm hatcheries etc.)
- Establish the legislative, environmental and economic foundation for the sector
- Position South African kelp farming as a unique investment opportunity in the region
- Undertake an economic feasibility study
- Secure cornerstone investments from the private sector

Project Components:	**Timeframe:**
• Assess hatchery plan	• T1
• Complete economic feasibility study	• T1
• Evaluate offering investment incentives to early-stage investors	• T2-3

4.2 Human Resources Plan

Description: Developing local skills is crucial in the kelp sector to ensure that specific requirements are met effectively and efficiently. Establishing knowledge transfer programmes will provide opportunities to learn from established kelp farming industries.

Key Objectives:

- Develop local skills to ensure human resource requirements for the industry are met
- Develop joint Government-Private sector education programmes

Project Components:	**Timeframe:**

• Identify desired and/or required skills, assess gaps and develop human resources plan to address gaps • Identify best training opportunities and send people for training through knowledge transfer programmes • Undertake comprehensive educational programmes aimed at ensuring South Africans are aware of opportunities in kelp farming both at operational and governance level	• T1 • T2-3 • T2-3

5. Community Participation Strategy

To facilitate successful community-based participation in farming and integration into the value chain, several issues must be addressed and well understood beforehand. All is of course predicated in the first instance by proof-of-concept and the establishment of sustainable and efficient farming techniques. Additionally, compelling business cases need to be developed and presented that outline suitable business model options. We recognise the challenges associated with the successful formation of SMEs and the development of entrepreneurs in South Africa and the current inadequate ownership patterns. These challenges must be addressed with the assistance of suitably experienced SME developers/advisors. This would include mentoring and practically assisting emerging SMEs from coastal communities to build sustainable, commercially viable businesses in the value chain (as in the case of the Imbaza Mussel Farming Empowerment Project). It is important that all business model options of community-based kelp farming transparently present all risks and advantages, thereby fostering trust and understanding among all involved parties. This strategy will need to be private sector-led and facilitated by the DFFE. Importantly, expectations need to be managed throughout this process.

Apart from kelp farming, coastal communities have various opportunities to integrate into the kelp value chain. For example, they could buy small quantities to craft unique value-added products like soaps, gels, salts, and other food items. These products could be marketed in local markets. Additionally, coastal residents could find employment in supporting services; working on farms as labourers, become involved in kelp transport and post-harvest activities, and participating and/or supporting the cold-chain.

The participation of communities in kelp farming and integration into the value chain may present a significant opportunity for job creation in the sector and contribute towards alleviating poverty in coastal communities.

5.1 Participation Plan

Description:

On proof-of-concept, assess community participation opportunities. For example, establishing an out-grower scheme (Felgenhauer and Wolte, 2008) where communities are contracted by processors

to farm and supply kelp presents a realistic opportunity with which to integrate coastal communities into the value chain. Additionally, where farming is not an option for coastal communities, purchasing small volumes of kelp to produce value-added food products or other products or to take up employment in post-harvest activities (i.e., transport and harvesting), are potential options for their successful integration into the kelp value chain.

Key Objectives:

- Establish intensive training and mentoring programmes for SMEs
- Determine minimum, commercially viable production volumes and entry costs
- Assess viable business model options (e.g., out-grower schemes, contract farming, joint ventures, etc.)
- Maintain dialogue between parties to foster trust and manage expectations

Project Components:	**Timeframe:**
• Assess opportunities for integration	• T1
• Prepare business case	• T2-3

8. CONCLUSION

This study adds to the body of knowledge presented in the pre-feasibility study. While the pre-feasibility study identified average market prices, price variability was not adequately assessed. This is an important consideration for market entrants who need to understand that prices vary considerably. In addition, this study quantified the volume of beach-cast kelp that is collected by concessionaires (most of which is dried, milled and exported). Furthermore, this study identified the export markets and provided indications of the volume and value of these markets. It has also been shown that kelp as an abalone feed is not the biggest market for kelp in general. This study also provides an update of the value of the South African kelp industry (pre-value-addition) of ZAR 56.5 million. Based on our initial estimates, the wholesale market value for biostimulants and liquid fertilisers is around ZAR 317 million. Overall, we estimate the entire value chain to be worth ZAR 357 million. Moreover, this study builds on the high-level market opportunities presented in the pre-feasibility study by providing recommendations for value chain development. Furthermore, this study provides suggestions for developing the kelp farming industry.

Several value chain gaps and inefficiencies were identified in the South African kelp industry. These include the lack of a local (Western Cape) food-grade processing facility, the paucity of supply to the niche restaurant market, an industry-wide supply inconsistency and difficulty with accessing raw product, a constrained and inefficient concession license system, as well as the lack of a kelp farming industry, which may constrain the supply of kelp to niche markets. Based on these gaps and inefficiencies several market opportunities for farmed kelp were identified. These included biostimulants, animal feeds, nutraceuticals and cosmeceuticals, bioplastics and fabrics, the restaurant and local food market trade, and the exploration of multiproduct development.

The data presented in this report, including the market opportunities, value chain inefficiencies and development needs are important insights that should be fully understood before investing in kelp farming. Similarly, identifying readily accessible and non-accessible markets (i.e., no demand or saturated with competitors) are important factors that must be assessed to understand what the future of the industry might look like. If these inefficiencies and market insights are not well understood, kelp farming investors run the risk of pursuing a production-driven business instead of a market-driven business which has unfortunately, as in many South African aquaculture ventures, resulted in failure. The roadmap is premised on the successful development of kelp farming technologies. If the technologies provide reliable and commercially useful proof-of-concept, then the five roadmap strategies can be implemented.

The data provided in this report, along with the market opportunities and value chain development, and the value chain roadmap, serves as a guideline for the establishment of a market-oriented kelp farming sector in South Africa.

9. NEXT STEPS

Regarding the next steps and immediate direction of the kelp farming industry, the primary focus lies in advancing experimental work to validate the technology. Following this, the next step would be to

establish a pilot kelp farm and to conduct trials to further demonstrate proof-of-concept and evaluate seasonal variations, among other factors as alluded to earlier. Additionally, ongoing collaboration and knowledge transfer with various institutions for research and development remains crucial. Learning from global kelp-based farming activities is equally important in this regard.

If these steps are taken and if the results show that money can be made, then the private sector will embrace it and develop the industry in the most sensible and business-orientated manner. It is not possible to predict how this would unfold. However, this study has provided a roadmap of strategies that should be considered by the private and public sectors to make kelp farming a success going forward.

10. ACKNOWLEDGEMENTS

Dr Lizeth Botes, the KFP project manager, is thanked for her guidance, support, and commitment to the success of this work. Additionally, we thank everyone in the KFP, specifically Professor Emeritus John Bolton, Andrea Bernatzeder and Dr Mark Rothman. We would also like to thank Vos Pienaar, Chairman of the BSASA for his support and guidance throughout this project. The funder, UK FCDO, represented by Kristin Klose is also thanked for the financial support for this project. We would also like to thank all the kelp stakeholders who shared their invaluable insights and data. Their willingness to participate was pivotal in shaping the outcomes of this study.

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