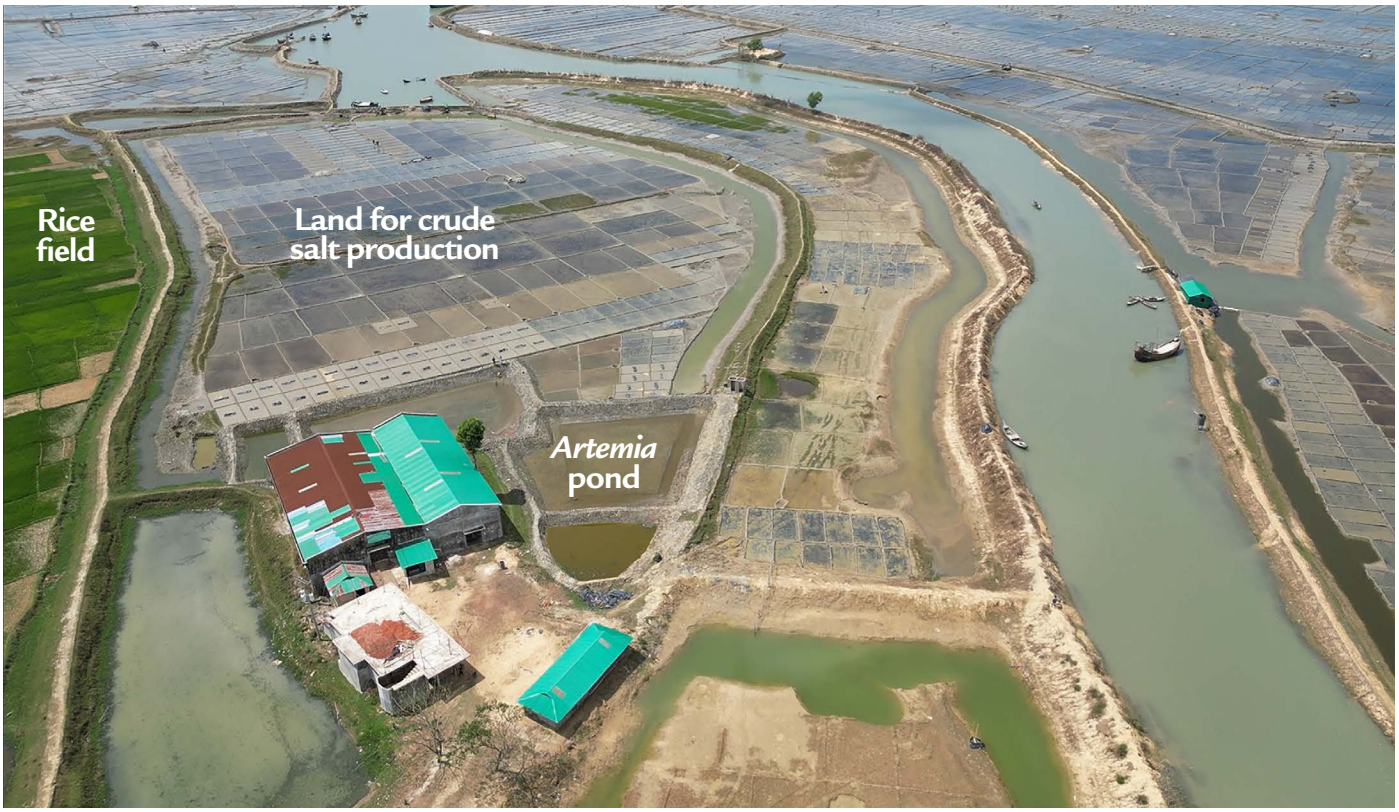

FIGURE 1. Artemia *cyst production pond at Moheshkhali, Cox's Bazar, Bangladesh.*

Brine Shrimp *Artemia* Pond Culture in Cox's Bazar, Bangladesh

Muhammad Meezanur Rahman and Patrick Sorgeloos

Introduction

In Bangladesh, 95 percent of crude salt is produced in the Cox's Bazar area by 50,000 artisanal salt farmers across about 27,000 ha of land. With roughly half a million people directly or indirectly involved in salt production, it is an important industry for the region. The industry faces several major challenges, such as increased operating, land and labor costs, unemployment during the rainy season and low productivity in aquaculture. Salt production is hampered due to climate-induced hazards such as erratic rainfall and cyclones. These are the biggest obstacles to improving the livelihoods of salt farmers in Bangladesh.

Salt farmers of Cox's Bazar are very poor. Recent surveys indicate that salt farmers average household size is 6.2, 80 percent operate salt production on leased land, annual income of the households is less than US$1,000/ha. Crude salt production contributes 60-70 percent of the annual income of salt farmers, 40 percent of salt farmers have no savings and 90 percent of the farmers' families have low dietary diversity. Approximately 75 percent of the salt production area is used for extensive aquaculture during the rainy season. Therefore, climate-smart and nutrition-sensitive technologies are needed to increase income, improve livelihoods and tackle malnutrition of the salt farmers' families.

Countries such as Brazil, China, Ecuador, Thailand and Vietnam have been successful in adopting technologies to improve the income of salt farmers through the production of *Artemia* cysts and biomass (van Stappen *et al*. 2019). WorldFish has been implementing a European Union funded project entitled "Introducing Circularity through Climate-Smart Aquaculture in Bangladesh (Artemia4Bangladesh)" under Development of Smart Innovation through Research in Agriculture (DeSIRA) program. The objective of the project is to increase productivity of salt producers and aquaculture farmers, facilitated by *Artemia*-related innovative initiatives in the Cox's Bazar area (Fig. 1).

Artemia Pond Culture Procedure

Critical parameters are the selection of *Artemia* strain, site selection, pond construction/preparation, maintenance of optimum salinity levels in the ponds, *Artemia* cyst hatching and nauplii inoculation, enhancement of algae growth, pond management, supplementary feeding, harvesting, processing and preservation of cyst and biomass (Rahman *et al*. 2022). Flat lands, clay and alkaline soils, a proper dike system to prevent leakage, a drain and canal system as well as favorable climate (i.e., long dry season, low rainfall and suitable temperatures to accelerate evaporation) are

FIGURE 2. Artemia *nauplii inoculation of ponds.*

FIGURE 4. *Concentrated* Artemia *biomass.*

important criteria for proper site selection of *Artemia* production.

Artemia franciscana Vinh Chau strain cysts were imported from Vietnam for the inoculation. Standard hatching procedures were applied (Rahman *et al*. 2022). It is critical to inoculate instar 1 *Artemia* nauplii in the culture pond (Fig. 2). *Artemia* pond production includes algae ponds and *Artemia* culture ponds. Algae ponds comprise 20-25 percent of the production area. Salinity of *Artemia* culture ponds should maintain a minimum of 70 g/l. Inorganic fertilizers (urea, triple super phosphate) and organic fertilizers (cow dung, chicken manure) are used for natural productivity in algae ponds and *Artemia* ponds. Approximately 1-3 cm of algae pond water is transferred 2-3 times per week, depending on food demand and water salinity. *Artemia* biomass and cysts can be harvested from one month after inoculation (Fig. 3).

Quality of *Artemia* Cysts and Biomass

Artemia biomass (Fig. 4) produced in ponds was tested for the presence of three major shrimp pathogens — white spot syndrome virus (WSSV), acute hepatopancreatic necrosis disease (AHPND) and *Enterocytozoon hepatopenaei* (EHP) through conventional polymerase chain reaction (PCR) method using OiE-recommended protocols. All samples were negative for these pathogens.

Nutritional analysis determined that *Artemia* biomass contains 43-45 percent crude protein and 6-7 percent crude fat. It contains

FIGURE 3. *Packaging of live* Artemia *biomass for transport.*

FIGURE 5. *Pond harvest of* Artemia *cysts.*

essential amino acids (arginine, histidine, leucine, methionine, phenylalanine, threonine, isoleucine and valine) and polyunsaturated fatty acids such as docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA), linolenic acid and arachidonic acid.

Fatty acid methyl ester (FAME) analysis of *Artemia* cysts (Fig.

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FIGURE 6. *Feeding live* Artemia *biomass to* Penaeus monodon *broodstock.*

FIGURE 7. Artemia *biomass feeding to shrimp post-larvae nursing in a hapa.*

FIGURE 8. Artemia *as human food: kebab.*

FIGURE 9. Artemia *as human food: omelette.*

5) revealed a high EPA content at 16-17 mg/g dry weight cysts. The average cyst size is 238 μm, with a hatching rate of 85 percent. The excellent nutritional quality of locally produced *Artemia* biomass and cysts and the small size of cysts opens the scope to promote marine aquaculture in Bangladesh and reduce dependence on imported cysts.

Live or frozen *Artemia* biomass is an excellent diet for shrimp broodstock (Fig. 6), post-larvae nursing (Fig. 7) and first month juvenile in grow-out, and also for mud crab nursing. The umbrella stage of *Artemia* is essential for the zoea stage of crablets, which can significantly increase their survival (Hai *et al*. 2020)

Artemia Biomass as Human Food

Five innovative recipes were developed for *Artemia* as human food: *Artemia* kebab (Fig. 8), omelet (Fig. 9), water spinach fritters, coconut milk curry and *jhal ferazi* (Fig. 3). The recipes were well accepted by salt-farmer families, as well as aquaculture stakeholders. The new food items will contribute to tackling malnutrition of salt-farmer families.

Summary

Salt and coastal aquaculture farmers in Bangladesh are poor and may be the most climate vulnerable population in the world. A new climate-smart and nutrition-sensitive *Artemia* pond culture opens the scope to increase the productivity of coastal aquaculture, increase income and tackle malnutrition of salt farmers' families.

Notes

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