TECHNICAL
GUIDELINES #5

BUILDING SUSTAINABLE AQUACULTURE THROUGH COASTAL FIELD SCHOOLS

Building with Nature to restore eroding tropical muddy coasts

TECHNICAL GUIDELINES SERIES

This guideline is part of a series of Technical Guidelines on technical and socio-economic Building with Nature measures that, in combination, help to restore eroding tropical muddy coasts. These guidelines are based on insights and lessons learnt during the implementation of a district scale pilot in Central Java as part of the Building with Nature Indonesia programme. By sharing our lessons learnt in these practical guidelines, we aim to enable replication by government agencies, the water and aquaculture sector and NGOs. Building with Nature measures need to be part of integrated coastal zone management and require a thorough problem-understanding and system analysis. Stakeholders interested in replicating our approach bear full responsibility for the success and sustainability of the approach.

AVAILABLE GUIDELINES

#1 Building With Nature Approach
#2 Systems Understanding
#3 Permeable Structures
#4 Associated Mangrove Aquaculture Farms
#5 Sustainable Aquaculture Through Coastal Field Schools

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Coverphoto credits: Tiger shrimp produced from a revitalisation pond from the Community group of Wedung-Gojoyo ©Maskur, Wetlands International

Community group meeting
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EXECUTIVE SUMMARY

Building with Nature is a water infrastructure design approach that combines ecological rehabilitation and smart engineering, while introducing sustainable land use practice. It offers an alternative to conventional built infrastructure solutions for coastal protection. Meaningful participation of local stakeholders, especially local communities, is key to successfully implementing and optimising any Building with Nature solution.

In line with this principle and based on analysis of the biophysical as well as the socio-economic systems, the Building with Nature Indonesia (BwNI) initiative integrates revitalisation of aquaculture with mangrove restoration for coastal protection at the landscape scale. This guideline focusses on achieving successful aquaculture revitalisation through the application of Coastal Field Schools (CFS).

In most tropical countries where shrimp ponds have replaced mangrove, as they have in Indonesia, farmers have typically learnt their aquaculture practices through trial and error. Knowledge transfer has often been limited and not always based on facts, particularly when advice came from salesmen. Lack of training is one of the factors explaining low and unpredictable yields of coastal brackish water ponds, which has contributed to the near disappearance of mangroves. To ensure long term success, it is therefore recommended that farmers receive training to develop knowledge and confidence in applying beneficial and ecologically sound aquaculture practices.

The BwN project in Demak district in Indonesia engaged farmers through Coastal Field Schools (CFS). These are extensive year-long learning programmes that enable communities to improve their livelihoods by sustainably managing their coastline and its natural resources. Such programmes can be implemented by public or private organisations.

Throughout the CFS, participants in Demak were able to experience the alternative, organic Low External Input Sustainable Aquaculture (LEISA) and compare it with traditionally managed ponds. Over time, the CFS participants learnt to manage their ponds and the surrounding agro-ecosystem, critically evaluate both pond issues and community issues, contribute to mangrove restoration for coastal protection and biodiversity, and discover new opportunities or solutions to emerging local problems. As a result of the training, farmers were able to increase their income from milkfish and shrimp aquaculture and underpin efforts to restore mangroves for coastal safety.
The BwNI programme demonstrated that farmers who participated in the CFS learnt to apply practices that tripled their income from milkfish and shrimp farming, and became open to give up ponds near the shoreline, or a portion of riverine ponds for mangrove restoration. CFS was of critical importance for both mangrove restoration and increasing production of sustainable aquaculture. This success made the investment in the training cost-efficient.

The creation of sustainable mangrove aquaculture landscapes, and therefore the CFS approach applied in Demak, is of global relevance, given that expanding shrimp aquaculture has been one of the main drivers of the worldwide loss of mangrove forests. The goal of this guideline is to promote sound replication of the BwN approach to revitalizing aquaculture that can mutually benefit from mangrove ecosystems.

1 INTRODUCTION

Worldwide, the expansion of brackish water aquaculture to generate income has been one of the main causes of mangrove destruction and coastal degradation. Non-compliance with environmental regulations, as well as some unconditional permits issued for the creation of fish ponds, have ultimately enabled this failure. Once without mangroves, precious land has been lost through erosion, as demonstrated along Java's north coast. This has also resulted in the loss of breeding and feeding habitat for economically important seafood species and the subsequent reduction in income for local communities.

Coastlines need protection from erosion, but building seawalls is too costly. With mangroves however, ponds are protected because the trees and roots reduce the intensity of waves and facilitate sedimentation. Moreover, mangrove roots absorb heavy metals and enrich the quality of the estuary and marine ecosystems. Fortunately, mangrove conservation and aquaculture can be complementary land-use systems, and pond farmers have both an interest and a role in protecting mangroves. Without mangroves, they could lose their ponds, land, livelihoods, houses, and village infrastructure1. In addition, the mangroves provide food, timber and non-timber products for local communities. However, at present, most brackish water pond farmers have low yields, fundamentally due to insufficient know-how on sustainable aquaculture practices, and low water quality due to pollution by industry.

Previously to the Building with Nature project in Demak (see Box 1), some farmers had tried to improve production through various intensification strategies (chemicals, fertilisers, antibiotics, feed, aerators), but most of these disturb the pond's ecological balance and fail, because of high cost and high risk. Low yields force households to work off-farm in low-paid activities. In order for farmers to have enough resources and be able to protect the mangroves, yields from their ponds needed to increase, with the simultaneous introduction of sustainable methods.

Building with Nature (BwN), as used in Demak, is a coastal infrastructure design approach that combines ecological regeneration and smart engineering, while introducing sustainable land management practices. BwN projects aim to create mutual benefits for people and the environment by engaging stakeholders, addressing inefficiencies in the local economy and livelihoods, and creating community ownership for a more resilient coastal landscape and land use. The BwN approach in Indonesia piloted in Demak had four components: restore and protect the coast using permeable dams, aid the recovery of mangroves, revitalise aquaculture, and advocate for considerable reduction in the abstraction of groundwater (see Box 1). To revitalise aquaculture in Demak, a field school approach was used, inspired by Farmer Field School developed by FAO for the integrated pest management that supported the multiplication of Asia's rice yields between 1965 and 1975.

This publication provides practical guidelines to enable replication of BwN approaches for revitalizing aquaculture that can support mangrove afforestation, and the uptake of CFS approaches by government agencies, NGOs and engineers in their respective contexts. In addition, the guideline will be useful for aquaculture departments of universities. The curriculum of the Coastal Field School (CFS) discussed in this guideline focusses on improved and sustainable coastal resource management which can cover all existing rural livelihood activities, such as agriculture, horticulture, aquaculture and forestry. However, most of the CFS curriculum applies to any pond aquaculture and could also be called *Aquaculture or Fish Farmer Field School*. In the next chapter, this guideline introduces the CFS approach, principles, conditions for success and participant criteria, as well as providing technical aspects on aquaculture. Chapter 3 advises on implementation and chapter 4 - supervision, monitoring and evaluation of the changes in the participant's knowledge, skills, yields and income. Chapter 5 suggests further activities to support alumni in the longer term.

Inside the mangrove greenbelt ©Cynthia Boll

BOX 1: BUILDING WITH NATURE IN DEMAK, CENTRAL JAVA

In Northern Java, millions of people are suffering from the consequences of coastal erosion. The Building with Nature pilot in Indonesia focussed on the coastal zone of Demak district, where coastal erosion had been projected to result in land loss of up to 6 km inland by 2100, affecting over 70,000 people and 6000 hectares of aquaculture ponds.

In the Demak district, *Building with Nature* solutions were introduced to halt land loss and revitalise aquaculture. Building with Nature is an innovative approach to tackle coastal and water management challenges. It provides an alternative or complementary approach to hard infrastructure, as it works with and alongside the dynamics of nature. Since 2008, large and successful *Building with Nature* pilots have been implemented by the EcoShape Consortium, through a wide variety of partnerships between Ecoshape members and local stakeholders.

Technical measures in Demak included the construction of permeable dams that helped establish a healthy sediment balance. Once the nearshore seabed level had sufficiently risen, mangroves were able to regenerate naturally and develop a natural defence against further erosion.

The coastal restoration efforts in Demak were severely challenged by land subsidence caused by unsustainable pumping of groundwater by cities and industries nearby. Young recovering mangrove trees were being washed away and ponds suffered from flooding. To facilitate a solution to this land subsidence, the project partners initiated Water Dialogues at national and province level, and worked with communities to help them express their needs.

By developing and implementing sustainable aquaculture practices together with the communities, one of the root causes of mangrove deforestation were addressed and it gave a boost to the local economy. Communities restored and sustained the greenbelt they needed for coastal safety. The measures were embedded in community development plans.

To promote successful replication, the project partners actively shared knowledge and tools and invested in capacity building.


Permeable structures with natural mangrove regrowth in front of Demak coast.
© Witteveen+Bos

CFS participants chop the waste of fruits and vegetables for the liquid compost ©Kuswantoro, Wetlands International

2 APPROACH

Coastal Field Schools aim to assist farmers in learning sustainable aquaculture practice, i.e. manage a pond in such a way that (1) they, and their children in the future, can earn a fair income, (2) natural resources remain in a condition that allows present and future generations to benefit, and (3) others are not negatively impacted by their farming. In the baseline situation, the soil condition of most ponds, either farmed extensively or intensively, had not been good (see Appendix B, e.g.: reddish brown or black water). Therefore, the CFS first trains farmers in the principles and practice of organic Low External Input Sustainable Aquaculture (LEISA). This practice allows the soil and other aspects of the environment to recover and to sustain aquaculture in the long term (Box 2). Before introduction in Demak, LEISA had been tested in Sulawesi, Indonesia[2], by Blue Forests[1], the Indonesian NGO that also led the implementation of CFS for the Building with Nature programme in Demak.

2.1 APPROACH AND CONCEPT OF COASTAL FIELD SCHOOLS

The CFS approach aims to empower coastal community members by increasing their technical and social knowledge. Instead of instructing farmers on technical steps of a production system, the approach uses experiential, participatory and learner-centred techniques to build the capacity of participants to analyse their production system and handle their own on-farm decisions. The method accentuates group observation, analysis, discussion, presentation, and collective decision making.

During the learning programme, CFS participants learn to:

1. apply ecological principles to better manage coastal resources within their specific agro-ecosystem,
2. use critical thinking skills at both farm/pond and community levels,
3. practice leadership skills to organise collaborative actions around coastal ecosystem management, and
4. implement discovery approaches that allow them to solve local problems.

Moreover, participation in a CFS improves social cohesion and the sharing of knowledge in the years after training.

2.2 KEY CHARACTERISTICS

A CFS consists of regular group meetings at agreed intervals, spanning a full cropping season, and is field-based. The primary learning material is the farming system. The training principle is not teaching, but facilitation of hands-on and discovery-based learning that enable farmers to be active learners and experts of their own field. The integrated and participant-defined curriculum covers the full cycle of production.

In every CFS, participants conduct a Participatory Comparative Experiment (PCE) with a demo-pond applying LEISA and a traditionally managed pond (control). One CFS learning unit consists of 20 to 30 villagers who share a common interest (same livelihood activity) and come from the same area. Each group should be diverse, including a mix of different genders, literacy levels, socio-economic backgrounds, etc. Such mixed composition will enable peer learning and empower the more vulnerable members. However, trainers should be aware of the risk of dominance by wealthier and more powerful participants.


CFS session amidst ponds ©Restiana Wisnoe

BOX 2: LOW EXTERNAL INPUT AND SUSTAINABLE AQUACULTURE (LEISA)

Low External Input Sustainable Aquaculture is based on a farming principle developed for agriculture (LEISA). Unwarranted or excessive use of external inputs, particularly synthetic chemicals, is avoided, in order to minimise the risk of pest resistance and disturbance of the soil ecosystem. LEISA for brackish water farming aims to optimise the use of locally available natural resources (soil, water, plants) and inputs (e.g., animals, organic wastes) to complement and provide the greatest synergy in the agro-ecosystem of the farm. LEISA is intended to be a sustainable farming strategy for resource-poor farmers through reduced production costs, a healthy agro-ecosystem, and good yields of healthy food. The LEISA principles for aquaculture are to:

- Maintain and enhance soil fertility using solid compost or manure and liquid compost;
- Stimulate recycling of organic matters in the pond with liquid compost;
- Conduct pest and disease management through prevention and safe treatment.

The common input for a LEISA brackish water pond is organic fertiliser, solid compost or manure, and/or a liquid compost of fermented waste (called MOL in Indonesia). The decomposed organic matter of the compost maintains and enhances pond bottom fertility by improving physical and structural properties of the soil, increasing the water retaining capacity, and improving soil chemical and biological composition. The liquid MOL adds energy, minerals and micro-organisms to the pond water to stimulate the growth of natural feed for the cultured organisms by enhancing the recycling of both deposited and suspended organic matter.

BOX 3: ALIGNMENT WITH GOVERNMENT STRATEGIES

In Indonesia, the Coastal Field School was aligned with the Work Mechanism and Training Methods proposed for the Ministry of Marine and Fisheries Affairs (Peraturan Menteri Kelautan Dan Perikanan Republik Indonesia Nomor 30/Permen-Kp/2014 Tentang Mekanisme Kerja Dan Metode Penyuluhan Perikanan). The law defines skills training as a learning process for the main stakeholders that enables them to plan independently and access market information, technology, capital, and other resources, as an effort to improve productivity, business efficiency, income and welfare, as well as raise awareness of the need to preserve ecosystem functions.

In Indonesia, field schools for dozens of industries have been developed since the 1990s. At present, field schools are used to address climate change issues and the Coastal Field Schools have become part of the programme of Indonesian Peatland and Mangrove Restoration Agency (BRGM).

2.3 CONDITIONS FOR A SUCCESSFUL CFS

Some of the conditions for successful implementation of CFS are:

- Alignment with government strategies (see Box 3);
- Ability of the farmers to apply the proposed technology that works in their production system;
- The proposed technology needs to contribute to the problem's solution;
- Clear understanding of the CFS concept and procedure by all stakeholders;
- Suitable site identification and participant selection;
- Farmers that are willing to learn and have the capacity to develop (see Box 6 and 8).

Ideally, Government Training Services (which provide advisory services), in collaboration with local education and research institutions, would use a field school approach to enhance the productivity of farmers. After a participatory assessment, they set the exact topics for a field school. In the Building with Nature Indonesia programme, non-governmental organisations have taken the initiative to provide CFS, and focussed on coastal aquaculture, in alignment with the project's objective to integrate revitalisation of aquaculture with coastal protection.

To ensure the learning and timely delivery of educational materials, the CFS requires also:

- Appropriate funding, and good administration and logistics mechanisms;
- Effective supervision, monitoring and evaluation for quality control;
- Experienced, or well-trained, field school facilitators.

In the next sections and chapters, most of these conditions are further elaborated.

Implementing a field school takes time, particularly in unfamiliar areas. Planning and preparation may take 6 to 12 months and the assessment before a programme can start after securing the budget (Box 4). Some field school activities could sometimes begin before the preliminary phase is complete. However, when the goal is to improve infrastructure, as is the case with creating Associated Mangrove Aquaculture systems, the preparation time may be longer.

Participants of a post-fieldschool planning workshop for greenbelt recovery ©Boskalis

BOX 4: TO DO BEFORE A FIELD SCHOOL PROGRAMME CAN START

Prior to participant selection in consultation with village leaders, but after securing the budget, the following actions are advised:

1. Literature review of social, ecological, economic and governance factors in the area.
2. Initial programme "socialization" with local stakeholders, including local government officials.
3. Stakeholder analysis (optional).
4. Participatory Rapid Appraisal with relevant agencies, to assess the Village Profile and understand its condition and livelihood issues, using tools such as:
   - Village Sketch or Participatory Mapping;
   - Historical Transect;
   - Historical Analysis of Change in the Village;
   - Analysis of the adaptive cycle and typification of the village.
5. Preparation of the facilitators.
6. Adjustment of the pond management plan to the local situation and assessment of the knowledge level of potential future participants.
7. Collection of equipment for the field schools and practical learning.

2.4 CRITERIA FOR SITE SELECTION

Sites for CFS application should meet several criteria:

- The site should be suitable for the use of previously identified aquaculture technology;
- The learning places (meeting place and learning farm) are accessible and acceptable to all the participants, and close to the community;
- The selected demo-pond should be protected from risks such as seasonal flooding and thieves, and should be close enough to the meeting place;
- The land-owner has agreed to the use of the pond for the entire culture period.

2.5 THE BENEFITS OF CFS

Key advantage of a well implemented CFS is the discovery-based learning that reinforces farmers' observation skills and fosters knowledge ownership. Moreover, the method allows farmers to:

1. Enhance their awareness of the connection between their livelihood and its impact on the environment, in this case the mangrove ecosystem;
2. Build their self-confidence and enhance their decision-making capacity;
3. Minimise risks when experimenting with new practices;
4. Substitute established practices for milkfish and shrimp farming with a more sustainable aquaculture approach;
5. Develop problem-solving capabilities.

Monitoring the practices of project alumni confirmed that their yields and income increased (see Box 5). Additional analysis showed that CFS is a cost-efficient form of training for aquaculture (Appendix A).

BOX 5: COASTAL FIELD SCHOOLS BOOSTED YIELDS AND INCOME

As part of the Low External Input Sustainable Aquaculture (LEISA) practice, once a year farmers spread home-made liquid compost and manure or dry compost on the dried pond. Thereafter, water quality is maintained by adding this liquid compost whenever needed, in accordance with water colour. General monitoring of all 277 alumni allowed us to calculate the adoption rate and yield increases, while closer monitoring of a smaller sample of 17 farmers provided revenues from sales, operational cost and gross margin. The alumni's results were compared to baseline data collected at 6 villages in Demak during 2015: 192 kg ha^{-1} yr^{1} of milkfish, 43 kg ha^{-1} yr^{1} of shrimp, and a gross margin of 10 million Indonesian rupiah (IDR) ha-1 yr^{1}.

About 85% of the alumni of the Coastal Field Schools applied LEISA to some extent. The farmers who neither applied LEISA, nor stocked shrimp, continued milkfish production using chemicals, harvested about 700 kg milkfish ha^{-1} yr^{1} and earned little. The milkfish yields of LEISA farmers in the sample were more than three times higher than the baseline, and their average shrimp yields were over six times the baseline. The farmers who applied LEISA doubled their cost, but their margins were 3 to 10 times higher than those who did not, and 2 to 4 times higher than the baseline (see Appendix B for details).

The farmers with the best results had applied more dry compost or manure. Farmers with small ponds invested more per cycle, but doubling pond size increased yield not 100%, but only up to 30%. For each additional hectare, there was a reduction of 40% gross margin. Farmers benefited from making ponds smaller.

Farmers working together to realign the dyke of the Associated Mangrove Aquaculture System ©Wetlands International

3 CFS IMPLEMENTATION

3.1 TRAINING OF THE TRAINERS

A coastal field school typically requires trainers, co-trainers, facilitators and assistants. The trainers, co-trainers and facilitators of a CFS need to have or be willing to acquire skills related to adult education. The assistants must be farmers who are able to grow the crop, e.g. shrimp, from preparation to harvest, and master the CFS methods and LEISA. If such individuals are not locally available, potential persons need to be identified and undergo an intensive training of trainers (ToT) to prepare them for organizing and conducting Field Schools.

The facilitators monitor the trainers during the CFS season, assist in problem solving, monitor cash flows, and evaluate the quality of implementation. They should have seniority in their institutions, and be able to spend a considerable amount of time in the field with trainers and farmers. Facilitators and trainers will need to meet frequently (twice or more during a season depending on the length of the season) to assist in planning work, budgets, and strategies for improving the CFS training programme. Trainers and co-trainers initiate field schools in the communities, and supervise several field schools during a year. They lead training sessions, guide the assistants, and organise external expertise for specific training deemed necessary by the farmers. All trainers, co-trainers and facilitators need to have skills in facilitation, leadership, management, and curriculum development before leading a CFS. They also need to be aware of gender biases and master methods to avoid these. Freshmen should be offered or given a special training workshop.

The assistants become the "core" of the training programme and can be made responsible for most aspects of a CFS. These assistants need to have participated in one CFS, and have assisted under guidance in at least a 2nd, and perhaps 3rd before working independently. Thus, this core group will advance through several stages of personal changes during the programme. One way to develop this mastery is to be involved in the above-mentioned assessment of LEISA or other techniques that are part of the CFS (Box 2).

Assistants or training agents that have undergone special training can become CFS trainers after first having led the implementation of one season-long CFS in a community. Trainers should be available to provide full time input to a CFS programme. Trainers will implement the CFS under the guidance of CFS facilitators, who have gained experience as trainers over several seasons.

In the follow-up stage of a CFS, trainers and facilitators can organise and facilitate further programmes as desired by the CFS alumni. This may include community-based actions to develop and implement village agro-ecosystem management plans. These are all skills which she or he will learn during the season-long ToT, during follow-up training, and at workshops conducted alongside CFS implementation.

Abdul Ghofur leading a review session during the ToT ©Blue Forests

BOX 6: FROM INTROVERT FARMER TO REPRESENTATIVE

Abdul Ghofur is a 47 year old milkfish farmer from Tambak Bulusan. In 2015, Abdul Ghofur and 20 others participated in the season-long Training of Trainers (ToT) for the Coastal Field Schools geared towards revitalising aquaculture productivity in the district of Demak. The 21 had been selectively recruited to be community organisers for the aquaculture improvement programme. When he was told that the ToT participants are expected to be an agent of change for aquaculture practices in their villages, he replied that this expectation was too high. He did not think that he could be of such influence, because he was convinced that the villagers would not be willing to listen to him.

Nothing could be further from the truth. As he progressed in his training, he became a confident speaker and facilitator. He occasionally led the training's review session and shared his farming progress. Since Abdul completed the ToT, he has co-facilitated weekly Coastal Field School training sessions for his community during each milkfish-shrimp culture season.

Moreover, owing to his potential champion quality, in 2016 he was invited to take charge of aquaculture affairs for the "National Outstanding Farmers and Fishermen Association" at the Demak district Skills Development Agency. Recently, he was also elected Head of the Building with Nature community in Tambak Bulusan, which surpassed his prior perception of himself.

3.2 PREPARING FOR THE COASTAL FIELD SCHOOL

Before starting a CFS, the project organisers need to be confident that the proposed innovation (LEISA, see Box 2) can realistically improve farmers' income. This verification might require the observation of a complete farming season at a new location. In Demak, this step was integrated in the season-long training of facilitators, trainers, co-trainers and the first assistants.

Prior to the CFS training, it is also necessary to understand the socio-economic system by carrying out a problem analysis of the local area in order to understand its needs and holding a community engagement session (in Indonesia called Socialisation). Problem analysis is a participatory process following the Sustainable Livelihoods Assessment (SLA) method and its tools (see chapter 6). This SLA, encompasses the following: (a) Mapping of Village Ecosystems; (b) Trend Analysis; (c) Seasonal Calendar; (d) Needs Analysis; (e) Institutional Analysis, and (f) Review of Problems and Actions (see Box 7). The SLA helps prioritise the follow-up actions and also serves as a baseline study for the programme. Subsequently, the project team organises community information and engagement sessions to outline community needs, recruit participants, and develop a learning contract. The Bamboo Bridge Activity is one of the tools that can guide such a session (Box 7).

The CFS uses simple practical tests to demonstrate the pond's ecology

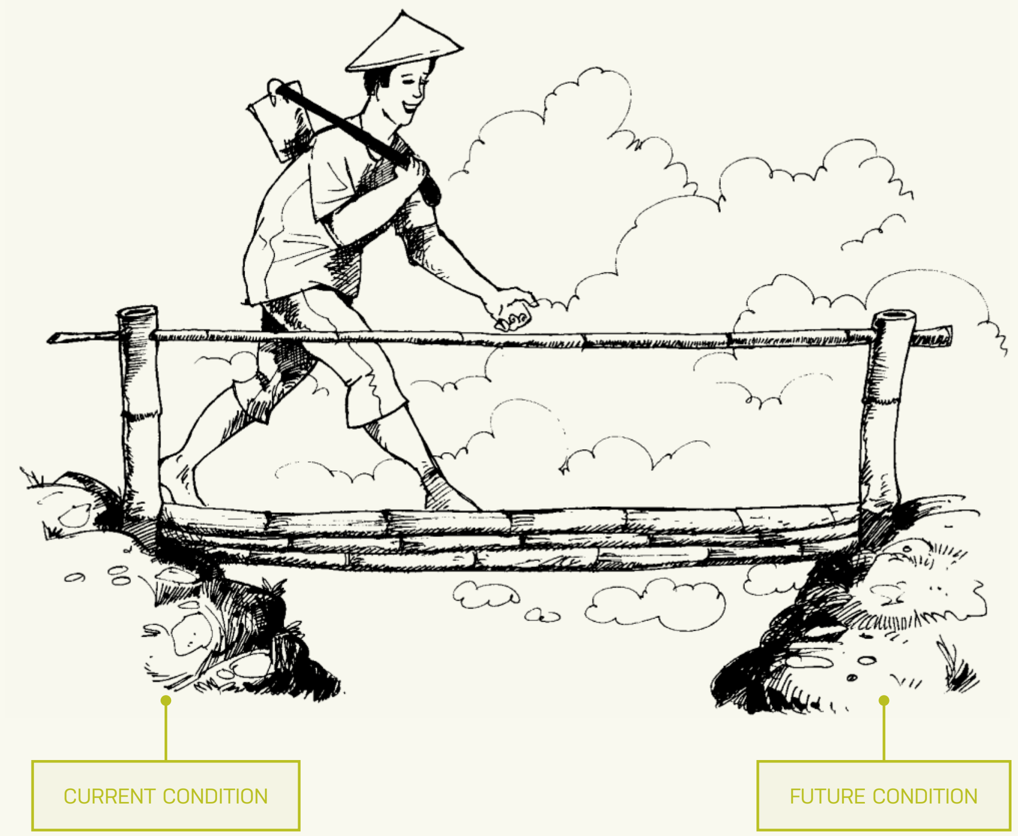
BOX 7: THE BAMBOO BRIDGE ACTIVITY

The Bamboo Bridge is a participatory tool that can be used to review problems and to identify community actions needed to reach the objectives or solutions to solve these problems. Before a session, the facilitator prepares a poster illustrating the problem identified earlier and another poster illustrating the objectives or visions. If this has not been done recently, the participants should be asked to list the characteristics of the current condition at the left, and those of the desired state at the right.

After displaying these posters, a string is attached between them with pins, and a small poster labelled "Community Effort" is attached to the middle of the string. Below, the facilitator displays three labels: "Barriers", "Steps" and "Resources", where the participants list the barriers and elaborate the steps and resources needed for the transition.

Further sources of information about this activity can be found in Chapter 6. The method was inspired by, and the figure below adapted from Clark et al 1985 [reference 3].

BAMBOO BRIDGE TOOL



3.3 CRITERIA FOR PARTICIPANT SELECTION

The participants of a group should have a common interest, and not an established preference for a specific intensive system. Persons with such a preference tend not to be willing to test the LEISA, and should instead visit a community that can tell successful, convincing stories of implementing LEISA under the same conditions.

Moreover, the participants should be:

- Actively practising aquaculture of the target species (see Box 8);
- Willing to participate voluntarily after the engagement session;
- Willing to work in a group and follow the norms set by the group;
- Willing to formally complete the curriculum;
- Have individual responsibility for the management of a pond; this applies in particular to women; husbands can be encouraged to bring their wife along;
- Socially acceptable in the community and have good relationship with other community members. The selection of the participants should be guided and monitored to prevent the recruitment from one social group (friends) or of non-farmers.

3.4 THE TOPICS COVERED IN THE CFS CURRICULUM.

At the CFS in Demak, participants attend 16 half-day sessions, held 2 to 4 times a month. The sessions are co-managed by trainer, co-trainer and assistant, who take turns in leading the various topics of a session. A session relates to a stage of the cropping season and addresses one or more of the topics listed in table 1 on page 27. Next to the specific topics related to the cropping season, each CFS meeting also includes at least three activities:

1. An agroecosystems analysis (AESA) to make informed decisions on the pond or farm management combined with the participatory comparative experiment;
2. A special topic to address wider livelihood issues encountered in the field and connected with the AESA, such as availability of food;
3. A group dynamics activity to aid community group cohesion;
4. Feedback on the process, topics and progress.

The conventional (traditional) method used by farmers is compared with the LEISA technique to be introduced in a demonstration pond. Starting with LEISA is preferred, as it enables farmers to learn more about the basic principles of good pond management. An important element of LEISA is using liquid compost (see Appendix C), for pond preparation (see Appendix C) and water quality management (see Appendix B). Other technical topics include pond preparation, stocking, water exchange, feeding, culture practices for shrimp and milkfish, all summarised in Appendix C.

The trainers and facilitators should be trained in methods of improving group dynamics. For some sessions, the CFS could engage experts from university or government. All CFS should, at or near the end, include a Field Day. During this field demonstration day, the participants present their learning and the results of the CFS to other farmers , trainers and extension workers.

BOX 8: DISAPPOINTMENT TURNS INTO OPTIMISM

Supardi (47 years old) was one of the participants in the Training of Trainers (ToT) for the Coastal Field Schools (CFS) in 2016. In addition to his main role as a village secretary in Surodadi village, he also manages his 3.5 ha pond. The training focussed on learning facilitation skills rather than aquaculture techniques, but during the first three sessions he repeatedly complained about the difficulty of raising shrimp in his ponds. His experience was that, after stocking, the expensive shrimp fry typically survived only about 6 weeks. At that point, the young shrimp would swim to the surface and would need to be harvested immediately, even though they had not yet fully grown. Supardi required a solution to this problem, and at the end of the sessions, he expressed his disappointment as he could not get sufficient information from the trainers regarding his concerns.

Three and a half months from the start of the training, Supardi invited the field facilitators to assist with the harvest of his 1,800 m2 pond. About one month after the training had started, he had already stocked shrimp fry in this pond where he applied what he learnt at the CFS. Two months and 3 weeks after stocking, they harvested 100 kg, which he sold at 3,5 million IDR. He said that the harvest had never been this good before. He explained that his first successful harvest had resulted from applying the LEISA system to raise his milkfish and shrimp. In order to prove the efficacy of LEISA system, he had experimented some rearing techniques learnt at the ToT in his pond: he had substituted the dry compost (manure) with artificial feed. From his first success, Supardi gained confidence to raise shrimp again, and pledged to continue using MOL and applying LEISA.

A university professor lectures at Coastal Field Schools ©Restiana Wisnoe

BOX 9: MRS. LIGNA (36 YEARS), WIFE OF MR. GHOFUR

When their first son was born, almost 20 years ago, Ligna and Ghofur finished building their house funded by the rare successful harvests of one of the last shrimp stockings at that time. Due to frequent disease outbreaks, stocking shrimp carried an unacceptably high risk, and consequently, like other farmers in Tambak-bulusan, they used to stock milkfish only. At the Coastal Field School her husband learnt, among other skills, how to use liquid compost to improve pond soil and manage water quality.

Now, Ghofur and Ligna stock shrimp again and harvest good volumes three times per year. They sell harvests of more than 150 kg directly to a fishmonger in the city of Semarang, and that brings in 50-100% more than what they earn by selling to the village collector. They are able to invest 5 million IDR per month into the education of their children. Without the improvement, they might not have been able to send their eldest son to university. They believe that their yields will increase further once Ghofur can fully implement the Integrated Multitrophic Aquaculture system by adding suitable seaweed and devices for tilapia.

©Roel Bosma

Ghofur has already started using Associated Mangrove Aquaculture by letting mangroves recover in one of his ponds along the river. In the 2nd year, the improvement in composition and yield of the daily harvest from his pond has become evident. Moreover, he has been able to harvest more of the local shrimp, *P. merguensis*, which fetches a good price with buyers.

NO	TOPIC	MINIMUM OBJECTIVES RELATED TO FARMER'S KNOW-HOW
A	Mapping of ecosystems	Identify and map resources using transects to understand local ecosystems and causes of poor conditions.
B	Needs analysis and calendar	Calculate the pond's daily need and production cost; Understand local livelihood activities during the seasons.
C	Hierarchisation & Institutional analysis	Hierarchise the problems and any identified solutions using the Bamboo Bridge method (Box 7), and identify stakeholders who can contribute to these through Institutional Analysis.
D	Planning & design of the PCE	Introduce LEISA and PCE. Agree on steps and timeline of raising the fish or shrimp; participants select two nearby demo-ponds: one for control and one for the LEISA test.
E	Coastal dynamics and safety	Understand the coastal dynamics (of Demak); raise awareness on the need for coastal protection and identify various coastal protection / rehabilitation techniques.
F	Compost with local micro-organisms (MOL)	Understand the function of organic fertiliser in maintaining soil and water quality and produce a compost called MOL with local microorganisms from local ingredients.
G	Fingerling selec-tion and release	Understand the selection of good quality fingerlings and the technique of stocking (see Box C3).
H	Introduction to Aqua Ecosystem Analysis (AESA)	Equip the participants with skills for PCE to examine, monitor and compare the improved and traditional demo-plots, using e.g. the water colour card (Appendix B).
I	Aqua-ecosystem Analysis (AESA)	Practise skills in monitoring the pond and stocks, and hands-on critical analysis for decision making on management of water quality and animal health.
J	Soil ecology	Improve farmers' understanding and awareness of the role of soil in aquaculture and how to maintain its fertility through drying and preparing the pond bottom (see Box C2).
K	Diseases	Improve understanding of factors affecting the pond and stock's health, and anticipation of diseases.
L	Feeds and compost	Practise farmers' skills in identifying fish/shrimp needs for feed and its components, and making suitable feed and compost from locally available ingredients (see Box C1).
M	Assess restoration opportunities	Introduce farmers to a flexible and affordable methodology for identifying and analysing (mangrove) landscape restoration opportunities.
N	Harvest and further learning	Measure outcomes (yield) of control and demo-ponds. Facilitate farmers' ability to apply lessons learnt at the CFS; and plan follow-up activities.

Table 1: The topics and learning objectives of the CFS curriculum

4 MONITORING AND EVALUATION

Monitoring and impact evaluation helps determine whether the learning goals of the CFS are met.

Monitoring is done through:
- a weekly report of CFS activities by the facilitators;
- regular control by the project leaders;
- an inventory of impact according to participants' perception.

Impact evaluation has two aspects:
- Assessing the participants' knowledge progression by conducting pre- and post-CFS interviews. These can also aid the identification of follow-up activities (see Chapter 6).
- Recording changes in the functioning of aquaculture ponds managed by CFS alumni by measuring (1) water quality (Appendix B), (2) productivity and (3) income from (one of) their pond(s), by monitoring a representative sample of the alumni. This impact evaluation also requires records baseline data, namely the yield and income of aquaculture prior to enrolment in the CFS.

In the Building with Nature project in Demak, facilitators were asked to assess the application of the practices and the yields of all participants. In addition, university staff were hired to monitor a small sample more closely (see Box 5 and Appendix A).

The final harvest of a pond by the farmer and some colleagues ©Wetlands International

CFS participants conducted pond monitoring using monitoring tools ©Blue Forests

5 POST FIELD SCHOOL ACTIVITIES

Upon completion of CFS activities, alumni are expected to apply new skills into their livelihood practices, where suitable and feasible. Moreover, they may pass on lessons learnt to friends, family and neighbouring farmers. Other opportunities for follow-up are:

- Sharing experiences and practices with others in the community either ad hoc or in an organised way (latter requires funding);
- Stakeholder innovation platforms.

Some group activities might require funding. If the project that delivered/funded the CFS also has the capacity to support extended learning, alumni activities are best supported by a dedicated unit. To keep staff focussed on the CFS, such a unit should be separate from CFS management. We recommend the integration of such a unit into Government Training Services, as this would improve the programme's sustainability.

Alumni should also be encouraged and/or supported to self-organise in Stakeholder Innovation Platforms, and develop supporting activities such as a 'money saving club'. A money saving club provides motivation to set aside, at regular intervals, capital for any substantial investment. This capital can be used to improve a pond by adding compartments or developing an associated mangrove aquaculture (AMA) system.

The Demak project supported a range of post-field school activities and accompanying measures such as Bio-rights, a financial incentive mechanism that reconciles economic productivity with environmental conservation and restoration (see Appendix D).

Among those activities was associated mangrove aquaculture (AMA), one of the flagships of the project. In an AMA system, farmers give up 10 to 20 metre of their ponds along a river to create a mangrove riverine greenbelt. The pond benefits from dyke protection and water purification, while the community will benefit from other mangrove ecosystem functions (see the Guideline on AMA in this Series).

An AMA, with planted mangrove, 6 month after construction in Tambakbulusan ©Wetlands International

Mr Kasmudi facing his grow-out pond with its clear water and the dark shadows of the seaweed visible at the bottom, with his nursery ponds in the background. ©Roel Bosma

BOX 10: YIELD BOOST AFTER TRAINING ALLOWS TO BY-PASS MIDDLEMEN

In 2016, Kasmudi from Tambak Bulusan took part in a coastal field school (CFS). Like most other farmers in the village, he used to stock milkfish, used to manage pests with chemicals, and used to apply urea and phosphate fertiliser to his ponds, but his yields were low. He had stopped stocking shrimp long ago. At the CFS he learnt about the LEISA approach and also about the effect of seaweed on water quality.

At the end of the dry season in 2017, he bought 1,000 kg of seaweed, which all appeared to die during the heavy rains of January and February. However, after preparing the pond and stocking shrimp following an increase in salinity, he saw that the seaweed grew again. Every year, the seaweed seemingly disappears, but later regrows and helps keep the pond water clear. To manage salinity, he has drastically reduced the frequency of water exchange and now keeps water quality good by adding liquid compost every week. He stocks shrimp post-larvae in three small nursery ponds and transfers the larger sizes to his bigger grow-out pond. There, from April to December, he can harvest more than 150 kg shrimp every 4 to 6 weeks with size of about 20 pieces/kg. This amount he can sell directly to a monger in Semarang, where he fetches nearly twice what the village collectors used to pay him.

In general, the yields and incomes of monitored farmers applying LEISA were higher in the 2nd year compared to the 1st. This can be explained by (1) farmers stocking shrimp more often, (2) more farmers using (more) industrial feed, and/or (3) other factors such as better application of their learning after discussions organised for the CFS alumni.

6 REFERENCES AND RESOURCES

This guideline touches on many topics relevant for aquaculture and the mangrove coastline. Background information can be found in other guidelines of this series and in the following documents:

COASTAL FIELD SCHOOLS:

1. Blue Forests: www.blue-forests.org; info@blue-forests.org; +61 411 440443. For the complete curriculum guidelines and the questionnaires.

2. Brown B & Fadillah R (2013). Fish Farmer Field School: Towards healthier milkfish / shrimp polyculture and fish farmer empowerment in South Sulawesi. Aquaculture Asia 18(2), 12–19.

3. Clark M, Harvey M, West K, Wilburn M (1985) Training Manual in Combatting Childhood Communicable Diseases: Volume I, Peace Corps, Information Collection & Exchange, Training Manual T039, 579 p. Accessed on 12-2 2019 from http://www.nzdl.org/; See Session 20A.

4. Dilts R, Bartlett A, Pontius J (1999) From Farmer Field Schools to Community IPM: Ten Years of IPM Training in Asia. FAO-Asia. Bangkok. https://ipm-info.org/community-ipm-documents/

5. FAO (1996) Field guide on gender and IPM. FAO-Integrated Pest Management office & Plant Protection Department MARD, Center for Family and Women's Studies. Hanoi. https://ipm-info.org/library/documents/gender_vietnam.pdf

6. Hagiwara T, Ogawa S, Kariuki P M, Ndeti J N, Kimondo J M (2011) Farmer Field School Implementation Guide. Farm forestry and livelihood development. Kenya Forests Service, FAO and JICA.

7. Khisa G (2004) Farmers Field School Methodology Training of Trainers Manual.

8. Widowati LL, Ariyati RW, Rejeki S, Bosma RH. The Impact of Aquaculture Field School on the Shrimp and Milkfish Yield, and Income of Farmers in Demak, Central Java. Journal of the World Aquaculture Society, 52: 362-377. https:/doi.org/10.1111/jwas.12770.

AQUACULTURE:

9. Yuniati W, Fadillah R, Sri Rejeki, Widowati LL, Ariyati RW, Apri S. Astra, Bosma RH (2021) Aquaculture Field Schools supporting mangroves for climate change adaptation of Indonesian milkfish-shrimp farmers. Aquaculture Asia April-June 25(2): 10-20. https://enaca.org/?id=1156

10. Hilbrands A & Yzerman C (2004) On-farm fish culture. Agrodok 21. Agromisa Foundation Wageningen. https://publications.cta.int/media/publications/downloads/863_PDF_1.pdf

11. Cameron A (2002) Survey Toolbox for Aquatic Animal Diseases. A Practical Manual and Software Package. ACIAR Monograph No. 94, 375p.

12. SEAFDEC, (2007). InfoTips on mangrove-friendly shrimp farming. Southeast Asian Fisheries Development Center. Iloilo, http://hdl.handle.net/10862/633.

LEISA:

13. Ariyati RW, Rejeki Sri, Widowati LL, Elfitasari T, Bosma RH (2019). Effect of three types of liquid compost combined with Avicennia marina leaves on growth and survival of Tiger Prawn (P. monodon). Intern. Aquatic Research 11: 311 -321. https://doi.org/10.1007/s40071-019-00239-x

14. Kessler & Moolhuijen (1994) Low External Input Sustainable Agriculture: Expectations and Realities. Netherlands Journal of Agricultural Science 42-3

15. Rukmana, R. (2007). Bertanam Petsai dan Sawi. Kanisius, Yogyakarta.

MANGROVE AND COASTAL RESTORATION:

16. Bosma RH, Debrot D, Rejeki S, Tonneijck F, Yuniati W & Sihombing W. (2020). Associated Mangrove Aquaculture Farms; Building with Nature to restore eroding tropical muddy coasts. Ecoshape technical report, Dordrecht, The Netherlands

17. GNF (2007) Mangrove Rehabilitation Guidebook. EU-ASIA PRO ECO II B Post Tsunami Project in Sri Lanka. Global Nature Fund (GNF) Radolfzell, Germany.

18. Mangrove Action Project - Indonesia (2006) Cooking With Mangroves: 25 Indonesian mangrove recipes. Yayasan Mangrove, Jakarta.

19. Eijk P van & Kumar R (2009) Bio-rights in theory and practice. A financing mechanism for linking poverty alleviation and environmental conservation. Wetlands International, Wageningen, The Netherlands.

20. Wilms T, Van Wesenbeeck BK, & Tonneijck F (2020). Permeable Structures; Building with Nature to restore eroding tropical muddy coasts. Ecoshape technical report, Dordrecht, The Netherlands

21. Spalding M, McIvor A, Tonneijck FH, Tol S, van Eijk P (2014) Mangroves for coastal defence. Guidelines for coastal managers & policy makers. Published by Wetlands International and The Nature Conservancy. 42 p. Link: https://www.wetlands.org/publications/mangroves-for-coastal-defence/

X APPENDIX A: CHANGES IN PRODUCTIVITY AND INCOME AFTER CFS

In 2017 and 2018, the Building with Nature Indonesia project completed a monitoring database with records of practices and yields of 125 CFS participants, and collected information on finances and water quality in a 10% sample. For the financial analysis, the alumni's results were compared to a baseline measured in 6 villages of Demak in 2015: 192 kg ha^{-1} yr^{-1} of milkfish, 43 kg ha^{-1} yr^{-1} of shrimp, and a total gross margin of 10 million Indonesian rupiah per farm, or about 630 USD ha^{-1} yr^{-1}.

Of the 17 sampled farmers from three villages, cost, yield and revenues were recorded. The gross margin (GM) was calculated as (revenue from sales) – (operational cost). Before statistical analysis, the two annual datasets of the sample were merged and three outliers were trimmed.

To calculate the efficiency of CFS training, the average additional GM per farm, adjusted for pond area, were compared to the cost of the CFS. The total cost of implementing the CFS was averaged over 277 alumni: 1,060 USD per farmer.

The alumni were expected to improve their pond management, and practise low external input sustainable aquaculture (LEISA). Once a year, LEISA farmers apply dry compost (if available) to a dried pond bottom and, later, a home-made liquid compost. They maintain water quality by adding this liquid compost whenever needed, as determined by the water colour. LEISA was adopted by 85% of the 125 alumni with complete records. The farmers who did not apply LEISA, nor stocked shrimp, continued producing milkfish using chemicals, harvested about 700 kg milkfish ha^{-1} yr^{-1} and earned less. Within the sample, milkfish yields of adopters and non-adopters were not significantly different. The milkfish yields of LEISA farmers were more than three times higher than the baseline (see figure 1). Their average shrimp yields were over six times the baseline.

	MILKFISH				SHRIMP			
	2015	2017/18	S-2017	S-2018	2015	2017/18	S-2017	S-2018
CONTROL	234	350	633	854	47	31	-	-
LEISA	-	243	770	1291	-	134	268	434

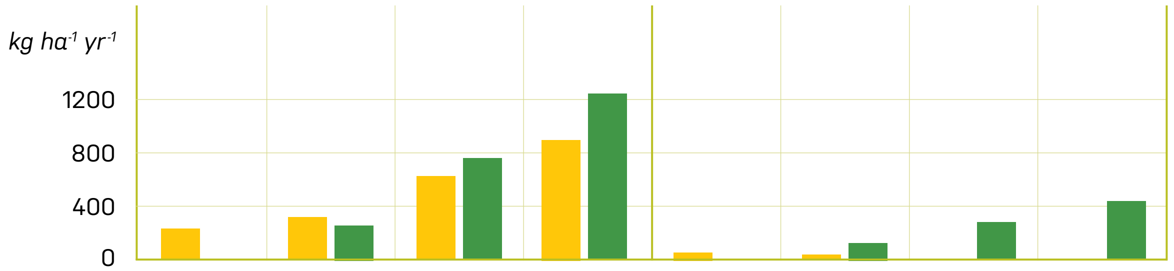


Figure 1: Yields of milkfish and shrimp of LEISA adopters and non-LEISA adopters among all trained (2017/18) and of the sample (S-2018 and S-2018), both compared to the baseline recorded in 2015.

The application of LEISA increased cost, but the GM of farmers applying LEISA was more than three times higher (1,344 USD ha^{-1} year^{-1}) than that of the non-adopters (405 USD ha^{-1} year^{-1}), and more than two times higher than the average in the baseline (see figure 2).

The yields and incomes of the farmers applying LEISA were higher in the 2nd year (2018) compared to the 1st (2017) which might be explained by (1) stocking more often, (2) more farmers using (more) industrial feed, or (3) other factors such as less flooding, or better application of their learning. The farmers who achieved the best results had smaller ponds and applied more fertiliser, particularly manure.

The results of the sample LEISA adopters were far better than for most of the 85% adopters of LEISA among 125 alumni with completed stocking and harvest data. Those among the 125 who stocked shrimp, just tripled the yields of shrimp. Nevertheless, improving the farmers' skills through CFS can double milkfish production and increase shrimp production by 25 to 50%.

GROSS MARGINS

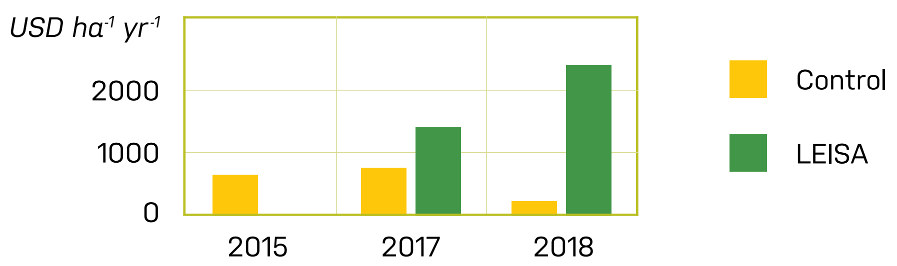


Figure 2: Gross margins of the LEISA adopters and non-LEISA adopters in 2017 and 2018 of a sample of the farmers trained in 2016, compared to the baseline in 2015.

Based on the difference in GM of 927 USD ha^{-1} year^{-1} between adopters and non-adopters in the sample, and the yields of the 125 participants, the increase in gross margin of the 105 adopters can be estimated at 714 USD ha^{-1} year^{-1}. On average these farmers have 1.9 ha of ponds. The estimated increase in GM after attending the CFS suggests that one farming household could achieve and increase in their gross margin between 1,360 and 1,950 USD year^{-1} from their ponds. Given the cost of 1,060 USD per farmer, the rate of return of the CFS was 1.3 for the 277 participants and 1.7 for the sample.
This indicates the payback period for the CFS is less than one year, allowing ample financial space to invest in post field school activities!

Ladies selling fresh seafood as a local market.
©Cynthia Boll

X APPENDIX B: PARAMETERS FOR WATER QUALITY MONITORING

The farmers can do daily monitoring of several factors themselves (see table 2). A colour card is used to monitor water colour, which is an indicator for the fertility and quality of the pond water (see figure 3). This monitoring is needed to recognise any development of algae that facilitate disease outbreaks.

Measuring dissolved oxygen (DO) content in the water requires expensive equipment, but farmers can also monitor DO by observing fish behaviour in the morning. When too many fish rise to the water surface to inhale air, this indicates DO is too low.

To measure pH, ammonia and salinity the farmer needs disposable kits or equipment. Monitoring salinity is important for ponds in a coastal estuary.

Measuring other water parameters needs more expensive equipment. For those analyses, water samples need to be collected and sent to specialised laboratories.

PARAMETER	METHOD / MATERIAL	LOCATION	LOCATION	RESPONSIBLE
Water transparency	Secchi disk	Pond	Daily	Farmer
Temperature	Thermometer	Pond	Daily	Farmer
Dissolved oxygen	Visual observation of fish	Pond	Daily, early morning	Farmer
Water colour	Visual observation using colour card	Pond	Weekly	Farmer
pH	Indicator stick	Inlet, Pond	Weekly at noon	Farmer
Ammonia	Test kit	Inlet, Pond	Weekly	Farmer
Salinity	Refract meter	Inlet, Pond	Weekly	Farmer
Nitrate, Ammonia, Phosphate, Plankton	Laboratory	Inlet, Pond	Monthly	Laboratory

Table 2: Measuring methods for water quality parameters, required equipment, location and frequency of monitoring.

WATER QUALITY MANAGEMENT WITH MOL BASED ON WATER COLOR IN THE POND

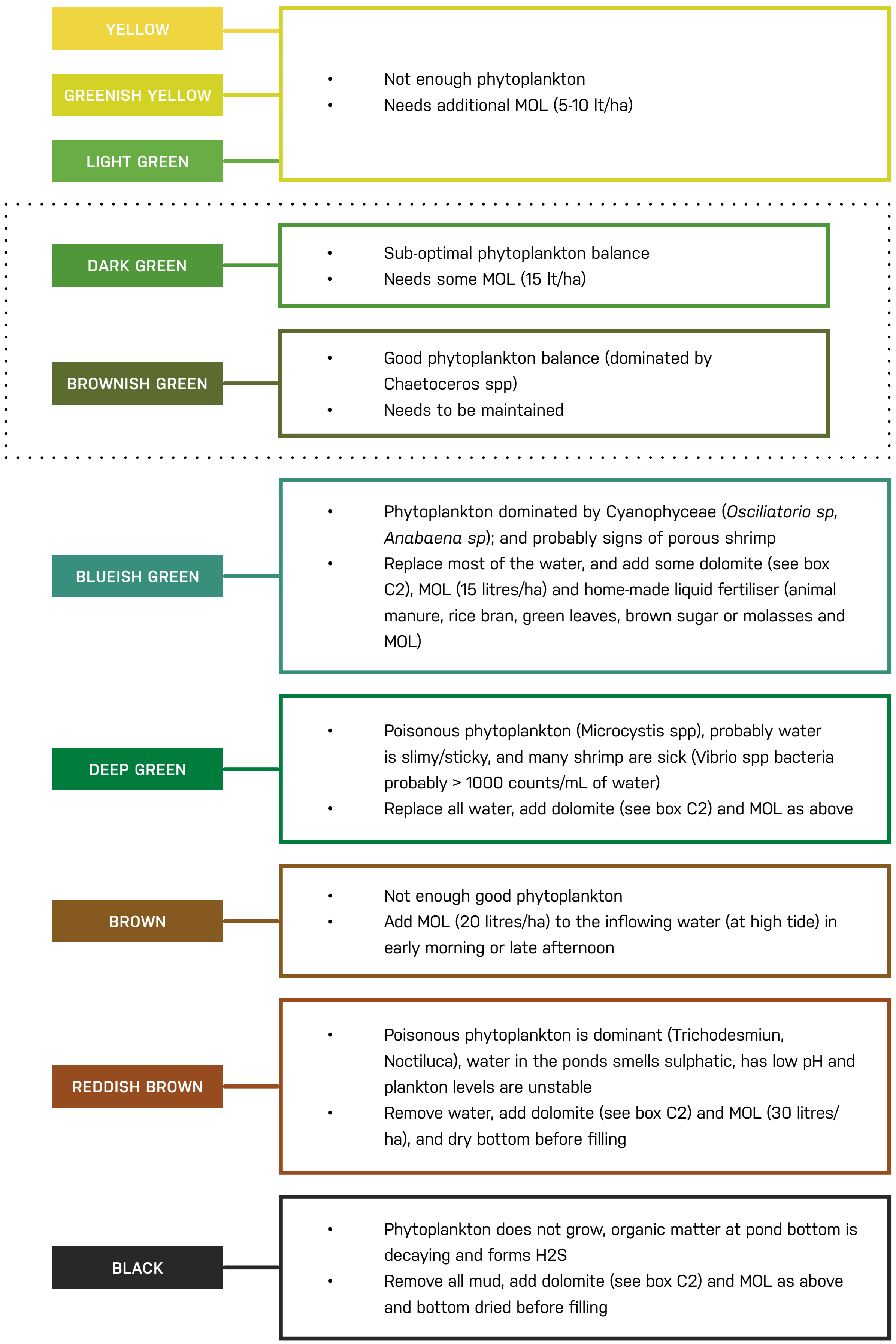


Figure 3: The colour card developed by the Indonesian Ministry of Marine Affairs and Fisheries (MMAF) and adapted by Blue Forests.

Water hyacinth that has been shredded and will be used as compost for LEISA practice ©Cynthia Boll

X APPENDIX C: MAIN PRINCIPLES OF AQUACULTURE LEARNT AT THE CFS

BOX C1: MAKING SOLID AND LIQUID COMPOST FOR LEISA

Compost is produced from organic waste. Its quality depends on the composition of the ingredients and the duration of fermentation. The ingredients of high-quality compost are organic waste from plant residues (straw, stems, branches), household/kitchen waste, livestock manure (from cows, goats, chickens, ducks), husk charcoal, kitchen ash, and others. The material has to be turned over regularly and fermentation should last at least 4 weeks.

The liquid organic solution called MOL in Indonesia, is made from organic waste containing carbohydrates, proteins, fats, vitamins and minerals and is produced using micro-organisms. The following gives examples of sources for the mixture:

1. Minerals and carbohydrates: waste from fruits or vegetables such as tomatoes, papaya, etc., some golden apple snail, or any other source of carbohydrates and minerals.
2. Carbohydrates: left-overs of rice, cassava, potatoes, sweet potatoes, etc.
3. Glucose: molasses, brown sugar, sugar, etc., to give bacteria food to develop and then colonise and digest the organic materials to produce a balanced manure or liquid compost for the pond.

The above are mixed in the ratio of 20:1:1. The non-liquid components should be chopped, the mix placed in a covered but not sealed drum, where four granules (about 20 grams) of yeast, such as the one used to ferment cassava, is added to each 22 kg of the mix. All is submerged in rice water, coconut water, or rice bran mixed with water or urine (1 in 10) and thoroughly mixed. The mix is left to ferment for 7 to 14 days. As long as the mix is submerged, the fermentation produces nutrients and beneficial bacteria.

During pond preparation (see Box C2), MOL is added to the compost or manure on the dried pond bottom at dose of 20 to 30 l/ha. During cultivation 10 to 25 l/ha may be added to the pond weekly if the water transparency is less than 40.

BOX C2: THE FOUR MAIN STEPS FOR POND PREPARATION

1. Remove a layer of fresh sediment from the pond bottom.
2. Turn over 10-15 cm of the bottom and allow to dry for 5-7 days, or more when the weather is not sunny. The goals are to remove and release toxic compounds and gases formed during the decomposition of organic matter from both the feed and excrements. The pond is dried until trampling feet only sink about 1 cm, or until the soil starts cracking, which happens when soil water content is below 20%.
3. Liming is needed, if during cultivation the water pH frequently falls below 7, and the soil pH after cultivation is lower than 6.5. The dosage depends on soil pH: 4 to 5 requires 500 to 1000 kg/ha; 5 to 6 - 250 to 500 kg/ha; 6 to 7 – 0 to 250 kg/ha.
4. Pest control: Saponin (150-200 kg/ha) or Nikotin (tobacco waste) at 200-400 kg/ha.
5. Fertilisation: 2000 to 3000 kg/ha of compost or manure is put on the pond bottom. After 3 to 5 days, 20 to 30 cm of water is added slowly. After 7-10 days the water is filled up to 60-75 cm depth.

BOX C3: GENERAL GUIDELINES FOR STOCKING LARVAE, FRY OR FINGERLING

1. Stocking is done in the early morning or late afternoon, when the water temperature is low.
2. The larvae, fry or fingerlings need adaptation for 15-30 minutes. This is done by immersing the plastic bag with the animals in the pond (see figure 4).
3. After 5-10 minutes, pond water is gradually added until temperatures are about the same.

BOX C4: WATER EXCHANGE

1. Exchange of the pond water should be avoided the first days after adding the liquid compost.
2. During cultivation, the water may be partly exchanged to control water quality. The easiest way to assess water quality is to measure water transparency with a secchi disk. If visibility of the secchi disk is less than 25 cm from the water surface, refreshing part of the water is needed. This is particularly important if animals indicate lack of oxygen by coming to the surface in the early morning.
3. Other parameters of water quality should be maintained within the ranges advised for each species (see block on fish species).
4. To avoid pests, such as barnacles and oyster, and competitors, such as fish, snails and crabs, the water should be filtered at the water inlet.

Figure 4: The closed bags are kept in the water for a while to let the water temperature adjust ©Blue Forests

BOX C5: HOW AND HOW MUCH TO FEED

1. Most fish should be fed three times every day: morning, afternoon and evening.
2. The feed is given little by little on all sides of the pond, while observing the fish. When they stop feeding, the remaining feed should be kept, as overfeeding leads to waste sedimentation on the pond bottom. This sediment can ferment and reduce water quality.
3. The total daily amount of feed in the 1st month is 5% of the total biomass per day. In the 2nd month this is reduced to 4% and from the 3rd month on, to 3%.
4. To estimate the amount of feed, the farmer needs to record all dead fish, and weigh a sample every week (or every 2 weeks), so that the total daily amount of feed can be calculated.

BOX C6: EVALUATION OF THE CROP AFTER HARVEST

1. After harvest, the farmer can calculate the feed conversion ratio (FCR). For intensive farming of tilapia and shrimp, feed is the highest cost factor, so this gives a quick indication of efficiency.
2. The FCR is calculated as: Total Feed Distributed divided by Total harvested weight.
3. For tilapia and shrimp in ponds, the FCR should be below 1.2, when using a factory pellet. FCR from home-made feed is mostly higher, while the feed is cheaper.
4. The farmer can also calculate their financial results. Then the farmer should consider all factors of cost, including for land and taxes, and income, including the harvest used by the household. The benefit could be divided by the estimated number of labour days, to compare the margin with industrial wages.

BOX C7: TECHNICAL GUIDE FOR FARMING TIGER SHRIMP IN LEISA

Pond Preparation is the 1st step towards good water quality and pest reduction. See Box C2.

GROW-OUT OF SHRIMP POST-LARVAE (PL) WITH COMPOST (SEE BOX C1)

1. For LEISA farming of tiger shrimp (*Penaeus monodon*) post-larvae (PL-20) are stocked at a density of 5 to 10 PL per m^2 (see Box C3)
2. If the water colour (see Appendix B) or transparency (see below) indicates that natural food is insufficient, then additional liquid compost can be applied at the dose of 10 to 15 L/ha.
3. As shrimp are sensitive, we advise to exchange the pond water only if really necessary. Best is to have a filter/storage pond for the refreshment water where salinity and other parameters are made optimal for the shrimp. Such a pond is particularly needed if farmers use the water gate to regularly harvest seafood.
4. Harvesting: if the pond's water condition is good and natural feed is abundant, the first shrimp can be harvested after 2 months. Harvesting can be done partially and selectively using a net with large mesh size. After about 3 months, all shrimp should be harvested if the farmer wants to start a new culture cycle.

WATER QUALITY

The water quality should be maintained through exchanging water (see Box C4) within the following ranges:

Dissolved Oxygen:	4 - 8 mg/L;
Ammonia <0.01 mg/L;	pH 7.5-8.5;
Temperature	28-32 0C;
Transparency:	30-40 cm;
Salinity:	5-25 ppt;
Total Organic Matter:	20-25 mg/L.

BOX C8: TECHNICAL GUIDE FOR FARMING MILKFISH

Pond Preparation is the 1st step towards good water quality and pest reduction. See Box C2.

FRY REARING

1. For rearing, fry are stocked (see Box C3) at the length of 2-3 cm and a density of 100 - 200 heads/m^2.
2. Larval rearing is generally done for 15 to 60 days, until fingerling length of 5-15 cm.
3. Fingerlings can be harvested partially, for example on the 15th day up to 60% can be taken out with a net of appropriate mesh size.

FINGERLING GROW-OUT

1. Fingerlings of 5 to 15 cm are stocked at a density of 7,500 to 10,000 per ha. The longer the fingerlings, the heavier the fish at harvest after 5 or 6 months.
2. The expected yield is 1 ton/ha at a survival rate of 90%. The yield can increase to 1.5 ton/ha if the availability of natural feed is abundant.
3. If the water colour (see Appendix B) or transparency (see below) indicates that natural food is insufficient, then fertiliser can be applied at 30% of the dose added after pond drying. During this application, the pond water level should be 40 to 60 cm. To avoid ammonia production, the compost can be dissolved in water before spreading on the water surface. This can also be done by placing dry compost in a porous bag and allowing it to float in the pond.
4. Harvesting: if the pond's water condition is good and natural feed is abundant, the milkfish can weigh 250-300 g/head (3 fish/kg) after 3-4 months. Harvesting can be done partially and selectively using a net with large mesh size. After about 5 months, all fish should be harvested if the farmers want to repeat the culture cycle.

WATER QUALITY

The water quality should be maintained through exchanging water (see box C4) within the following ranges:

Dissolved Oxygen:	3 - 6 mg/L;
Ammonia <0.01 mg/L;	pH 7.5-8.5;
Temperature	28-32 0C;
Transparency:	30-40 cm;
Salinity:	5-25 ppt;
Total Organic Matter:	20-25 mg/L.

BOX C9: GUIDE FOR FARMING TILAPIA / NILA (*OREOCHROMIS SP.*)

Pond Preparation is the 1st step towards good water quality and pest reduction.
See Box C2.

FRY REARING

1. The rearing pond is stocked with fry of 2-3 cm at a density of 100 - 200 heads/m^2.
2. The fry are fed 3 times/day, with in total 5%, 4% and 3% of the biomass, respectively, in the 1st , 2nd and 3rd month (see Box C5).
3. Fry rearing is done until a fingerling length of 5-15 cm, depending on the customers.
4. Fingerlings can be harvested partially with a seine net of desired mesh size.

FINGERLING GROW-OUT

1. For extensive and semi-intensive culture, the advised stocking density of fingerlings having 8-12 cm length is: 10 fish / m^2.
2. If the famer aims to harvest fish of 500 grams, the density should gradually be reduced to 4-5 fish/ m^2, by doing partial harvests with a seine net of large mesh size.
3. Fish should be fed three times every day: morning, afternoon and evening (see box C5).

WATER QUALITY

During cultivation, the water quality should be maintained through exchanging water (see block 5) within the following ranges:

Dissolved Oxygen:	4 - 8 mg/L;
Ammonia <0.01 mg/L;	pH 6.5-8.5;
Temperature:	28-31 0C;
Salinity:	10-30 ppt;
Transparancy:	> 25 cm;
Total Organic Material:	20-25 mg/L.

Life continues around houses that are regularly flooded due to subsidence ©Cynthia Boll

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APPENDIX D: POST-FIELD SCHOOL ACTIVITIES OF BUILDING WITH NATURE INDONESIA

The Building with Nature programme in Demak had two frameworks to support post-CFS activities: Stakeholder Innovation Platforms (SIP) and Bio-rights scheme.

SIPs build upon the previous CFS and aims to improve aquaculture through advanced field studies, e.g. on calculation of the benefits (see Appendix C4). Advanced studies might include pond infrastructure modification, such as separate green-water pond; inputs, such as compost, local micro-organism, complementary feeding; as well as rearing other species, such as tilapia (see Appendix C7).

Bio-rights is an innovative financing mechanism for linking poverty alleviation and environmental conservation (Eijk and Kumar, 2009). The mechanism involves the provision of micro-credits for the local communities to improve their livelihoods through sustainable practices and in return, requires the communities to deliver conservation and/or restoration measures. Upon successful delivery of these services, the micro-credits are converted into definitive payments (grants). The Bio-rights mechanism consists of three steps:

1. **Contracting:**
   • Negotiation;
   • Signing Bio-rights contract.

2. **Implementation: - Capacity building;**
   • Micro-credits disbursement;
   • Conservation and development activities.

3. **Project monitoring and evaluation:**
   • Monitoring project outcome;
   • Converting micro-credits to grants;
   • Evaluating lessons learnt.

In Demak in 2017, Bio-rights contracts were negotiated with 10 community groups, representing 300 villagers. Legal contractual agreements were set up with community groups, rather than with individuals, and were witnessed by the village government. Bio-rights package deals consisted of:

4. Mangrove restoration through pond conversion;
5. Maintenance of permeable structures;
6. Mixed mangrove Aquaculture;
7. Revitalisation of aquaculture;
8. Alternative livelihoods, joint economic ventures;
9. Policy, advocacy and communication;
10. Community group management.

All communities agreed to convert some ponds into mangroves to avoid further erosion, which had previously been deemed impossible. Economic activities by community groups (aquaculture, alternative livelihoods and joint ventures) allowed some of the profits to be set aside into a group savings fund that was used for mangrove rehabilitation. The measures were incorporated into village development plans. Community groups also organised themselves in an ocean management forum called Bintoro (Bina Noto Negoro), which allows networking with the government and is a mechanism to secure funding for the sustainability of Building with Nature interventions.

X LIST OF ACRONYMS, FIGURES AND TABLES

Acronym or abbreviation	Description
AESA	Agroecosystems analysis
AMA	Associated Mangrove Aquaculture
BRGM	Peatland and Mangrove Restoration Agency
BwN	Building with Nature
BwNI	Building with Nature Indonesia
DO	Dissolved Oxygen
FAO	Food and Agriculture Organisation
FCR	Feed conversion ratio
GM	Gross margin
IDR	Indonesian rupiah
LEISA	Low External Input Sustainable Aquaculture
MOL	Compost with local micro-organisms
NGO	Non-governmental organisation
PCE	Participatory Comparative Experiment
SIP	Stakeholder Innovation Platform
SLA	Sustainable Livelihoods Assessment
USD	United States Dollar

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BUILDING SUSTAINABLE AQUACULTURE THROUGH COASTAL FIELD SCHOOLS

BUILDING WITH NATURE TO RESTORE ERODING TROPICAL MUDDY COASTS