Managing Aquatic Agricultural Systems to Improve Nutrition and Livelihoods in Selected Asian and African Countries: Scaling Learning from IFAD-WorldFish Collaboration in Bangladesh

under the Programme

Putting Research into Use for Nutrition, Sustainable Agriculture and Resilience (PRUNSAR)

2017 Technical Report

Shakuntala Haraksingh Thilsted, Olivier Joffre, Bun Chantrea, Sven Genschick, Sharon Suri

WORLDFISH

IFAD
Investing in rural people

EU

WorldFish

Overall project goals and objectives

The goal of the project is to improve nutrition and livelihoods of poor, rural households in aquatic agricultural systems in Cambodia, Zambia and Indonesia through increased consumption and production of micronutrient-rich small fish and vegetables.

The objective of the project is to scale up the integrated Aquaculture/Agriculture-Nutrition Linkages approaches developed and introduced in Bangladesh, in targeted communities in Cambodia, Zambia and Indonesia. Specifically, by improving production and productivity of household ponds and dykes; increasing fish production, particularly small fish production and fish species diversity in wetlands; and supporting initiatives to increase consumption of micronutrient-rich small fish and vegetables.

Cambodia Component

I. Summary and context

Over the past decade, Cambodia has enjoyed strong economic growth resulting in improved livelihood for its population of 14 million. Despite significant progress, 4.8 million Cambodians remain poor, with 90% living in rural areas. Subsistence farmers, members of poor fishing communities, landless people and rural youth comprise the majority of Cambodia's poor. Generally, within this demographic group dietary diversity is low, and malnutrition remains high among children under five years of age.

Fish is an integral part of Cambodia's culture, economy, and food security, contributing around 7% to national GDP and supplying 66.3% of households' animal protein intake. Yet, the diet of many rural Cambodians remains heavily dependent on the staple food, rice, and dietary diversity is low. Increasing fish production and productivity, and in particular of small indigenous fish species, using the integrated Aquaculture / Agriculture-Nutrition Linkages approach can provide smallholder households with increased income and support food and nutrition security.

Household aquaculture ponds stocked with both larger, marketable fish and small, nutrient-rich fish species can be managed with limited inputs to generate extra income for households and provide additional nutrient-rich food supply to households over an extended period of the year. In addition, ponds can be integrated into the smallholder's farming system, providing water for homestead vegetable production on pond embankments. This integrated approach has the potential to help address the constraints faced by many.

In 2017, the project in Cambodia supported 65 households for homestead pond nutrition sensitive aquaculture and selected 9 additional households to test intervention in seasonally flooded rice field ponds. Of the 65 households supported by the project, all received training on nutrition sensitive aquaculture techniques, 23 started a series of training modules on hygiene and nutrition and 31 received training on homestead vegetable production. 29 households developed and committed to a 'family vision' to support gender equity in the household. The remaining beneficiaries will be trained in 2018. Three local partners NGOs and Fisheries Administration cantonment officers received training on:

- Nutrition-sensitive aquaculture, led by an expert from the Fisheries Administration (18 trainees);
- gender transformative approaches and 'family visioning' (8 trainees)

Baseline surveys and monitoring systems for nutrition and fish and horticulture production, were developed and deployed in 2017. The monitoring system has been designed to include gender empowerment and equity indicators.

In 2017, the local partners allocated 3 more staff (1 per NGO partner) to support training, technical support and monitoring of farmers. The WorldFish Cambodian Office organized a Global Workshop on Nutrition-sensitive Fish Agri-food Systems, held in Siem Reap from 5th to 8th December 2017, which strengthened national and regional collaborations for scaling nutrition sensitive approaches.

II. Results

Project achievements in 2017, in relation to the four target outputs listed in the project 'Logframe'.

a. Output 1: Increased availability, access and consumption of micronutrient-rich small fish and vegetables

i. Activities 1: Aquaculture and horticulture production

The project selected 65 households in 3 provinces around the Tonle Sap Lake - Battambang, Siem Reap and Pursat (Table 1). Households were considered eligible if they had either children under 5 years old (48 households), children between 6 and 10 years old (25 households), a lactating woman (15 households) and/or a pregnant woman (1 household).

Table 1: Project target households (HH) and administrative location

Province	*District*	*Commune*	*Village*	*HH – Homestead pond*	*HH – Rice field ponds*
Battambang	Bovel	Kdol Tahen	Tuol Krasaing	7	0
		Khlaing Meas	Along Raing	5	0
	Thmar Kol	Ou Taky	Trash & Ou Taki	14	0
Siem Reap	Kralanh	Kralanh	Kralanh & O'Kralanh	12	3
		Sranal	Sranal	7	3
Pursat	Krakor	Sna Ansa	Veal Long & Ansa Kdam	20	3
Total				**65**	**9**

In Pursat and Siem Reap, seasonally flooded rice-field ponds, ranging from 200 to 500m^2, have been selected and identified for future intervention in early 2018. In Battambang province, the area of intervention has a higher elevation, thus hindering the presence of rice-field ponds. Next year, interventions will include an additional village in Battambang province closer to the Tonle Sap lake where rice-field ponds are found. The selected households are within the same communes as another WorldFish-led project (Rice Field Fisheries project, USAID-funded) to create synergies between projects.

Capacity building

Three local NGO partners, Universities (Royal University of Phnom Penh, Prek Leap National College of Agriculture) and local Fisheries Administration officers received an aquaculture training conducted by the Fisheries Administration, Department of Aquaculture Development (DAD). In total,18 trainees participated in the training on 22nd - 24th August. The training included key technical dimensions of fish culture (pond preparation, water quality management, stocking and fish raising technique) but facilitators also delivered specific information on nutrition-sensitive aquaculture including: i) the identification and harvesting of small

indigenous fish species in rice fields, ii) the transportation of these fish to aquaculture ponds, and iii) sequential harvesting techniques.

Aquaculture technicians from three local partner organizations also received training on the project guidelines and farmer selection. They attended a 2-days training session on project monitoring systems, provided by the WorldFish Monitoring, Evaluating and Learning (MEL) team. These aquaculture technicians provided technical support to farmers, in a total of 743 farm visits. Specifically, the technicians ran short thematic trainings which were conducted in the target intervention communes and one-day workshops on aquaculture techniques in each province. In addition, the Fisheries Administration conduct a monthly visit to beneficiaries in each province to monitor fish culture and provide technical support to local partners.

Photos: Left: Training of Trainer conducted by Fisheries Administration; Right: Training of farmers in Pursat province

Vegetable production commonly happens next to the homestead ponds and rice-field ponds and thus can be integrated. A horticulture specialist designed and provided training on nutrition sensitive vegetable production to target beneficiaries. In 2017, 31 farmers received training on home garden vegetable production, compost creation and received inputs to start vegetable production at the onset of the dry season (December 2017). In 2018, the remaining 34 households will be provided with similar support and monitoring.

Technical dimension of nutrition-sensitive aquaculture

The protocol tested is based on WorldFish-IFAD experience from Bangladesh and adapted to the Cambodian context. In 2017, we promoted fish polyculture for income generation. Fish were advisedly stocked at 5 fish per square meter and small indigenous fish species collected from nearby rice fields. The polyculture composition promoted to intervention households is as follows: 55% of silver barb; 20% of silver carp and 20% of common carp or Indian carp. Nutrient-rich small fish are added at a density of 500 g per 100 square meter.

Polyculture in this instance has been introduced as a low-cost affordable technology, therefore fish feeding systems/regimes promoted are based on locally available aquafeed ingredients and ‘green water technology’ that enhance the natural productivity of the pond. The expected growing period for carp

polyculture is 9 months, in this case from August 2017 to April 2018. Sequential harvesting of nutrient-rich fish for household consumption started in December 2017 and occurred every other week. A monitoring system is in place to assess the productivity and financial sustainability of the polyculture system introduced. This system will allow for evaluation, learning and inform the adaptation of interventions where necessary.

Input support

- 65 farmers received in-kind support to establish nutrition-sensitive aquaculture including resources for fence erection, *happa* (a fingerling nursing) construction and pond preparation.
- A total of 132,400 carp and silver barb fingerlings were distributed to farmers.
- Farmers also personally contributed to the intervention by providing labor force to construct a composter, upgrade pond flood protection systems and collect 87 kg of micronutrient-rich small fish to stock in homestead ponds.
- Aquaculture specialists have also been provided with water quality testing kits to monitor water quality.
- The project supported micro- and home-garden vegetable production by providing materials including fencing, watering cans, plastic sheeting, hand-held fertilizer spraying-cans, seeds (specifically long bean, pumpkin, amaranth, bitter gourd and water spinach seeds).

Photos: Left: Pond preparation (Pursat province); Middle: Fencing the pond to protect aquaculture fish from predators (Tuol Krasaing village, Battambang); Right: Farmer stocking micronutrient-rich fish in the pond (Anlong Raing village, Battambang)

Progress toward indicators

A weekly monitoring system of the pond and vegetable production has been in place since August 2017 or since the introduction of fish culture. The system is based on logbook entries - updated daily by farmers and monitored weekly by an aquaculture technician. The monitoring variables include: pond and plot inputs and outputs, workload disaggregated by gender, and destination of the product (household consumption,

gifted, sold). Nutrition outcomes will also be assessed using the monitoring system for Nutrition and Hygiene (see section 2.1.2).

Photo: Horticulture training, Sranal village, Siem Reap

Technicians visiting the households, on a weekly basis, are also required to record their observations.

This monitoring system will support the assessment of the financial outcomes of the technology tested, and provide feedback on technology adaption in local contexts.

ii. Activity 2: Nutrition and hygiene training

To improve nutrition and daily hygiene in target households, training on nutrition, dietary diversity, hygiene and sanitation were conducted in project sites. The training consisted of a series of "in house" training with groups of 6 to 8 households. In total each household attended three sessions that covered the following topics: i) *Good Water and Sanitation Practices*; ii) *Appropriate diets for pregnant and lactating women, and children from 6-24 months of age;* iii) *How to include micronutrient-rich fish in the family diet*.

In total 31 households received nutrition and hygiene training. The remaining 34 households will be engaged in this training in 2018, together with the additional selected households joining the project in 2018.

Progress toward target

A baseline survey was undertaken to create a benchmark for the production and consumption of fish and vegetable among project households. The data collected in this baseline survey includes adult (disaggregated by gender) and child nutrition, hygiene and women's roles in the households.

A 6-months periodic survey is planned to monitor and assess changes and progress toward the following targets: a three-fold increase in fish production from household ponds and two-fold increase in vegetable production by the end of the project.

In addition, the periodic survey monitors behaviour changes, specifically in relation to the consumption of micronutrient-rich fish and vegetables, diet composition, and hygiene practices in the household.

Gender disaggregated data will also be collected on the role of different household members in livelihood activities and income generation.

b. Output 2: Improved gender equity and women's empowerment, especially regarding intra-household food intake, agricultural practices and workload

i. Activities 1: Capacity building in nutrition and gender equity

This activity was designed to assess, in a participatory manner, the gendered roles and responsibilities of household members and identify future actions to improve gender equity in workload, agricultural activities and nutrition.

Local partners received training to implement 'family visioning' and planning with household beneficiaries. In total 8 local partners received the training in September 2018. A consultant developed the training materials using existing training manuals on gender-inclusive approaches in aquaculture/agriculture and adapted these to the local context. The intervention also included the design of 'a tool box' for family visioning and the development of a simple gender guideline/checklist for aquaculture projects. The tool box for family visioning includes 3 main sections: *Introduction* (Section 1); *Daily work activities and gender roles* (Section 2); *Family visioning and planning* (Section 3). This approach led to the development of a 'family action plan' to support gender transformative approaches in aquaculture.

In 2018, the remaining 36 households, and additional beneficiaries joining the project in 2018 will receive similar support for family visioning and planning. The results of the family visioning and planning will be compiled and analyzed in 2018, and provide a baseline to assess progress toward greater gender equity and women's empowerment.

Photos: Left: Gender consultant and VSG staff has facilitated in testing of family vision and planning with farmer at Treos Village Ou Taky Commune Thmar Kol District; Right: Family visioning map in Okrakalanh village (SIem Reap)

Progress towards indicators

Target: 75% of the women in targeted households report greater decision making.

The baseline and 6-months periodic survey will provide an indication of the status of women's empowerment, women's roles in decision making, particularly in decisions related to spending and investment. An analysis of the family visioning sessions will also provide a better understanding of women's aspirations and help to shape interventions that contribute to these aspirations.

Target: 80% of project staff trained on gender equity.

This target was achieved in 2017, with 100% of project staff trained on gender equity.

c. Output 3: Increased knowledge, awareness and training of government and NGO partners in integrated aquaculture and agriculture-nutrition linkages approach for influencing policies and implementing interventions for scaling up

i. Activity 1: Local workshops

- Training local partners and Fisheries Administration officers on nutrition-sensitive aquaculture (described in section 2.1)
- Local partners, and NGO partners participated in training on nutrition and horticulture, gender equity and women's empowerment (described in section 2.2)
- One orientation meeting for local partners was organized by WorldFish on July 10th 2017, and a provincial project inception workshop was held in Siem Reap province on 30th August 2017 to inform relevant national and provincial stakeholder about the project and our approach.

Photo: Inception workshop in Siem Reap (30th August 2017)

ii. Activity 2: Global Workshop on Nutrition-sensitive Fish Agri-food Systems

WorldFish held a Global Workshop on Nutrition-sensitive Fish Agri-food Systems, held in Siem Reap (Cambodia) from 5th to 8th December 2017 (see section 2.4). The Deputy Prime Minister and his cabinet, the secretary of the Ministry of Agriculture, Forestry and Fisheries, the Deputy Secretary General of the Council for Agriculture Development, the Director General of the Fisheries Administration, the Director of the Department of Aquaculture Development of the Fisheries Administration joined the workshop and thus learnt about nutrition-sensitive fish agri-food system approaches.

At this four-days event, participants were invited to share and discuss approaches to, and studies on aquaculture and agriculture-nutrition linkages. Communication materials on WorldFish's Nutrition-sensitive Aquaculture Approaches were distributed during this event (including a project brochure and reports from interventions in Bangladesh).

d. Output 4: Strong regional and national partnerships and collaboration for adoption and dissemination of the aquaculture and fisheries/agriculture-nutrition linkages approach

i. Activity 1: Partnership and resource mobilization

The project organized a provincial and national workshop with partners to strengthen partnership between non-direct stakeholders and local administration (see section 2.3.1). The project collaborated closely with the Rice Field Fisheries Project (USAID-funded), NOURISH (USAID-funded) and the World Vegetable Center to exchange and homogenize raising awareness approaches to nutrition, hygiene, and vegetable production. The project also decided to double the number of staff allocated to field activities by local partners to increase the beneficiaries target (see section 2.5).

National and regional partnership was strengthened during the Global Workshop on Nutrition-sensitive Fish Agri-food Systems. In total, 153 participants from different regions attended this global workshop, including 53 Cambodian development partners and development agency representatives. Sixty-three participants from South and South East Asia joined the workshop, including 32 staff from WorldFish, representatives from FAO, IFAD and the World Bank. It was also an invaluable opportunity for different project partners from Bangladesh, Cambodia and Zambia to meet.

Beside the three local NGO partners, the Fisheries Administration (FiA) and Department of Aquaculture Development (DAD), WorldFish also partnered with the National Research and Aquaculture Development Institute (NARDI) to start research to identify local micronutrient-rich fish for future domestication. The research identified two species: *Esomus longimanus*, an abundant rice-field fish species rich in zinc and iron; and *Rasbora tornieri*, a small fish species with a high vitamin-A content. The research aimed to develop a method for the characterization of morphological traits, dietary requirements, reproductive cycles and growth rates, and the collection and transportation of the two species. This research is funded by the CGIAR Research Program (CRP) on Fish Agri-food Systems (FISH).

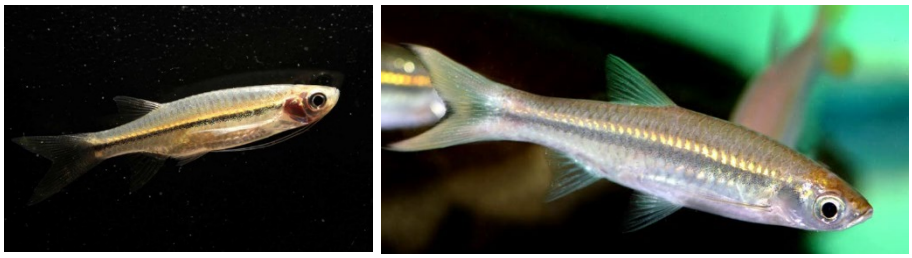

Photo: Left: Esomus longimanus; Right: Rasbora tornieri. Two main micronutrient-rich fish species found in Cambodian rice field

e. Activities planned for 2018

- In 2018, the project will have more presence in the field, with three more aquaculture technicians hired by local partners
- The number of households supported and trained for nutrition sensitive aquaculture and vegetable production will increase to 200 household beneficiaries
- Complete training on nutrition and vegetable production and ‘family visioning’ for the 200 households

- Conduct additional training on aquaculture to local partners
- Study tour for local partners and WorldFish staff to a Helen Keller International (HKI) project site to learn from their approach
- Study tour for local partners, the Fisheries Administration, and WorldFish staff to Bangladesh to learn from IFAD-funded WorldFish-led nutrition-sensitive aquaculture approaches
- Produce a brochure on the preliminary results of the project
- Conduct an annual reflection workshop in May 2018 to reflect on and learn from the year activities and accordingly adapt our approach

III. Visibility and Communication Plan

The current project brochure and global workshop invitation clearly acknowledged the European Commission and the European Union as the funding agency of this project and event.

Zambia Component

Activities planned for 2017

In Zambia, the following principal activities were planned for the year:

a) Recruitment and conditioning of indigenous fish species for pond poly-culture trials in Nsombo, Luwingu, including nutrient-rich small fish.
b) Set up and implementation of pond poly-culture trials
c) Set up of 'fingerponds'
d) Baseline data collection to assess:
    a. Household's involvement in aquaculture, agriculture and fisheries, including workload among household members; identification of household access, availability to, and utilization of key commodities produced by the household, with particular focus on fish.
    b. Assessment of Household Dietary Score through 24-hour recall and food sourcing to complement the access, availability, and utilization tools from a consumption perspective. This includes the assessment of the 'Household Food Insecurity Access Scale (HFIAS)' to measure the impacts of 'development food aid programs' on the *access* component of household food insecurity.
    c. Assessment of household dietary patterns over a 4-week period (recall) for evaluating usual food intake at the household level.
e) Qualitative data collection:
    a. In-depth assessment and exploration of particularities in food procurement, preparation, preferences and perceived barriers (including cultural perceptions) to selected foods and intra-household food allocation.

Activities undertaken in 2017

According to the work plan for 2017, the following activities were undertaken.

I. Recruitment and conditioning of indigenous fish species for pond polyculture trials

Given the assessments conducted in 2016, which included a rapid assessment of a) small indigenous fish species (SIS) in Zambian aquaculture / fisheries and b) SIS as food commodities in rural markets within the research area, the research team concluded to recruit the following fish species for pond polyculture trials:

Tilapiine cichlids:

a) *T. rendalii* (*Coptodon rendalli*) – or "Redbreast tilapia": prefer quiet, well-vegetated water along river littorals or backwaters, floodplains and swamps. Tolerant of a wide range of temperature (8-41°C) (Ref. 3) and salinity. *T.rendalii* form schools; is mainly diurnal. Juveniles feed on plankton.

Adults feed mainly on higher plants and also algae, insects and crustaceans. Make excellent eating. Prefers a sloping spawning ground near the marginal fringe of vegetation. Builds nest in shallow water where both parents guard the eggs and young.

b) *T. sparrmanii* – or "Banded tilapia": Occurs in widely diverse habitat. Favors areas where plant cover exists along the edges of rivers, lakes or swamps. Prefers shallow sheltered waters and does not colonize the open water of large lakes. Adults feed preferentially on filamentous algae, aquatic macrophytes and vegetable matter of terrestrial origin (leaves, plants, etc.) (Ref. 3). Juveniles feed small crustaceans and midge larvae. Forage fish for bass. Undertake seasonal upstream migration and breeds before and during these migrations. Male spreads his milt over the cluster of eggs which are deposited on the bottom or even attached to the branches of aquatic weeds. Parents guard the eggs. Eggs and fry may be moved into the mouth to alternative sites during hatching operations but there is no evidence of actual mouth brooding.

A mix of Cyprinids, of genus Enteromius

- *E.radiatus* (*Enteromius radiatus* (Peters, 1853)); *Redeye barb* is widespread, especially prevalent in the Zambian Congo and the Okavango delta. The fish prefers marshes and marginal vegetation of streams, rivers and lakes. It is mostly active in subdued light and at night (Skelton 2001).
- *E. trimaculatus* (*Enteromius trimaculatus*) or "Threespot barb": Found in shallow water near river outlets or close to swampy areas. This species commonly occurs in a wide variety of habitats, especially where there is vegetation; feeds on insects and other small organisms; breeds in summer - shoals of ripe adults move upstream in spate after rain. Females produce as many as 8,000 eggs.
- *Barbus bifrenatus* (*Enteromius bifrenatus)* is a benthopelagic, potamodromous species. It occurs in floodplains, pools and shallow streams with vegetation, but not in strongly flowing rivers. *Barbus bifrenatus* feeds on detritus, algae, seeds, small invertebrates and aquatic insect larvae; it migrates upriver to breed after heavy rains in the summer; breeding pairs lay eggs on submerged roots and vegetation. Reaches maturity within a year.
- *Barbus kerstenii* (*Enteromius kerstenii*) or "Redspot barb". Quick, active fish found in shoals and occurs in lakes and rivers. Feeds on insects (Ref. 12523, 36900), debris, molluscs, plant material, seeds and algae. Migrates upstream when rain comes. Breeds in flood plains during rains.

Fish from the genus ***Barbus*** are a very diverse group in the region, and most species are present in the Okavango/upper Zambezi aquatic systems. The collective term used for barbs is '*misenga'*, with *Barbus trimaculatus* being the only common species with its own vernacular name, '*mushipa'*. Most of the barbs are locally referred to and retailed as a mix of species, referred to as 'misenga' - fishers and fish farmers do not differentiate between the different species. The barbs tend to shoal together and are generally caught as a mix. So, we decided to stock a mixture of barbs, locally available/abundant species.

Marcusenius macrolepidotus, genus of elephant fishes

- *Marcusenius macrolepidotus,* or "Mintesa"*. Marcusenius macrolepidotus* is found in the order of *Osteoglossiformes*: one of the most primitive bony fish groups in existence. It belongs to the family of the *Mormyridae*, a unique group of freshwater fish possessing electric organs, possibly used for communication and prey detection. In Zambia, seven genera and nine different species can be found. The bulldog fish is distributed all over Zambia and invaluable for capture fisheries

(Kenzo & Mazingaliwa 2002). The fish, grows up to 300 mm long, and its body colour varies from golden yellow to dark brownish. The caudal fin is forked with bluntly pointed tips. The fish's most notable feature is its lower lip which is used as a sensory organ (mental lobe) and projects forward (Kenzo & Mazingaliwa 2002). It is found in well-vegetated shallow water habitats of rivers and floodplains. During the daytime, the nocturnal species hides in the vegetation. In the rainy season, when the plains are flooded, the fish migrates to the plains during the night for spawning. Local fishermen in the Bangweulu wetlands have observed large shoals of fish spawning during the night with the advent of the rains in November (Huchzermeyer 2013). One female can carry up to 6,000 eggs (Skelton 2001). The fish mainly feeds on invertebrates, especially midge and may fly larvae and pupae found in the bottom sediments or on plants (Skelton 2001). In the Bangweulu wetland fisheries, the bulldog fish is possibly the most important fish species. Due to its extended spawning season and rapid growth it can be caught using various methods throughout the year (Huchzermeyer 2013).

The combination of species to be stocked was based on principles of 'integrated multi-trophic aquaculture', where species are stocked according to the biological / environmental niches they occupy. An attempt was made to avoid species competing for feed. Both tilapiine cichlid species, *T.rendalii* and *T.sparrmanii* are known to be prolific breeders, even in ponds. *T.rendalii* is a common species in local aquaculture and is considered as a larger species, though offspring / juveniles can be harvested for consumption and retail. *T.sparrmanii* on the other hand, is a smaller sized tilapia, and this fish species is commonly consumed and retailed in small sizes. Barbus are widely available in local markets, though exclusively sourced through capture fisheries. Given the large variety of barbus species and the fact that many of these are locally labelled as "misenga", a mix of barbs was sought after for stocking. Lastly, *marcusenius macrolepidotus* was chosen to explore if this species would reproduce in an aquaculture setting. *Marcusenius macrolepidotus* are rich in micronutrients and often caught and retailed in small sizes, and consumed as a whole fish. Given the fact that we try to enhance nutrition outcomes through aquaculture, the consideration of fish species nutrient content, of course, has been considered too. To date, however, very limited information on the nutrient content of Zambian fish is available (see Table 1 & 2). As most small fish species are eaten whole, the bones and other micronutrient-rich fish parts are also consumed and thus, the intake of micronutrients is increased. On the other hand, larger fish species are prepared and consumed and have plate waste.

Table 1: Fat and protein content of selected fish species

Species	Content per g dry weight		Content per 100 g edible portion	
	Protein [g]	Fat [g]	Protein [g]	Fat [g]
Limnothrissa miodon (Kapenta)	0.74	0.08	16.45	1.77
Marcusenius macrolepidatus	**0.61**	**0.29**	**17. 06**	**8.13**
Barbus radiatus	**0.66**	**0.17**	**17.29**	**4.38**
Orecochromis niloticus (Nile Tilapia)	0.90	0.08	17.11	1.54
Tilapia rendalii	0.80	0.18	16.49	3.76
Tilapia sparrmanii			**14.27**	**4.91**

Species highlighted in **bold** were stocked in trial ponds.

Table 2: Micronutrient content of selected fish species

Species	Content per g dry weight						Content per 100 g edible portion					
	Ca [mg]	Fe [mg]	Zn [mg]	K [mg]	Mg [mg]	Se [µg]	Ca [mg]	Fe [mg]	Zn [mg]	K [mg]	Mg [mg]	Se [µg]
Limnothrissa miodon	36.83	0.13	0.17	15.22	1.86	1.58	823.80	2.86	3.71	340.42	41.64	35.41
Marcusenius macrolepidatus	**24.66**	**0.04**	**0.12**	**10.37**	**1.27**	**1.21**	**692.24**	**1.19**	**3.41**	**290.96**	**35.72**	**33.95**
Barbus radiatus	**39,74**	**0,16**	**0,18**	**9,26**	**1,63**	**1,64**	**1044,88**	**4,11**	**4,62**	**243,36**	**42,81**	**43,21**
Tilipia sparrmanii	**45,90**	**0,70**	**0,10**	**10,11**	**1,65**	**1,06**	**1055,05**	**16,06**	**2,35**	**232,51**	**37,93**	**24,40**

Species highlighted in **bold** were stocked in trial ponds.

II. Set up and implementation of pond polyculture trials

A team of local fishers were hired over a one-week period to recruit fish from Lake Bangweulu and its attached wetlands. The Department of Fisheries in Luwingu was actively involved in facilitating this process. As some of the above-mentioned species are diurnal and others nocturnal, fish were caught both during the day and night. All fish caught were temporarily kept in drums on boats, and afterwards were released to a holding pond. The process of conditioning is critical as fish are stressed when caught and handled, which can lead to mortalities. Thus, the live fish was handled with care and released in the shortest time possible. For about two weeks, the fish were kept and maintained in holding ponds.

Stocking of ponds

In total, 8 ponds were prepared for the trials. The ponds were approximately 100m^2 each and fed by ground and stream water. Each pond was stocked with 75 *T. rendalii*, 40 *T. sparrmanii*, 50 barbs, and 75 *Marcusenius macrolepidatus*. Four of the eight ponds were additionally prepared with some water lilies to test whether the availability of vegetation in ponds would have an effect on growth and reproduction as some of the species naturally occupy well vegetated habitats.

Treatment

An extensive fertilization regime was chosen to cultivate and grow fish, and designed in consideration of local small-holder production technologies. Hence, no compound feeds were used. At regular intervals, locally available chicken or goat manure was applied to ponds for fertilization and stimulation of phytoplankton and zooplankton growth as natural food for fish. This treatment is widely employed to grow fish in rural areas, where access to other inputs, such as feeds, is poor.

Duration of the trials

The fish was stocked on 28th September 2017, approximately a month before the start of the rainy season in Northern Zambia. The timing was crucial as most local species mate and reproduce during or after the rainy season. Hence, the trials started in 2017 and continued in 2018. Final sampling is tentatively scheduled for April 2018.

Photos: The pond polyculture trial site in Nsombo, Luwingu district and from sampling during trials

III. Set up of 'fingerponds'

In addition to the pond polyculture trials with SIS, the research team prepared another experimental site near Luwingu town, where fingerponds are being tested as an alternative, low-cost and extensive production technology to increase access to small fish. In collaboration with Peace Corps, WorldFish identified a damboo area (a natural depression along a small stream, which is inundated during the rainy season) within which the research team set up five small ponds. These ponds are expected to flood during the rainy season, and subsequently act as a natural sanctuary for fish. When the water level recedes, fish become trapped and thus, available for harvesting or grow out.

The fish in these fingerponds will be sampled after the rainy season (April / May), when the damboo is accessible again. After sampling and identification of the species trapped, the team will develop plans, in consultation with partners, on how to best utilize the fish or to continue the cultivation of fish in these ponds.

IV. Baseline data collection

The expected outcomes of the research project are (1) to understand the potential and actual impact of the innovative pond-polyculture approach with nutrient-rich small fish species on the availability, accessibility and consumption of small fish species among three different household groups - aquaculture with treatment, aquaculture without treatment, and non-aquaculture. The treatment is defined as the introduction and training of pond polyculture with micronutrient-rich small fish, which includes activities regarding the recruitment, handling, feeding and harvesting of fish.

To assess and evaluate the impact of planned treatments, a baseline assessment of agriculture and aquaculture production as well as consumption practices at household level was led by WorldFish and Palm Associates, and addressed the overall research question:

- To what extent can the innovative polyculture approach with micronutrient-rich fish species in homestead pond aquaculture increase accessibility, availability and consumption of small-fish among aquaculture and non-aquaculture households?

The baseline survey collected information on:

1) The extent of household engagement in capture fisheries as a means to access fish, in particular micronutrient-rich small fish species for household consumption, retail or other purposes.
2) The extent of household engagement in aquaculture as a means to access fish, for retail and home consumption; including an assessment of the species cultivated to assess the current role of small-fish species in aquaculture production.
3) Household dietary diversity (via a Food Frequency Questionnaire) and food insecurity (via a Household Food Insecurity Access Scale), with particular focus on the role of large-fish and small-fish consumption in comparison to other food commodities.
4) Household dietary recall (via a 24 hour Household Dietary Recall) to verify and compare dietary assessments with different (short vs long) recall-periods.

5) Intra-household food allocation and barriers to the consumption of small fish among household members (sex- and age-disaggregated).
6) Distribution of household labour (sex-disaggregated) in agriculture, fisheries and aquaculture to better understand workload and access to resources within the household.

Overall, 380 households were surveyed and questionnaires were administered to the household member(s) chiefly responsible for 1) agriculture, fisheries, and aquaculture and 2) food preparation within the household. All interviewee(s) were older than 15 years of age and represented a permanent member of the household and a permanent resident in the village (*cluster*) selected.

The following primary and secondary indicators will be monitored at the start, and at the end of the intervention period to assess impact:

Primary Indicators

- Household Food Insecurity Access Scale (*HFIAS)*
- Household Dietary Diversity Score *(HDDS)*
- Household dietary patterns

Secondary Indicators

- Household production diversity (agriculture, fisheries, aquaculture)
- Household economic access to food
- Household sourcing of orange sweet potato (OSP) and fish, especially indigenous small-fish species for home consumption and income generation

The data collected are currently being analyzed and will be - in parts - published in 2018. An endline survey is planned for 2019 to assess the project's primary production, and food and nutrition security indicators.

V. Qualitative data collection

In addition to the quantitative household survey, a qualitative research component was designed to better understand the barriers, opportunities and entry points for improving (small-) fish production and consumption among households. Semi-structured interviews were conducted with 30 randomly selected households from the baseline sample. The qualitative research aimed to collect additional data to gain a better and more in depth understanding of the local particularities on food procurement and preparation, food preferences and perceived barriers, intra-household food allocation, and cultural food perceptions. The interviews were carried out by a member of the study team and a field interpreter. Each interview was administered to the main food preparer of the household. The semi-structured interview questionnaire is attached in the annex. Data analysis is ongoing.

The research was conducted in collaboration with Esther J. Lee, a student from Johns Hopkins Bloomberg School of Public Health, who did a six-months internship at WorldFish, Lusaka.

Ethical Clearance

Ethical clearance was approved by the University of Zambia, Directorate of Research and Graduate Studies, Humanities and Social Sciences Research Ethics Committee and the ethical procedures stipulated were followed. In addition, all village and community leaders were informed of the project's objectives and activities prior to the start of data collection. Consent was obtained from all participants who were selected to participate in the household survey, and qualitative semi-structured interviews. A combined consent form and information sheet were given to the participants, together with an explanation of the study and how the information they provided are to be used. All participants were free to decline participation at any time.

I. Key activities planned for 2018

a) Analysis of baseline and qualitative data collected. The information gathered will be used to produce a science paper, in which we will analyze the role of livelihood strategies and other independent factors on fish consumption patterns at the household level. In addition, the information will be used to identify behavior change communication tools as well as training content for target households under the project.
b) Design of training and behaviour change material will be informed by the quantitative and qualitative data collected and created in collaboration with local partners, e.g. Department of Fisheries, Department of Agriculture, and Self Help Africa.
c) The training of households enrolled under the project is scheduled for June / July 2018. The trainings will be done in collaboration with Self Help Africa.
d) After the trainings have been implemented, selected households with aquaculture ponds will be encouraged to test the pond polyculture with small indigenous fish at farm level. This activity needs to be done after the cold season and before the rainy season (September / October 2018).

ANNEX 1

Qualitative INTERVIEW TRANSCRIPTION sheet

Interviewee ID: xx

Study Title: Exploring the Consumption of Small Fish Species and Orange Sweet Potato in Northern Province, Zambia

---

Food procurement and preparation

Q1: Who is mainly responsible for obtaining food for your household?

Q2: Please describe the process(es) of obtaining food for your household and how frequently this is done.

Q3: How can your household obtain food other than purchasing with money?

Q4: If you want to eat fish, are there any special considerations you have to make or anything you have to do that is different from planning to eat something else?

Q5: Other than eating small fish whole, what are some common methods of preparing fish for consumption by the household?

Food preferences and perceived barriers

Q6: What are some animal proteins that your household likes to eat the most ("favorite")?

Q7: Are there any reasons your household cannot eat these proteins as often as desired? If so, what are the obstacles you experience?

Q8: What is/are the fish species that your household likes to eat the most (including large and small fish species)?

Q9: Are there any small fish species that your household prefers not to eat? If so, which species and why?

Q10: Are there any household members who don't eat any fish? If so, who and why?

Q11: In what form does your household usually obtain fish? (Dried, smoked, fresh, salted)

Q11a: Why this form over other forms?

Q11b: What are some reasons that your household would eat a different form of fish than is usually eaten?

Q12: What are the foods your household normally eats?

Q12a: If you don't have [food listed above] what do you eat instead?

Q12b: Would your household substitute one small fish species for another? If so, which ones would be switched? *E.g. Instead of eating _____, we would eat ____.*

Intra-household food allocation

Q13: Think about the process of eating a main meal together with the household. Please describe what happens from the time the food has been prepared until the last person has finished eating. Include each household member.
If unmentioned, prompt about how each person's portion is determined (served by someone or serve yourself) and the order in which that is done (if applicable).

Q14: If there is a limited amount of a relish, please describe how this is usually distributed. To whom is this usually distributed?

Cultural food perceptions

Q15: What are the local thoughts or perceptions about eating fish?

Q15a: Do these perceptions apply to both large and small fish species?

Q15b: Are there any (other) reasons people are discouraged from eating fish?
Can prompt: types of fish, life stage or physiological state (age, health/sickness, pregnant)

Additional Q: Are there any reasons people are encouraged to eat fish?

Additional Q: Knowing that it is healthy, does that encourage [you] to eat more even if [you don't] know the exact reasons?

Additional Q: Are these two things conflicting? Does the husband have a hard time teaching pregnant women to eat fish because they think that it's going to cause the defects? Does this cause a problem?

Q16: Have you heard of orange sweet potato?

Q16a: If yes, does your household consume it? Why or why not?

Q16b: What are some things that you have heard about orange sweet potato?

Indonesia Component

WorldFish has developed a close partnership with the Ministry of Marine Affairs and Fisheries, (MMAF), Indonesia. Building on several initiatives by the Government of Indonesia: the Gemarikan Initiative "Eating Fish Campaign" to increase national fish consumption, Scaling up Nutrition (SUN) and 1,000 Days as well as Global Alliance for Improved Nutrition (GAIN): Post-harvest Loss Alliance for Nutrition (I-PLAN), focusing on fish loss and food safety, plans have been developed to trial nutrition-sensitive fish agri-food systems components in targeted locations of Indonesia, which have high rates of malnutrition in children, fish as a common food and the potential for pond polyculture.