Nordic Development Fund

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WACA
West Africa Coastal Areas Management Program

CASE STUDY 04

Building with Nature

We must ensure the transition of traditional infrastructure designs that fight against nature, towards solutions that work with the nature.

Sediment accumulation behind permeable grids in Demak, Central Java, Indonesia. (Source. Wetlands International)

Context

Socio-economic background

The main sources of income in Demak, Indonesia, were traditionally based on rice cultivation and productive mangrove fisheries. In the 1960s, Demak's economy was based mainly on dry land crops, coconut and rice (Ecoshape 2015). To support this practice, canals for irrigation and drainage were built, with the coastal mangrove belt left intact. Between 1970 and 1980, the rural population was very wealthy due to the abundant harvest of rice, shrimp and milkfish. In the 1980s, however, the green revolution resulted in decreased world market prices for rice. Simultaneously, fish trawling was banned in Indonesia, yet demand for shrimp increased. This situation led the local populations of Demak to push for the transformation of both the paddy fields and mangrove forests into shrimp ponds. Frequent losses of shrimp harvests due to diseases pushed also farmers to open new ponds in the mangrove.

The present inhabitants of the Demak's district coastal communes are specialized today in aquaculture, while some inhabitants still practice traditional fishing. The main livelihood occupation of the households in the villages of the Demak project area is fish farmer or fisherman (70%). Other important income sources are: farm labor (25%), temporary and industrial labor (10%), trader (8%), and government staff (2%) (Ecoshape 2015). Yet, fisheries generate less income compared to the other sources. A study identified that, on average, the household income from other sources is higher (3.3 million IDR/yr) than from fisheries (Ibid.).

Establishment of aquaculture ponds close to the waterline, which usually is associated with the removal of mangroves has initiated a self-accelerating coastal erosion process. This is then aggravated by establishing traditional hard structures for coastal protection. Habitat destruction, coastal erosion, loss of freshwater influx (due to industrial groundwater extraction), and inadequate water circulation results in marginality of aquacultures. At present many ponds are either farmed extensively, unused, or used for other purposes. The current state of coastal erosion, flooding (due to sea level rise) and the lack of water management are currently severely hampering socio-economic productivity. These populations have either lost everything or are on the edge of losing critical natural resources on which they depend for livelihood and income.

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Physical characteristics of Demak's coast

Demak's coastal zone is characterized by strong ocean-to-land environmental gradients. On the landward side, the vegetation is dominated by grasses on the bunds with the occasional small-fast-growing tree, such as Leucaena leucocephala and Sesbania grandiflora, respectively known by the locals as Petai Cina and Turi, as well as the occasional banana trees. The coastal zone is very shallow, with slopes of around 1:600. The seabed and sub-bottom are extremely muddy. There is a pronounced variation in tidal water levels, ranging from 40 cm (neap tidal) to 100cm (spring-tide tidal). Currents in the Demak's coastal waters vary, with maximum velocities of around 15 cm/s. The average wave height over a 14-year period is 0.46m (Ibid.). In 2009, much larger wave heights were recorded, with a highest wave height of 2.2m and a period of over 8s, likely related to the *El Niño* phenomenon (Ibid.).

The climate and hydro-sedimentological behavior of the Demak's coastal zone is strongly governed by the monsoons. Weathered sediments are carried by numerous small rivers to the coastal zone. This supply has been active for centuries, and has even increased over the last decades owing to changes in land-use in the hinterland (terrestrial erosion). Those sediments used to be captured by the mangroves originally present in the coastal zone of Demak. However, with the loss of these mangroves, parts of those historic deposits have been lost in deeper water. A very rough estimate suggests that about half of those historic deposits have currently been lost, implying that will not be possible to restore the eroding Demak's coast entirely (Ecoshape 2015). And as the loss of these sediments from the Demak's coastal zone continues, measures for restoring the fine sediment balance in the coastal zone cannot be postponed.

Main Challenges

The coastal zones in Demak suffer from severe erosion at an average rate of 100 m/year, mainly caused by:

- **Mangrove conversion for aquaculture**. In the 1990s, farmers suffered frequent losses of shrimp harvests due to diseases. The situation pushed farmers to open new ponds in the mangrove forests. The loss of mangroves, including its provision of ecosystem services (especially its function as crustacea and fish nurseries), affected the livelihood of the people living in the coastal plains. At present, Demak is virtually devoid of the once extensive mangrove forests.
- **Infrastructure development**. There was a mismatch of spatial planning for infrastructural development between the different administration levels, i.e. the interests for infrastructure development between village, district and provincial levels differed. However, all of them have neglected the importance of the greenbelt zone along the coastline. Instead, the local authorities have allowed establishment of industries along the coastline, which also led to excessive groundwater extraction.

Severly eroded coastline in Demak, Central Java, Indonesia (Source Wetlands International)

Without its mangrove forest, coupled with unsustainable coastal infrastructure planning and excessive groundwater extraction, Demak thus suffers from:

- **Land subsidence and severe erosion**, which make rice culture no longer possible and fisheries have become marginal bringing major economic losses to the two pillars of the regional economy.
- **Salt water intrusion**, which penetrates much further land-inwards than in former times.
- **Industrial pollution influx** can limit the ecosystem's ability to serve its function as shrimps and fish breeding ground. However, mangroves are quite resistant to most forms of environmental pollution, and therefore should not impede mangroves growth and recovery.
- **Catastrophic flooding**, which occurs during high tides, storm surges and periods of excessive rainfall. More than 3 km of land have already been swallowed by the sea including entire villages (Wetlands 2016).
- The changing climate has resulted in **sea level rise that is projected to cause flooding up to 6 km inland by 2100** (Wetlands 2016). More than 14,000 hectares of land will be inundated and 6000 hectares of aquaculture ponds will be lost, affecting over 70,000 people (Ibid.).

Flooded house in a village in Demak. (Source. Boskalis)

Objective Of The "Large-Scale Building With Nature" Project

"Building with Nature" is a project initiated by Ecoshape, a consortium of private parties, government organizations, NGOs and research institutes. A small-scale pilot was initiated in Demak, in 2013. Following its success, Ecoshape consortium and their Indonesian partners agreed, in 2015, on a new five-year cooperative venture to improve coastal safety around Demak to restore 20km of coastline and increase aquaculture production. The project envisions a safe delta coastline in Northern Java, particularly Demak. It aims to enable vulnerable communities and economic sectors to prosper, to be more self-reliant and resilient against hazards. The initiative is expected to enhance coastal security for about 70,000 vulnerable people and to avoid further coastal flooding and erosion in Central Java. Furthermore, "Building with Nature" also provides these people with a long-term perspective for sustainable economic development.

Building with Nature intends to manifest an integrated coastal zone management approach that provides resilience by combining smart engineering and ecological rehabilitation, while introducing a sustainable land use practice. The project is characterized by the use of services that nature provides as an integral part of the design of hydraulic infrastructure. And thereby, offering an alternative to conventional hard-infrastructure approaches to coastal security. Instead of fighting nature with dams and dikes, Building with Nature solutions work with and along the dynamics of nature. It provides benefits for nature and society – such as adaptation to climate change, flood prevention, biodiversity conservation, food supply and carbon sequestration.

Major Activities

During the small-scale implementation, in 2013, the project constructed three permeable grids, encompassing a few hundred meters of permeable wooden dams, that catch fine sediment and therewith facilitate the restoration of mangroves. Despite providing benefits to socio and economic component of the Demak's communities, this pilot was focused mainly on the potential of hybrid engineering approach. The combination of a green (mangrove) measure and grey measure (hard structures or permeable dams depending on the setting) have proven its success which then initiated the implementation of a "Large-scale Building with Nature" in 2015.

The "Large-scale Building with Nature" project applies the following three-pronged approaches:

1. Reclaiming the land and restoring the mangrove belt. The pilot applies an innovative approach in addressing coastal and water management challenges, based on the presumption that coastal safety will be regained if the mangrove greenbelt is restored. In the rural area, the pilot started with the construction of a new series of permeable structures (permeable dams), mud-nourishment and agitation dredging along with mangrove rehabilitation. Permeable dams replicate the structure of mangrove root systems. It was undertaken to reclaim the land and restore the fine sediment balance, thereby recreating a stable environment for mangrove forest recovery. Its principle is to work with and along the sea currents, river flows and waves rather than fighting against these natural processes. In this sense, the pilot also introduces Integrated Water Management Planning, river restoration, and demonstration activities that offer an alternative to the deep ground water extraction which is currently causing land subsidence. Meanwhile, in urban areas where there is little space, hard engineering techniques are strengthened by mangrove belt, thus, diminishing the maintenance costs while increasing value, e.g. for recreation.

2. Climate smart and productive land-use. The project area was previously a prosperous district, however with the collapse of the prawn farming so too did the economy of the community. Therefore, the project has focused on boosting the economic situation by promoting a Bio-Rights[1] approach, which was successfully implemented in other areas in Indonesia. In this case, the project is introducing

[1] Bio-Rights is a financial incentive mechanism that reconciles economic productivity with environmental conservation and restoration by providing conditional support to local communities.

sustainable aquaculture in the abandoned ponds, which can co-exist with a healthy mangrove forest. It is done in a way that allows space both for the mangroves and for the ponds, and with techniques that use less chemicals, increase yields, and prevent soil subsidence and hydrological disturbance. This substantially enhances shrimp production and the near shore fisheries, the two important industries for local economic growth. Part of the extra income will finance coastal safety measures, which in turn will ensure the future sustainability of these activities.

3. Securing the long-term maintenance of the mangrove belts. To ensure the sustainability of the "Building with Nature" initiative, and to enable replication in other areas, training and embedding the approach in policy and planning are crucial elements. The project supports integral solutions for improved coastal zone management by contributing to the development of a district level Master Plan, together with communities, government, private sector and civil society. This plan will address the root causes of coastal vulnerability, sustainable land use and finance options that together ensure the long-term maintenance of a stable coastline and its ecosystem services.

Expected Results and Impacts Achieved

Small Scale Pilot Project (2013)

The small-scale pilot project resulted in inducing a net sedimentation rate of about 0.5m within 12 months, with some early mangrove colonization at specific locations. From the hydro-sedimentological point of view, the project is deemed highly successful in keeping the sediment behind the dam, where mangrove trees can grow again. With such a success, the large-scale project embracing other villages in the area, which hinterland aquaculture has been destroyed over the past five years was initiated in 2015. Lessons learned, from the small-scale project are addressed in the concept of the large-scale one, such as:

- the devastating effects of shipworm, destabilizing the permeable dams,
- lack of sediment supply and increasing wave exposure are hampering mangrove recovery and functioning,
- lack of hydrological connectivity, due to construction of bunds, channelization and degraded tidal creek, will limit the ability for mangrove recovery, as well as
- availability of space for recovery due to the dense aquaculture activities in the pilot area.

Furthermore, socio-economic co-benefits have become one of the main focuses of the project.

Permeable dams (Source. Wetlands International)

Large-Scale Building with Nature (2015-2020)

The "Building with Nature" project design aimed at five results, associated with various expected impacts, comprising:

- **Design and Engineering Plan**: As a first step, following the pilot in 2013, a Design and Engineering plan of the large-scale demonstration project was published in 2015. This plan provided concepts, reasoning, design and practicalities for the timely implementation of Building with Nature measures in Demak. The plan also addressed limitations and risks that faced during the small-scale implementation. They are accounted for and to be resolved in an adaptive approach, for example by restoring hydrological system and applying Bio-Right approach which include the implementation of innovative systems of aquaculture as well as improving water management system.
- **Implementation of a large-scale flagship project in the severely eroding setting of Demak**: The project will re-establish coastal security and support sustainable revitalization of 6000 ha of aquaculture ponds along a 20km shoreline. In 2015, 1.9km of permeable structures were built, of which 0.9km by the project and 1km by the Ministry of Marine Affairs and Fisheries (MMAF). Monitoring showed up to 50cm of sedimentation behind some of the structures and mangrove seedlings are emerging naturally. If the grids stay in place, a small mangrove forest can within a few years take over to reduce wave intensity and keep the sediments in place. Recently, another 0.8km was

constructed. To speed up the process, the project applied mud nourishment. Furthermore, the restoration of the mangrove belt is expected to enhance protection against natural hazards, protect arable land from erosion, revive fisheries and (non-timber) forest products, improve water filtration and enhance carbon storage.

- **Contribution to Demak Coastal Masterplan**: Building with Nature measures in Demak will be embedded in the community development plans, in a district level master plan and in provincial development plans. The project sets the scene by providing a useful framework for better coastal management. As a result, a new draft spatial plan for Demak encouragingly shows a greenbelt zone along the coastline, although its exact location and width is not yet clear. Several aquaculture ponds located on the sea front will need to be converted back into mangrove for coastal safety. Compensation of the loss of ponds will occur through the revitalizing of aquaculture in the hinterland.
- **Capacity building and knowledge transfer**: In May 2016, twenty-five fish farmers completed their season-long Training of Trainers (ToT) on the revitalizing of the aquaculture productivity. They adopted critical adaptive thinking to develop, test and implement best practices, such as producing farm inputs locally to reduce costs in an ecologically sound way. The trained villagers are passing on their insights in new training sessions in 5 other villages. Additionally, the initiative is developing a series of technical and practical guidelines as stakeholders are eager to replicate the approach. The guidelines cover issues such as: 'permeable structures' to trap sediment for mangroves to recover, system understanding, community planning, fish pond rehabilitation, mud nourishment and ecological mangrove rehabilitation (EMR).

Natural mangrove regeneration behind the permeable structure. (Source: Wetlands International)

"Learning by Doing" – The community is trained to construct the permeable dams. (Source: Wetlands International)

Lessons Learned

Shifting paradigm from fighting nature to work with nature

Until recently, sea walls, dykes and other kinds of hard measures, have been placed in front of coasts to halt erosion. Such solutions may work in some areas, but it could also be ineffective in others, for example on muddy mangrove coasts. Having understood the nature of Demak coast, installation of hard measures could disturb the balance of incoming and outgoing sediment, and thus likely to cause further erosion. "Building with Nature" promotes sustainable coastal engineering approaches that make use of the natural protection provided by ecosystems such as mangroves. It represents the transition of conventional infrastructure designs that typically fight against nature, towards solutions that work with and alongside nature. The approach also offers an inclusive coastal zone management approach that is based on in-depth understanding of the functioning of the wider coastal system. Based on the systems understanding, it is believed that "restoring the eroding tropical mud coasts requires revival of a healthy mangrove belt", which are more often cost-effective, while bringing in more prosperity to the local economy such as through enhanced fisheries and carbon storage.

Applying Systems Thinking and Interdisciplinary Partnership

The permeable structures technique applied in this project is already used by the Dutch for salt marsh restoration for 100 years. The first question that may rise would be, could it be applicable in Indonesia, specifically Demak? Or any other place in the world? As highlighted earlier, before applying any specific adaptation option it is important for one to understand the nature of the area. Adaptation to climate change is very localized, and therefore, exact

Building with Nature require high community involvement to determine its success. (Source: Wetlands International)

technical methodologies are highly site-specific. It must be tailored to fit the social and ecological situation of the area. In the "Building with Nature" initiative, an expert team needs to initially develop a good understanding of the specific ecological and hydrological system based on a system thinking approach. To do so, interdisciplinary partnership is key. The Building with Nature team consists of ecologists, engineers, physical geographers, aquaculture experts. Moreover, support from national and regional governments and cooperation of local residents is indispensable.

Mixture of engineering and nature based approach

In the case of Demak, brushwood structures are used to dampen the incoming waves, creating a sheltered area behind them where mud is trapped, so mangroves can regenerate and avoid further erosion. Different materials and techniques are tested and used, depending on the circumstances of the specific site. The tests will help improve the lifetime and robustness of the technique for further upscaling of the concept in Demak and in other erosion affected areas in Java.

Bio-Rights agreement for compensation

Based on an agreement among relevant stakeholders upon the initiation of a Bio-rights and after the formulation of a full project plan, Bio-rights implementation starts with the provision of micro-credits to local community groups. The funds can be used for the development of all kinds of ecologically, socially and economically sustainable activities as alternatives to harmful practices that pose a threat to the environment (Wetlands International 2009). Upon termination of a contractual period and in return for active engagement, the micro-credits can be converted into definitive payments, providing the conservation activities prove successful. In the case of Demak this translates into coastal safety measures and sustainable aquaculture.

The approach covers the costs communities face to change their current unsustainable practice into long-term sustainable livelihood strategies, motivating them to take a long-term interest in their conservation work. Legal contractual agreements were set up with community groups and witnessed by the village government, ensuring a greater group cohesion and responsibility in implementing the agreement. As such increasing the project implementation efficiency, contributing to the project sustainability and reducing overhead costs. In the context of "Building with Nature" in Demak, the communities were eager to cooperate, however level of success is still yet to be measured.

Plant or not to plant

Despite still being very popular, planting efforts are largely failing across the globe. As planting is often done in the wrong places where mangroves do not grow naturally, or are simply unnecessary. Furthermore, mangrove restoration requires a proper risk assessment and consultation with experts. There is a common belief that there is no harm done by planting mangroves, which unfortunately is not true. For example, single species planting creates monocultures that are not resilient to storms and surges. Also, thin mangrove belts are not perceived as a safe solution against any hazard. There is a need to have a better understanding regarding the selection of appropriate methodologies for mangrove restoration through critical systems thinking, and adjusting it to the specific location. The "Building with Nature" initiative" applied Ecological Mangrove Rehabilitation (EMR) principles to create the right biophysical and socio-economic conditions for mangroves to grow back naturally. There is no planting involved. This way EMR promotes natural zonation and optimal species to site matching. In addition, it delivers fast growth of the forest and high survival rates and if implemented at scale it is a very cost-effective method.

Adaptive Management

Building with Nature is a no-regret approach as the interventions are reversible, allowing a learning-by-doing strategy. The project is therefore flexible and adaptive and is updated frequently with lessons learnt that are widely shared to support sound replication of the approach.

Potential for Scale Up and Replication

The initiative is the leading international case of the "Building with Nature Innovation Program"[2] . The project partners aim to replicate and scale up "Building with Nature" approach to other vulnerable muddy coastlines in the world, not necessarily related to Wetlands International project. Replication will be supported by mobilizing existing knowledge institutes to provide training on a broad range of "Building with Nature" measures applicable in a wide range of settings. A help desk facility will be set up to provide on-the-job guidance on all aspects of the project life cycle. The demonstration project in Demak, and lessons learned from Building with Nature projects around the world will be introduced into international policy dialogues on climate change, disaster risk reduction and biodiversity, inspiring national governments to integrate the approach in their plans for adaptation and development.

BIBLIOGRAPHY

- Boskalis. *Building with Nature in Indonesia*. 2016. https://boskalis.com/csr/cases/building-with-nature-in-indonesia.html (accessed March 09, 2017).
- Building with Nature Indonesia. *Newsflash 2016*. December 14, 2016. https://buildingwithnatureindonesia.exposure.co/building-with-nature-indonesia (accessed March 06, 2017).
- Eco Shape. *Building with Nature Indonesia; Securing Eroding Delta Coastline*. Eco Shape, 2015.
- IADC. "International Association of Dredging Companies." B*uilding with Nature: Sustainable Protection of Mangrove Coast*. September 2016. http://www.iadc-dredging.com/ul/cms/terraetaqua/document/4/9/7/497/497/1/terra-et-aqua-144-complete.pdf (accessed March 06, 2017).
- NWP. "*Using the Power of Nature*." 2016. https://www.nwp.nl/sites/default/files/2016magazine_indonesia_webversion2.pdf (accessed March 09, 2017).
- Wetlands International. *Like Music to My Ears* (with Hydraulic Engineers). September 27, 2016. https://www.wetlands.org/blog/as-music-in-my-ears-with-hydraulic-engineers/ (accessed March 2017, 08).
- Wetlands International, T*o Plant or Not to Plant? Stopping Malpractices in Using Mangroves to Increase Coastal Resilience*. July 25, 2016. https://www.wetlands.org/blog/to-plant-or-not-to-plant/ (accessed March 08, 2017).
- Wetlands International. b. *New Series of Mangrove Restorarion Wokrs on Eroded Coast in Java*. October 24, 2016. https://www.wetlands.org/news/new-series-of-mangrove-restoration-works-eroded-coast-java/ (accessed March 06, 2017).
- Wetlands International.a. *Building with Nature*. April 11, 2016. https://www.wetlands.org/casestudy/building-with-nature-indonesia/ (accessed March 09, 2017).

[2] The Bulding with Nature Innovation Programme is a public-private partnership (PPP) that is coordinated by Ecoshape. It explores inclusive engineering approaches to promote sustainable coastal development in the Netherlands and abroad.