

Marine Tilapia – South Africa’s new affordable whitefish alternative

By R. Kourie & n. dladla¹

Despite a significant annual Cape hake quota, which fluctuates from around 100,000 to 140,000 tonnes per annum in South Africa, fish has become increasingly unaffordable for most food insecure households. Wholesale prices of South Africa’s most favoured Fish & Chips choice, Cape hake, have climbed in recent years in Rand terms to above R45.00/kg on a whole weight basis. Similarly, retail prices of tinned pilchards, a national favourite food basket item, have climbed above R60.00/kg on a drained weight basis, putting food insecure households increasingly at risk of not acquiring adequate omega-3 fatty acids in their diets.

Building on a concept vision sourced from private innovators – Thapi AquaKulcha – identified through an open call for expressions of interest in 2019, the *Eastern Cape Rural Development Agency* (ECRDA) has taken the lead to address this undesirable fish supply situation by taking aim at an ambitious project to domesticate the local Mozambique tilapia (*Oreochromis mossambicus*) species for seawater culture in a project called the Marine Tilapia Industry (MTI).

Over and above the Marine Tilapia Industry project being a response to a hake market that will grow more constraining in affordability, along with the threat of diminishing ocean stocks from sea-catch, this project aims to take advantage of the natural bounty that is the endowment of South Africa’s temperate seaboard stretching along the coastline of the Eastern Cape and KwaZulu-Natal provinces – the *Oreochromis mossambicus*.

The ambition is to establish and develop a veritable value-chain for an industry that will grow to a scale of 100,000 tonnes of marine cultivated tilapia by the year 2035. The growth trajectory maps the course of an industry that will start with the establishment of a Marine Tilapia Industry Incubator (MTII) in Mbhashe as the base for growing a range of commercial clusters along the coastline of the Eastern Cape and KwaZulu-Natal over the years.

Mbhashe Marine Tilapia Industry Incubator (MbMTII)

The MbMTII will be situated at the Mbhashe Local Municipality coastline with a clear set of seeding and catalytic output objectives including improved gene lines of pure breeds of Mozambique tilapia and an ongoing human resource development program to feed into the commercial growth to follow.

¹ Kourie is technical director of Thapi AquaKulcha and dladla is the chief executive officer of the ECRDA.

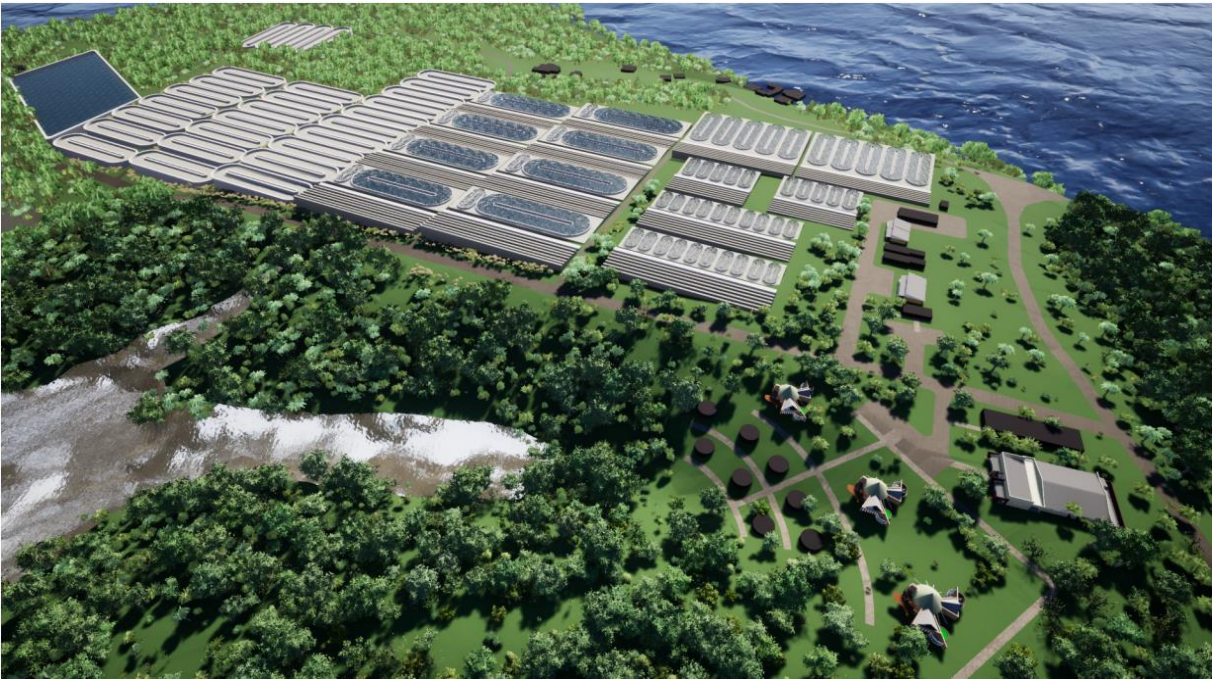


Figure 1: A 3D generated architectural impression of the Mbhashe Marine Tilapia Industry Incubator (MbMTII) earmarked to produce 2,000 tonnes of seawater farmed Mozambique tilapia annually.

Why tilapia, and why Mozambique tilapia in particular?

- ✓ Mozambique tilapia are indigenous to the east coast territory of the Eastern Cape and KwaZulu-Natal and as such the commercialization of marine tilapia aquaculture poses no biodiversity risks to endemic fish fauna.
- ✓ They grow 1.66 to 2 times faster in seawater (SW) than they do in freshwater (FW)



Figure 2: Mozambique tilapia (*Oreochromis mossambicus*) harvested from a large-scale Biofloc Technology (BFT) farming system in Malawi.

- ✓ Improved palatability when grown in sea water, on par with the best line fish offering improved meat texture and flavour properties and therefore higher marketability. Sold as a marine fish

seawater farmed Mozambique tilapia overcomes market biases favouring the consumption of marine fish in South Africa;

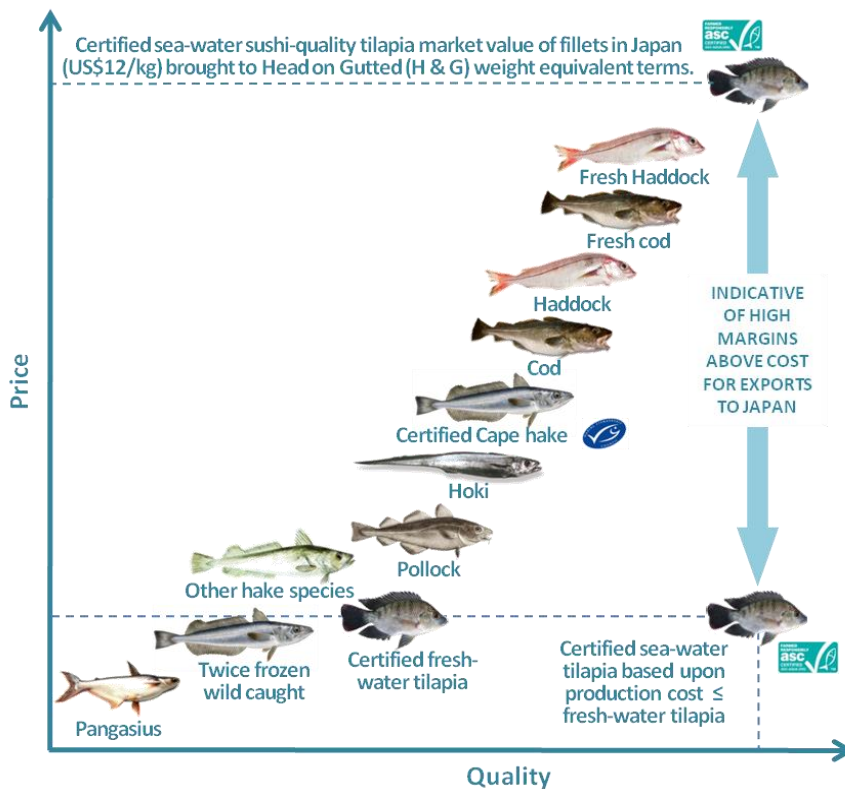


Figure 3: Perceived quality versus prices for the most common whitefish species from Geldenhys (2013) and Lallemand *et al.* (2014). Aquaculture Stewardship Council (ASC) certified marine cultivated tilapia (*izumidai*) and Marine Stewardship Council (MSC) certified hoki were added above based upon their market value.

- ✓ Taiwanese marine farmed tilapia fetch a premium price of US\$12.00/kg for fillets in Japanese sushi markets where seawater farmed tilapia hybrids are called *Izumidai*. That's about 80% higher than the retail price of Cape hake fillets. See Figure 3 for perceived price-quality rankings of the major whitefish species. Note that exports from a future east coast marine tilapia industry are not among the objectives of the *THAPI Marine Tilapia Vision 2035* rather the marketing of higher quality marine cultivated tilapia aims to leverage market share rather than higher local prices or exports;



Figure 4: Top quality Taiwanese seawater reared red tilapia fillets packed for the Japanese sushi/ sashimi/ nigiri markets brings premium rewards to Taiwanese fish farmers earning US\$12.00/kg.

- ✓ Mozambique tilapia are a low trophic level species with a highly efficient digestive system capable of good growth on animal-free all-plant based feeds therefore contributing to the alleviation of food insecurity due also to their low cost production.

A fairly sanguine outlook prognostication can be expected for this new farmed whitefish industry based upon the seawater culture of Mozambique tilapia over that of freshwater farmed tilapia due to several added advantages apart from improved texture and flavor properties;

1. Based upon several studies Mozambique tilapia use feed more efficiently capable of achieving lower Feed Conversion Ratio's (FCR's) in seawater (SW) over freshwater (FW) farming systems. These advantages are further amplified by the use of Biofloc Technology (BFT) using seawater and all-plant based feeds carrying a lower protein content of just 20% where FCR's are anticipated to be lower than around 1:1 achieved in FW BFT systems in Malawi;
2. Reduced energy inputs of 1.05kWh per kilogram (kg) of farmed tilapia production output in seawater attributed to a higher alpha-factor (α -factor) of 2.5 for sub-surface aeration (freshwater α -factor 0.92-1.0) at sea level and salinities of 32-36‰ (salinity of seawater). The main drive air blowers used to furnish air for diffuser airlift aerators in SW would absorb 29.2kW (1.02kWh/kg of tilapia produced) as opposed to 39.8kW (1.40 kWh/kg of tilapia produced) in a 250 tonne FW multi-cohort sequentially managed BFT tank system;
3. Efficient use of capital for infrastructure based upon an optimized design philosophy (proven on a large scale in Malawi) applying a multi-cohort sequential production schedule which improves production throughput capacity by almost 50% on an annualized basis under similar capital expenditure outlays;
4. Upstream and downstream scale and scope economies and the beneficial effects of specialization including a reduced gestation period from investment to first income;
5. More efficient use of labour and management an effect of farm size and the manageability of fewer larger-scale grow-out production units (20 tanks each producing 250 tonnes annually = 5,000 tonnes per grow-out farm per annum).



Figure 5: Large-scale freshwater Biofloc Technology (BFT) fish farm developed by Thapi Aquakulcha in Malawi where both Mozambique tilapia (*Oreochromis mossambicus*) and Shiranus tilapia (*Oreochromis shiranus*) were reared achieving FCR's around 1:1 on 20% protein all-plant based feeds

The value proposition in the development of a scalable and competitive marine tilapia farming industry in South Africa hinges on the use of reduced input all-plant based low-protein feeds and BFT aquaculture tanks placed under greenhouse enclosures to capitalize on solar heat gains to enhance productivity (unit production/unit volume/surface area) and hence capital employed in farm infrastructure under reduced land acreage requirements.

Farm gate production costs for large-scale BFT Mozambique tilapia aquaculture is seawater systems are anticipated to be around R15.00/kg (US\$1.00/kg) before sales to a dedicated processing plant serving four 5,000 tonne per annum grow-out farms.

Marine tilapia farming in South Africa, a niche market opportunity, or the answer to food insecurity?

It's no secret that food insecure households in South Africa are finding it increasingly difficult to put affordable animal protein sources into their daily dietary regimes not least because of the impacts of the COVID-19 pandemic and rising food prices. Excluding tinned pilchards, around the year 2005/06 broiler chickens took the crown from our marine capture fisheries to become the least cost animal protein source in the country. This despite the large price spreads ranging from 50-100% between the large-scale producer cost at the base of the broiler chicken value chain and that of the supermarket retail price hovering around the R45.00-R55.00/kg (VAT inclusive) in 2021 for frozen dressed birds in recent times. While, there appears to be economic opportunity for small-medium scale broiler producers despite higher feed, abattoir and other input costs for direct retailing to consumers by-passing the formal value chain. Using the small scale producer cost model our estimate puts the ex-abattoir cost of broiler birds in the R29.00-R31.00/kg of live bird. We used R30.22/kg of live bird following added abattoir costs converted to an edible meat yield at 46.1% in Figure 6 below.

Beef, lamb and pork cannot compete with the price of broiler chickens and as such these animal protein sources were excluded from the most appropriate cost comparison to establish the food security value proposition of the various animal protein sources brought to an edible meat yield basis. Figure 6 provides an account of the whole weight and edible meat yield pricing of broiler chickens (small-scale, farm-consumer sales), Cape hake, pilchards in a tin (net weight, or drained weight, brought to a kg) and that of marine farmed tilapia using a large-scale Biofloc Technology (BFT) approach.

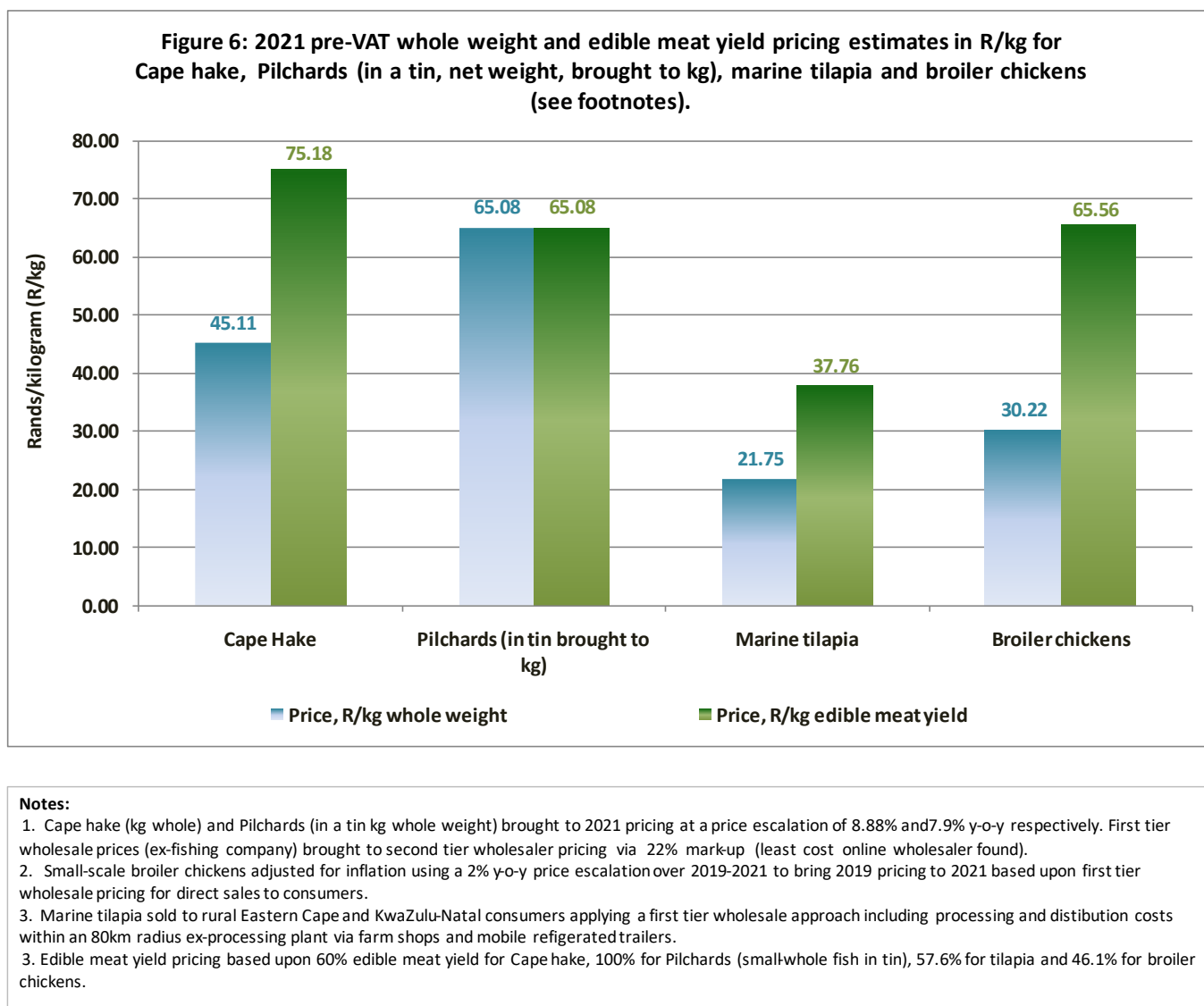


Figure 6 indicates that a large-scale marine tilapia industry could provide consumers in the rural Eastern Cape and KwaZulu-Natal with affordable fish at R37.76/kg edible meat yield offering unrivaled food security impact potential. That's around half the cost of Cape hake (R75.18/kg) and less than two-thirds of the cost of tinned pilchards (R65.08/kg) and less than two-thirds of the cost of broiler chickens (R65.56/kg) all on an edible meat yield pricing basis (see Figure 6). Current tilapia farming production philosophy based upon the use of intensive pond farming and Recirculation Aquaculture Systems (RAS) and complete extruded aquatic feeds at a cost of R14.00/kg for a 28-32% protein grower ration, puts the farm gate break-even production cost in the R28.00/kg (best case) and R35.00/kg (worst case) producer price range which is then uncompetitive against large-scale broiler producer costs (ca. R21.00-R23.00/kg; SAPA, 2019) at the base of the value chain,

also the preferred meat choice nationally. Clearly winning the substitution challenge when the farm-gate break-even producer costs are much above R20.00/kg for farmed tilapia on a live weight basis is a tall order offering little merit as an affordable alternative meat protein targeting food insecure households in rural and urban South Africa.



Best and worst case production costs of farmed tilapia using intensive ponds and *Recirculation Aquaculture Systems* (RAS) based upon the use of complete extruded tilapia feeds costing R14.00/kg in South Africa at present.

Best case break-even farm gate production cost	Worst case break-even farm gate production cost
Assumption 1: Grower feed cost 50% of production cost	Assumption 2: Grower feed cost is 60% of production cost
$R28.00/kg = R14.00/kg / ((100-50)/100)$	$R35.00/kg = R14.00/kg / ((100-60)/100)$

The major cost drivers and challenges confronting the fledgling tilapia farming sector in South Africa are 1) high feed cost at > R14.00/kg for 28-32% protein grower rations, 2) sub-optimal water temperatures most of the year (Figure 8) due to the poor location of tilapia farms > 500m above sea level and outside the warmer east coast and low elevation inland sites [still climatically sub-optimal for efficient tilapia culture for water temperatures above 25°C for more than 3 months of the year], 3) the use of inappropriate production technology for low-cost and scalable production viz. intensive pond farming and RAS and, 5) lack of scale- and scope economies of operations. The future large-scale farmed production of Mozambique tilapia (*Oreochromis mossambicus*) in sea-water, or marine farmed tilapia, using Biofloc Technology (BFT) applying today's costs and pricing in 2021 clearly represents potentially the least cost animal meat protein source in South Africa as indicated by Figure's 6 and 7.

Figure 7: How does tilapia farming compare to broiler chicken farming in terms of feed use efficiency and cost ?

How does Biofloc Technology, Recirculation Aquaculture Systems (RAS) and cage and intensive pond grown tilapia compare to a broiler chicken production metrics, 1) in terms of feed use, 2) nutrient recovery efficiency and 3) feed cost per unit of edible meat yield?
[\[Calculated on R15.00=US\\$1.00\]](#)

Comparative feed use, nutrient recovery efficiency and feed cost per unit of edible meat yield in BFT and RAS/Pond grown tilapia vs. broiler chickens	 RAS/Pond/Cage grown tilapia (500g fish, 30% protein feed, GE 16MJ/kg)		Broiler chicken 
	BFT grown tilapia (500g fish, 20.2% protein feed, GE 16MJ/kg)		
Feed Conversion Ratio (FCR) =	1.4 : 1.0	1.0 : 1.0	1.79 : 1.0
Net Protein Recovery, %/edible yield =	20.5%	45.6%	21%
Net Energy Recovery, %/edible yield =	20.0%	28.0%	10%
Edible meat yield, % (500g fish) =	57.6%	57.6%	46.1%
Feed cost, US\$/tonne (ZAR/t)=	US\$ 933.33/t (R14,000/t)	US\$ 283.33/t (R4,250/t)	US\$ 253.33/t (R3,800/t)
Feed cost, US\$/kg (ZAR/kg) edible meat yield =	US\$ 2.27/kg (R 34.03/kg)	US\$ 0.49/kg (R 7.38/kg)	US\$ 0.98/kg (R14.75/kg)

Note: Edible meat yield in tilapias is not the same as the fillet yield. Edible meat yield includes skins and all edible portions (see Sahu *et al.*, 2017)

Figure 7 provides the accounting of the efficiency of feed use in BFT tilapia aquaculture as compared to intensive pond farming and the use of a Recirculation Aquaculture System (RAS) in tilapia aquaculture versus broiler chicken farming. BFT tilapia production competes favourably against broiler chicken farming in terms of feed use efficiency accounting on both a live weight and edible meat yield basis. Whereas tilapia culture neither when using intensive ponds > 7 tonnes/ha/year nor RAS tilapia production technology would be competitive in terms of feed use efficiency when gauged against broiler chicken farming given current pricing of standard extruded tilapia grower feeds at a cost of R14.00/kg ex-factory in South Africa.

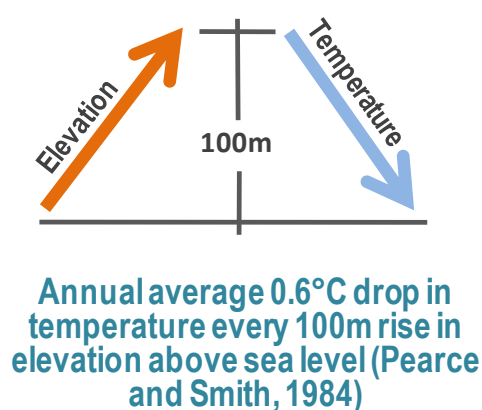


Figure 8: Prime areas for tilapia culture in South Africa are below 500m above sea level along the east coast and inland low-lying regions

The solution to the local sub-optimal climate for productive and efficient tilapia culture, high feed costs (extruded feed for tilapia costs around R14.00/kg for a 28-32% grower ration) and lack of the

benefits of scale economies calls for a more determined, targeted and sophisticated response to solve these peculiar challenges.

THAPI AquaKulcha sees large-scale professionally managed majority worker co-owned scalable sustainable intensification of the tilapia farming sector, emulating certain elements of the highly successful broiler farming model, adapted for local sub-optimal climatic conditions and the use of Biofloc Technology (BFT) as key to the success of an efficient and competitive tilapia culture sector in South Africa.

The new marine tilapia industry proposed by the *THAPI Marine Tilapia Industry Vision 2035* at scale producing 20,000 tonnes of tilapia per cluster potentially offers the least cost animal protein source in South Africa (see Figure 6) at farm gate break-even costs as low as R15.00/kg (US\$1.00/kg) live weight at the base of the value chain after the attainment of the benefits of scale- and scope economies and specialization based upon long-run costs at today's input prices before onward sales to a processing plant. Then, a large-scale BFT based marine tilapia industry along the east coast would be the least cost producer of tilapia in the country, the least cost source of animal protein in South Africa and the least cost producer of scalable quantities of tilapia in Africa.

Table 1: Farm gate break-even production costs in Malawi, Ghana, Kenya, Uganda, Nigeria and South Africa *vis-à-vis* China in recent years

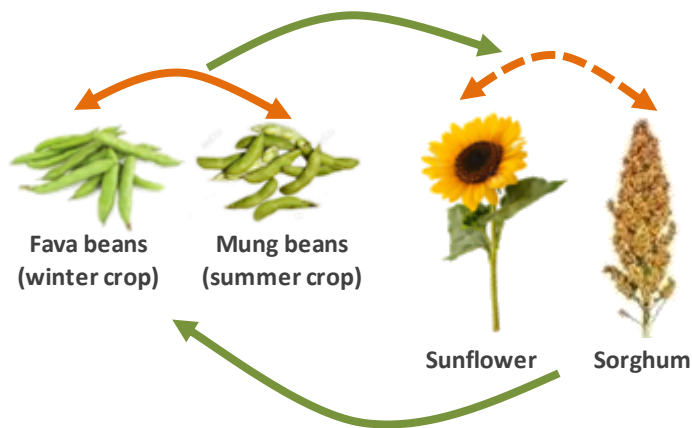
Country	Production system	Break-even cost, US\$/kg	Source
<i>African tilapia farming production costs as a function of system and location</i>			
Malawi	Semi-intensive ponds	2.00	Phiri and Yuan (2018)
Malawi	Large-scale cage culture	2.01	Kourie (2017)
Malawi	Large-scale greenwater pond farm	1.39	Kourie (2017)
Malawi	Medium scale Biofloc Technology (BFT) farm	1.25	Kourie (2017)
Malawi	Medium-scale Recirculation Aquaculture System (RAS)	1.69	Kourie (2017)
South Africa	Large-scale Biofloc Technology (BFT) farm	1.00	Kourie (<i>unpublished</i>)
South Africa	Intensive pond and RAS farms in South Africa (feed, R14.00/kg for 30-32% protein grower)	1.87-2.33	R28-R35.00/kg estimate (Kourie, <i>unpublished</i>) [at a rate of R15.00 = US\$1.00]
South Africa	Small-scale RAS tilapia production, Gauteng	2.32	Kourie (<i>unpublished</i>)
Kenya	1Ha pond farm	2.72	Ngugi <i>et al.</i> (2017)
Ghana	Small-scale cage culture	2.16	Ofori <i>et al.</i> (2009)
Uganda	10Ha pond farm	1.97	Hyuha <i>et al.</i> (2017)
Nigeria	Cage farm	3.25	Atanda and Fagbenro (2017)
<i>Chinese pond farming of tilapia</i>			
China	Intensive pond farming < 1Ha to > 10Ha	1.22-1.32	Yuan <i>et al.</i> (2017)

Equally on the international stage the *THAPI Marine Tilapia Industry Vision 2035* would be highly competitive where the farm gate break-even production costs of around R15.00/kg (US\$1.00/kg) live weight (Table 1) are then some 18.4-25% less than break-even production costs of R18.30-R19.80/kg (US\$1.22-1.32/kg) for tilapia farm sizes ranging from < 1Ha to > 10Ha] in China (Yuan *et al.*, 2017).

Equally significant is the positive pull effect created by the *THAPI Marine Tilapia Industry Vision 2035* for feedstock raw materials which in addition provides a choice opportunity to transform available land, water and human capital [for food security and income generation] involving 15,000-30,000 farmer families per cluster [=20,000 tonnes of tilapia] in the rural EC and KZN. Note that five (5) clusters are planned at Phase 5 [up to 150,000 farmer families and 100,000 tonnes of fish production] on the Eastern Cape and KwaZulu-Natal coastline. Farmers would plant feedstock crops for the

Marine Tilapia Industry and also produce nutritious crops such as pulses and legumes, maize and sorghum for local/regional consumption and other markets (Figure 9).

Figure 9: Small-scale irrigated agroforestry/regenerative farmer feedstock development program to support the *THAPI Marine Tilapia Industry Vision 2035* for the production of aquatic feeds to feed marine tilapia



Alley cropping legumes, grains and oil seeds in-between nitrogen fixing White Acacia (*Faidherbia albida*) trees – a low-input agroforestry/regenerative farming/climate resilient approach to crop production in the rural Eastern Cape and KwaZulu-Natal.

The *THAPI Marine Tilapia Vision 2035* then offers a prime opportunity to rescale developmental objectives, using new inclusive growth conduits to address the triple challenges of rural poverty, unemployment and inequality on the one hand, as well as address rural nutritional security and food sovereignty on the other hand. The vision addresses SDG 2, to end hunger, achieve food security and improved nutrition and to promote sustainable agriculture [and aquaculture], and both, indirectly and directly via substitution, supports SDG 14 which targets healthy oceans for food security, nutrition and resilient communities. Given this mission then the *THAPI Marine Tilapia Industry Vision 2035* offers one of the most attractive solutions to countering the prevalence of household food insecurity with nearly 60.6% and 50% of households dependent on social grants in 2019 (Stats SA, 2019) and an official unemployment rate of 47.9% and 29.6% (Stats SA, 2021) in the rural Eastern Cape and KwaZulu-Natal respectively over the period October-December 2020.