BUSINESS MODEL 18

Leapfrogging the value chain through aquaculture

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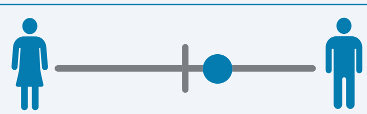
Key characteristics

Model name	Leapfrogging the value chain through aquaculture
Waste stream	Domestic wastewater
Value-added waste product	Reclaimed water, fish feed, fresh fish and/or packaged fish, irrigated crops
Geography	Regions where inland fish is in higher demand than supply
Scale of production	Small–medium scale; 200–1,000m^3 wastewater intake per day
Supporting cases in this book	Kumasi, Ghana; Mirzapur, Bangladesh
Objective of entity	Cost-recovery [ ]; For profit [X]; Social enterprise [ ]
Investment cost range	USD 20,000 to 100,000 plus cost of suitable land/lagoons of about 1–5 ha
Organization type	Mostly public-private partnership, but also other options
Socio-economic impact	Environmental pollution reduction, health risk reduction, job creation, food security
Gender equity	Inequity likely on farm in view of access to land, knowledge and capital, while gender roles in fish marketing vary between countries 

Business value chain

Wastewater-fed aquaculture has a long tradition, especially in South and Southeast Asia, and is being recognized as an innovative business-oriented reuse system where sufficient land is available and possible health risks can be controlled, e.g. by avoiding mixed wastewater, which contains industrial effluent.

There are two different conceptual variations possible. From a safety perspective, a model as used in the presented case of Bangladesh is being preferred where the treatment process includes duckweed to absorb large amounts of nutrients, transforming them into high quality protein. The harvested duckweed is then used to feed fish grown, e.g. with groundwater in vicinity. Possible chemical contamination of the food is being monitored.

In a variation of the model, fish receives its food directly in the treatment system, where it is cultivated in the last maturation pond of multiple treatment pond set-up. To reduce health risks in this case, WHO guidelines are strictly to be observed. The treated water can be released safely in the environment, or reused for crop production in areas where irrigation water is scarce. The business model adds economic value to an existing pond-based treatment infrastructure by offering with limited additional investments different revenue options linking into high revenue value chains. The model is suitable for small- to medium-scale operations at community or institutional level where land is available, water quality is known and fish and irrigated crops have an assured local market demand (Figure 229).

The dotted short cut can further reduce capital costs but although increases public health risks, thus can only be recommended where strict water quality monitoring is possible.

In both studied cases, the institution in charge of safe wastewater disposal teamed up with an entity experienced in wastewater treatment and aquaculture. This could be a public-private partnership (PPP), but also private-private partnerships, e.g. where a private university or hospital is teaming up with an enterprise or NGO, or only public operation. In the public-private case, the public entity provides wastewater and [a budget to set up] infrastructure for wastewater treatment and safe disposal, while the private partner offers treatment expertise and invests either in additional fish ponds and/or fish fingerlings, and assures the O&M of the overall treatment system.

The interesting aspect of the PPP is the realization of a multiple win-win situation: while the public partner gets the treatment and waste disposal done without paying for the O&M service, the private partner benefits from the – in large – already existing/budgeted infrastructure and can with very limited own capital investment produce a high-value product for revenue generation. Depending on demand and supply, the contractual agreement for using the land and/or pond system can also include a profit sharing arrangement like in the Ghana case, which allows the public entity recover some of its own operational costs. Finally, the generated revenues can allow the authorities to 'pro-poor' waive sanitation fees for the served wastewater generating households or entities.

The key players in the business set-up are the aquaculture business entity, if needed with (access to) expertise in phyto-remediation, the local municipality and/or local organization in need of wastewater

FIGURE 229. POSSIBLE REVENUE STREAMS – PROTEIN GENERATION FOR AQUACULTURE AND CASH CROP IRRIGATION

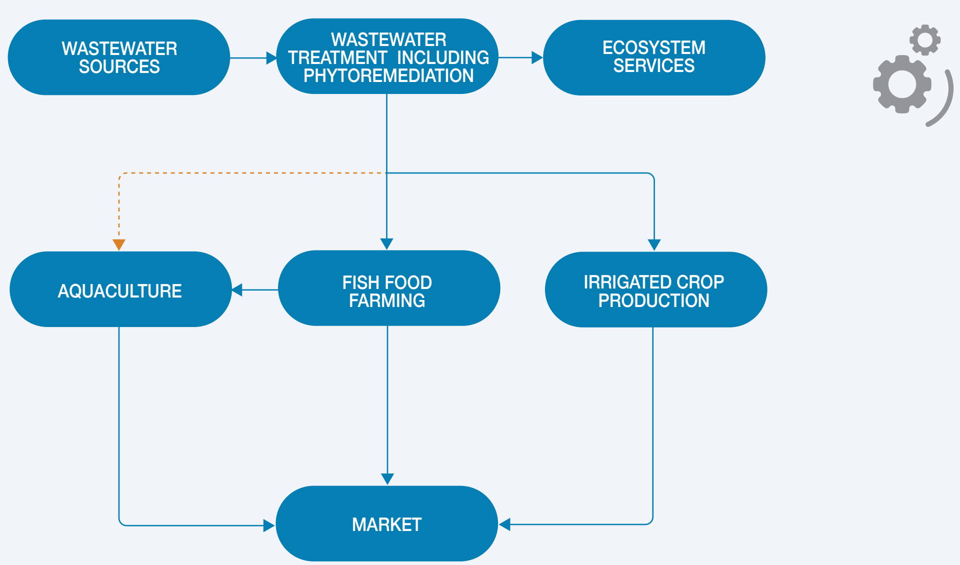
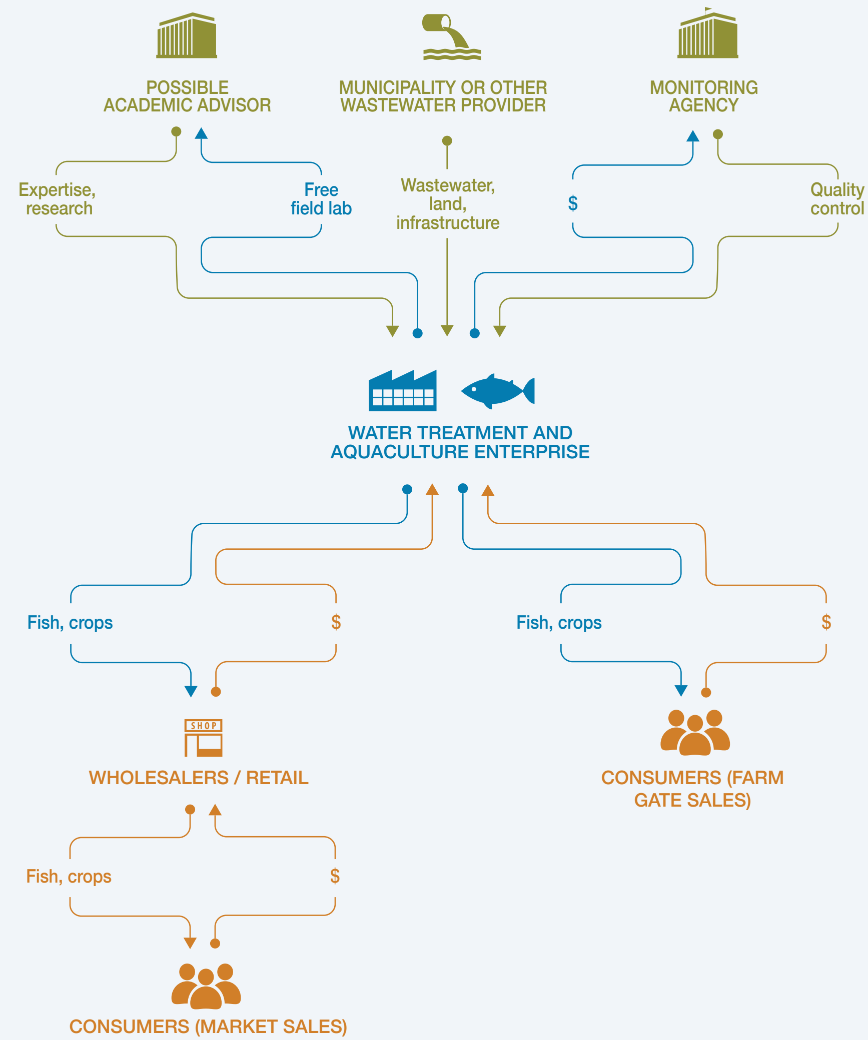


FIGURE 230. KEY PLAYERS AND VALUE CHAINS IN THE MODEL



treatment, and the local market, i.e. produce buyers and consumers (see Figure 230). An expert partner, able to carry out locally applied research in fish or duckweed farming, like a local university, could add value. Finally, an important stakeholder is the one in charge of monitoring water, crop and fish quality. Although the fish farming business will give highest priority to maintaining consumer trust, independent quality control is recommended. This could be the local agency in charge of food safety.

Given the limited capital investment needs for the enterprise, financing should be possible in many countries through a bank loan at a term of five years, best at a subsidized lending rate given the public sector support. The business has the potential to impact local residents through the production of inland fish and the creation of employment opportunities along the aquaculture value chain.

Business model

The wastewater from the community is brought to the treatment ponds through an existing sewerage network (in case of municipal wastewater treatment). Fish farming can be integrated in the treatment system or preferably be indirectly linked via the harvested phyto-biomass (e.g. duckweed). The recommended business model uses wastewater to produce on-site fish feed and with the feed off-site (i.e. not within the treatment system) fish. It offers through the sale of fish to end-users and/or intermediate traders a value proposition with a much higher revenue stream than the sale of the reclaimed water would allow (Figure 231). The business usually relies on a (public-private) partnership, which acts on an opportunity that derives from a need for both wastewater treatment and a market which can absorb more fish than on offer. The business is cost-driven, and can offer cheap produce through minimal capital costs for infrastructure, and low-cost operation. Low cost operation is enabled through the free provision of nutrient rich water and the duckweed technology which allows

FIGURE 231. BUSINESS MODEL CANVAS FROM THE PERSPECTIVE OF THE AQUACULTURE BUSINESS PROVIDER

KEY PARTNERS

- Authority in need of wastewater treatment
- Expertise / research provider
- External financier (optional)
- Fish traders

KEY ACTIVITIES

- Treat wastewater to advanced tertiary quality
- Grow duckweed and irrigate crops
- Fish farming
- Water quality monitoring
- Fish processing, marketing and sales

KEY RESOURCES

- Right to use treatment ponds for duckweed cultivation/ water treatment
- Space to establish fish ponds
- Expertise in phyto-remediation and fish farming
- Capital for fingerlings and pond construction
- Fish and crop marketing and sales

VALUE PROPOSITIONS

- Self-financed wastewater treatment building on cost-competitive fish production which takes advantage of free resources (water, nutrients, infra-structure) pond based treatment systems offer

CUSTOMER RELATIONSHIPS

- Personal (direct product sales)
- Partnership contract with wastewater-producer or authority in charge of treatment

CHANNELS

- Pond-side (farm gate) sales
- Word-of-mouth
- Local marketing channels
- Meetings, negotiation with wastewater provider

CUSTOMER SEGMENTS

- Traders and consumers of local fish and fruits and vegetables
- Authority in need of wastewater treatment

Extended Beneficiaries

- Wastewater producing households/ entities
- Fish and crop consumers
- Dwellers depending on downstream water quality

COST STRUCTURE

- Capital investment in fish and fish ponds (unless part of final treatment system)
- O&M of ponds, mostly labor incl. security against illegal fish harvest; debt repay
- Fish and crop marketing and sales
- Research collaboration (fish growth and produce safety)
- Benefit sharing with public partner (optional)

REVENUE STREAMS

- Pond-side sales of fish to customers, retail, whole sale
- Pond-side sales of crops and fish feed (if in excess)
- Payment for water treatment service (optional)

SOCIAL & ENVIRONMENTAL COSTS

- Possible human health hazard from consumption of fish grown in (proximity to) treated wastewater, where human pathogens may still exist and may be carried into human
- Laborers' health risk due to contact with wastewater, especially when harvesting duckweed

SOCIAL & ENVIRONMENTAL BENEFITS

- Wastewater efflux of organization(s) is treated, which results in reduced environmental pollution pressure to water bodies and downstream water users
- More fish protein and crops on the market at low cost
- Job creation

to produce most of the required fish feedstuff within the treatment system. Costs are also kept low due to farm gate marketing and no need for storage. Irrigated crop production offers a secondary revenue stream. Labor required for duckweed management and feeding to the fish and for fish harvesting is locally available and manpower can be trained on-site. Although the manual operations are simple which helps to save costs and to move the business towards net profits, aquaculture and even more wastewater-aquaculture requires significant management experience and skills to maintain a high fish survival rate and manage the right feeding for optimal fish growth. Partnering with an expertise provider/research institution on phyto-remediation and fish rearing will be useful unless the expertise is internally available to avoid high startup costs through 'learning by doing'. This type of enterprise may flourish at small to medium scale wherever sufficient land for both, pond based treatment and fish farming can be set up in proximity or interlinked, and where water for fishing or fish farming is generally limited. In coastal regions, possible competition from saltwater fish has to be explored. In any situation, either if fish is grown with reclaimed water (or fish is fed with plants produced in wastewater) the business requires a conducive legal-regulatory setting and quality monitoring given potential consumption as well as occupational health risks.

Potential risks and mitigation

The business model presented here was designed based on a detailed analysis of the two case studies from Ghana and Bangladesh, as well as other cases and references. There can be a variety of business risks affecting the successful implementation of such a model, most of them being more generic than model specific. For example, as reuse projects involving wastewater are potentially harmful to human and environmental health, particular health risk (mitigation) options are obvious and have to be addressed, like also community acceptance. However, also other risks such as those defined below have to be addressed, although there will be location specific differences.

Market risks: Fish is a protein-rich, nutritious source of human food and the assumption is that a strong market exists for onsite direct sale to consumers and/or sale through retail. Where the source of fish on the market is known, some consumers might not like to eat fish raised with duckweed grown in wastewater. However, it is unlikely that traders will brand their produce in a way that could jeopardize their business.

Competition risks: Fish produced on wastewater competes directly with local freshwater (or also sea water) fish and indirectly with frozen product from oversea markets, which at times could be cheaper than the local produce in some countries. Therefore, the advantage of low-cost production (using free feed) have to be used to sell the fish at a competitive price.

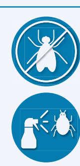
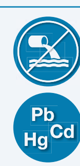
Technology and performance risks: Natural water quality remediation measures are usually low-cost. The technology of duckweed production for fish farming is straight forward and mature, and can build on decades of research and development. Local workforce can be trained in the operations. Fish farming itself requires more expertise than the water treatment as well as quality monitoring.

Political and regulatory risks: Fish farming in general is a supported agricultural practice, and there are no known political and regulatory risks in most settings. If the water used for the fish is part of the treatment chain, the business requires a legal-regulatory setting that is conducive to this situation, and thus a threat to the business might come from particular or changing safety regulations.

Social equity related risks: The model is considered to have more advantages for male entrepreneurs (farmers) although in many places cultural tradition steers if more men or women are involved in fish farming. However, in many regions, women have comparatively to men less access to land, education or capital, which are crucial for entering aquaculture. Still, there can be regionally more women working in the sector than men. In Asian countries such as Cambodia, Bangladesh, Indonesia and Vietnam, for example, women carry out 42–80% of all aquaculture activities, with equally large variations along the value chain. See also World Fish Center (2011).

Safety, environmental and health risks: The model can be very safe but requires significant attention to risk monitoring and control (Table 54). There can be specific health concerns for workers harvesting the duckweed from the wastewater, which can however be addressed with protective gear, harvesting equipment and good hygiene. In the less preferred variation of the model where fish is grown with reclaimed water, the risks extend also to the fish and thus the consumer. For this situation, the WHO (2006) guidelines for wastewater use in aquaculture apply. A common way to reduce consumer microbial

TABLE 54. POTENTIAL HEALTH AND ENVIRONMENTAL RISK AND SUGGESTED MITIGATION MEASURES FOR BUSINESS MODEL 18

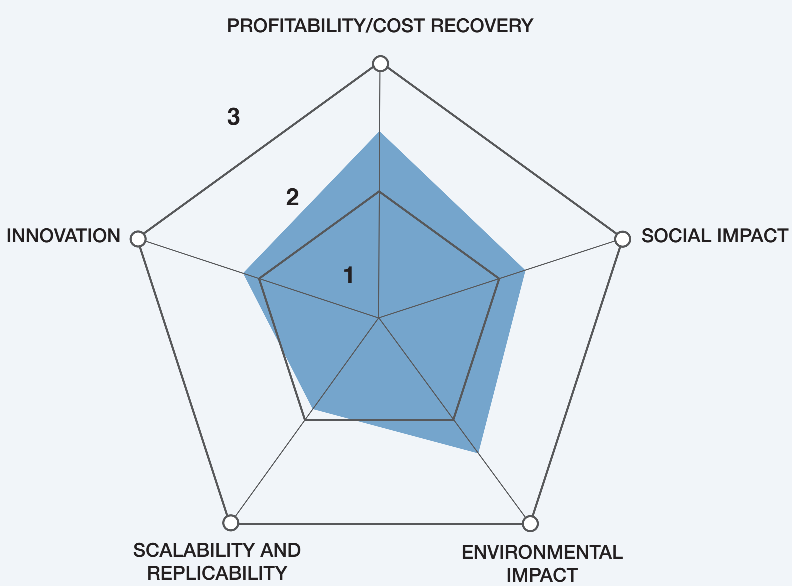
RISK GROUP	EXPOSURE					REMARKS
	DIRECT CONTACT	AIR/ ODOR	INSECTS	WATER/ SOIL	FOOD (FISH)	
Fish farmer/operator	HIGH RISK	MEDIUM RISK	MEDIUM RISK	MEDIUM RISK	NOT APPLICABLE	Consumer awareness and information has to be supported on the source of the traded fish
Community	NOT APPLICABLE	LOW RISK	LOW RISK	MEDIUM RISK	NOT APPLICABLE	
Fish consumer	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	MEDIUM RISK	
Mitigation measures						

Key: NOT APPLICABLE · LOW RISK · MEDIUM RISK · HIGH RISK risks is through fish smoking or grilling, although contaminants might survive, in particular within the fish. Purification in clean water ponds could address this challenge to some degree, as well as careful separation of meat and the digestive tract during slaughtering, and cooking. Regular monitoring of the inflowing wastewater and fish could help detect possible chemical risks, although laboratory capacity for so-called “emerging contaminants” is still missing in many developing countries.

Business performance

The business model supports the move beyond cost recovery towards profitability. The combination of ponds or zig-zag flow systems with a phyto-remediation step are applied low-cost technologies which treat wastewater to an advanced tertiary state. Using the phyto-(plant) biomass as ‘in-house’ production of fish feed, such as duckweed, and the low labor requirements of the system significantly reduces operational costs for nearby fish farming while the free use of land reduces capital cost. Where fish has a market, the system can make profits even where no subsidies are received and no wastewater treatment fees are charged. Capital costs could be further reduced where fish is grown within the last part of a pond based system. However, this variation of the model is significantly increasing health risks and can only be considered where water quality and risk mitigation measures fully correspond with safety recommendations. The model ranks also high in terms of environmental impacts due to the wastewater treatment, in particular nutrient removal, and on social impact due to protection of public health, plus the additional supply of nutritious fish and local jobs (Figure 232). The model ranks lowest on scalability and replicability criteria due to its land requirements. Yet, the business model highlights strong potential for replication for a developing country setup with limited institutional capacities and its applicability to peri-urban areas and towns where land is not yet in short supply. The model is thus attuned to the needs of small- and medium-size communities where high tech wastewater treatment plants will not achieve cost-economies and/or might not be affordable. The system can be scaled to the needs of the local communities as the inputs are as simple although

FIGURE 232. RANKING RESULTS FOR AQUACULTURE BASED BUSINESS MODEL



the rearing of fish should not be underestimated and requires an experienced partner. Further, the regulatory setup should support production and sale of fish from such a system, even if fish is only indirectly in contact with the water. There exists a greater potential for this model in countries that are land-locked (no sea food), have limited surface water resources while fish is a welcomed staple food in the local diet.

References and further readings

World Fish Center. 2011. Gender and aquaculture: Sharing the benefits equitably. Issues Brief 2011-32 http://pubs.iclarm.net/resource_centre/WF_2832.pdf (accessed 5 Nov. 2017).

WHO. 2006. Guidelines for the safe use of wastewater excreta and greywater. Volume III. Wastewater and excreta use in aquaculture. Geneva: World Health Organization.