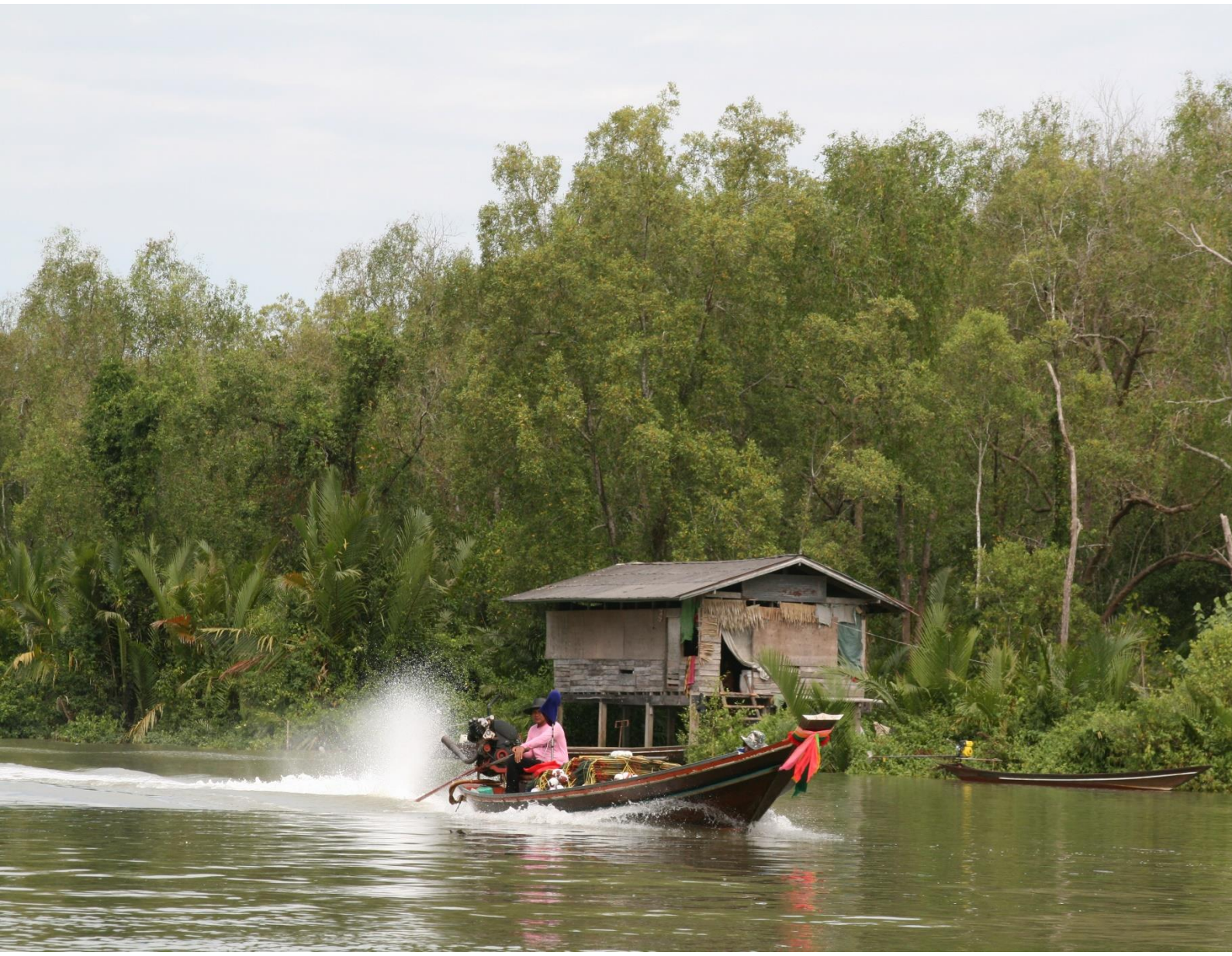

Options for mangrove-friendly alternative livelihoods in the mangrove ecosystem

(Opsi Mata Pencaharian Alternatif di Ekosistem Mangrove yang Ramah Linggunkan

Author(s): Adolphe O. Debrot[1], Sri Rejeki[2], Rudhi Pribadi[2] and M. Nazrul Islam[3]

Wageningen University &
Research report C075/22

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Contents

1 Abstract

In the context of developing bio-economies, tropical mangrove forests provide many options for sustainable livelihoods based on their many non-timber forest products such as fish, shellfish and many plant-based forest products. Integrating human livelihood needs into mangrove ecosystem conservation is of foremost importance for long-term sustainability of mangrove forests. However, because of their complicating biological characteristics, the development of such forest product resources for sustainable livelihoods has long been neglected. In this report we briefly discussed a number of promising options for mangrove-compatible livelihoods based on recent examples and highlight a few of the most critical requirements for their successful development.

2 Introduction

In the last decades efforts are being undertaken around the world to restore mangroves because of their many functions and uses. They are one of the world's most productive forest types which among others provide food, timber, charcoal, materials for local art and handicrafts and opportunities for ecotourism development, guard against sea level rise and sequester and store vast amounts of atmospheric carbon (Armitage 2002). In addition, they provide coastal protection, fulfil essential ecological functions such as that of entrapping pollutants, nutrients and sediments and provide nursery and spawning habitat for many important coastal fish species (Nagelkerken et al. 2008, Kimirei et al. 2013, Hutchison et al. 2014). The many functions they fulfil of importance to ecosystems and to man (Figure 1) can be divided into four basic types:

- Supporting functions, such as soil conservation and the fish nursery function,
- Regulating functions such as climate regulation and flood protection,
- Provisioning functions such as food, fresh water and materials
- Cultural functions such as recreation and esthetics.

Because of these many values, healthy mangroves contribute much more to the sustained economic well-being of tropical coastal regions than practically any other type of largescale land use, whether it be traditional agriculture (like rice) or aquaculture (like shrimp). The main current economic values of mangroves are in terms of protection of the coastline, property and infrastructure, and in terms of coastal fisheries production.

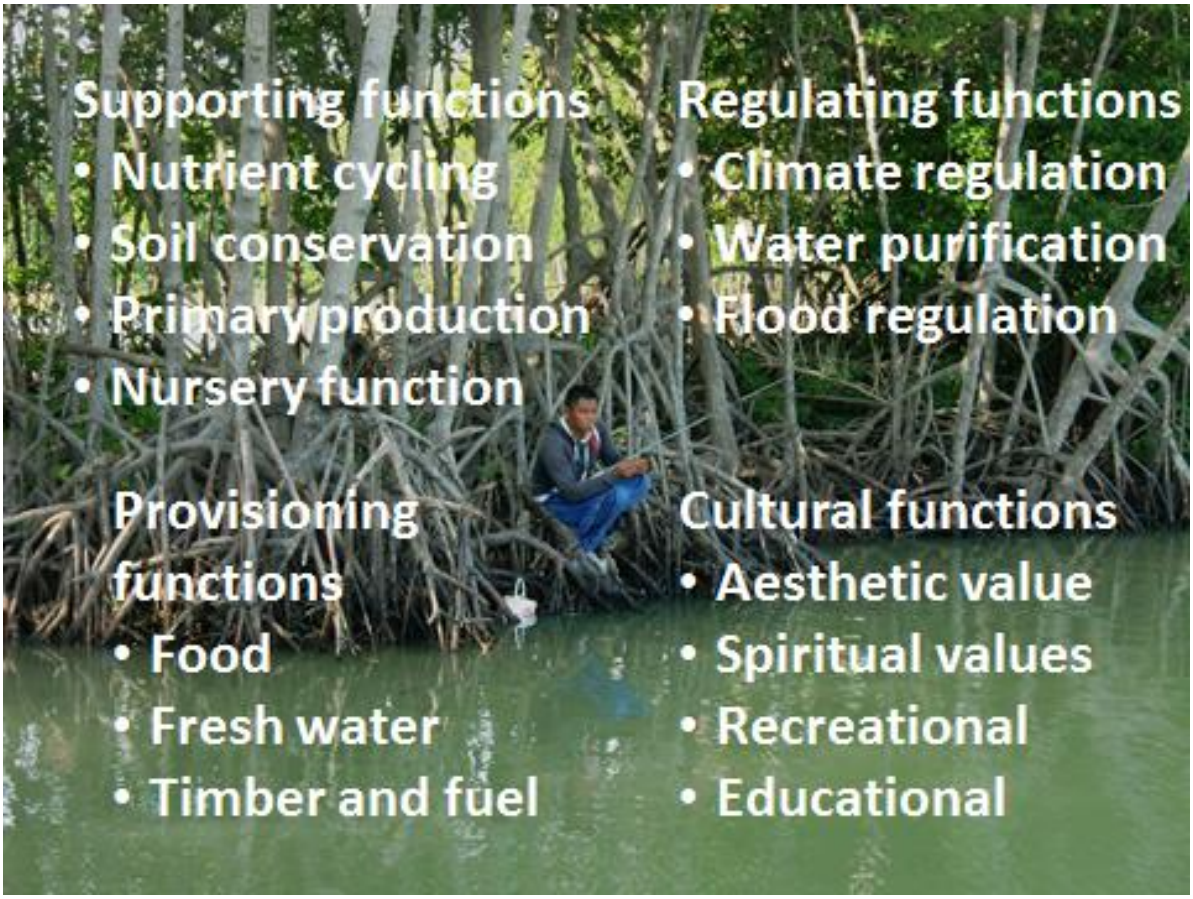

Figure 1. *Overview of important ecosystem services provided by mangroves (Photo: A.O. Debrot).*

Even though the value of mangroves is widely appreciated, more than 35% of the mangroves were lost worldwide during the 1980s and 1990s alone (Romañach et al. 2018). The greatest losses have occurred in Southeast Asia and the key driver of loss was the expansion of agriculture, aquaculture and urban use (Thomas et al. 2017). Indonesia has lost about 40% of its mangroves since the 1980s (FAO 2007) but total losses for Java are now around 70% (Ilman et al. 2016). This represents a great reduction in coastal safety and fisheries production and the urgency to restore the mangroves is high. According to Ilman et al. (2016) aquaculture, followed by palm oil plantations will continue as the main driver of mangrove destruction in Indonesia for the next two decades. Because shrimp pond productivity declines within years once in use, farmers are forced to continue to clear more mangroves to construct new shrimp ponds.

In order to halt and reverse this destructive trend, it is essential to recognize the high value of mangroves to coastal communities, to transform current unsustainable aquaculture practices into sustainable practices and to develop mangrove-compatible alternative livelihoods that do not depend on the unsustainable removal of mangroves. The development of mangrove-compatible livelihood options is especially important simply because, at the end of the day, the people living in mangrove areas need to make a living. However, the commercial development of such sustainable mangrove livelihood options has greatly been neglected (Debrot et al. 2020). The result of such neglect are that local communities often have no choice other than to continue with unsustainable practices that lead to the ultimate destruction of both mangroves and livelihoods.

Recognizing, allowing, developing and properly valuing alternative livelihood options is key to mangrove rehabilitation success. Tapping into the economic potential of mangroves can also serve to diversify livelihoods which is an important strategy used elsewhere to boost socio-economic resilience in rural areas (Wu et al. 2014).

Therefore, the goal of this essay is to briefly highlight some of the many possibilities for mangrove-compatible livelihood options for coastal communities. Also, we aim to highlight a few of the challenges that need to be addressed in order for these to successfully develop and sustain these options. Examples of options for the sustainable use of the economic riches of mangrove forest are presented from both Indonesia and other areas in the world.

3 Fisheries

Fish, shrimp, crabs and shellfish like oysters and mussels are among the most valuable renewable products that support livelihoods on mangrove coastlines. They are also very good quality protein sources for healthy nutrition and often depend on mangroves during their early life stages. For instance, Kimani et al. (1996) found that 63% of the fishes associated with mangroves were juveniles, while 44% were species typically associated with coral reefs. All three most important species for the coastal fisheries of Kenya are mangrove dependent (Hicks & McClanahan 2012) while in Malaysia the Grey eel-catfish (Sembilang), the most important species in the coastal commercial landings (21% of total landings) of the west coast, depends on mangrove estuaries during its young life stages (Leh et al. 2012). For these reasons, productive coastal fisheries along tropical coasts depend on protecting and restoring mangrove areas to fulfill the critical nursery function (Figure 2).

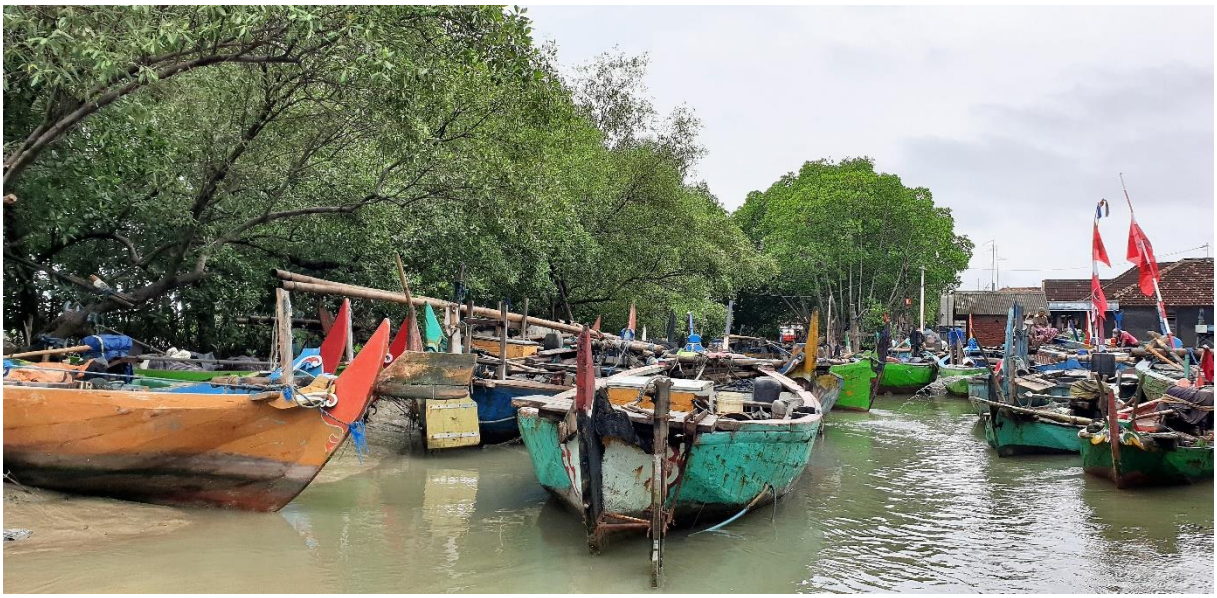

Figure 2. *The coastal fishing fleet of Surodadi, Demak, Java. Most fishing takes place off-shore at some distance from mangroves but catches still intimately depend on the nursery role of mangroves (Photo: Y. R. Noor).*

In addition, mangroves also export food in the form of leaf litter and nutrients to coastal waters, making them of great importance for coastal productivity. Without a source of juveniles and food for growth of fish and shrimp, areas that have lost their mangroves also typically lose their fisheries. The importance of mangroves to coastal fisheries has been demonstrated in several areas such as for India, where mangroves were found to contribute 1.86 tons of coastal fish catch per ha/year (Anneboina & Kumar 2017), and for Thailand where fishery yields benefit from mangrove forests at a minimum of US$ 253.4 per ha/year (Barbier 2003). Das (2017) calculated the value of mangroves for offshore Gujarat prawn fisheries (in 2013-2014 prices) at a minimum of US$ 7002 per ha/year, while for the Philippines replanted mangroves benefit local incomes by US$ 564–2316 per ha/year (Walton et al. 2006). Even without counting the value of all the other economic benefits of mangroves, based on fisheries alone, it is already wise to protect and restore mangroves. Mangrove restoration has been shown in several studies to restore fish populations and the commercially very valuable mud crab population (Ulfa et al. 2016, Debrot et al. 2022). Studies show that fishermen that fish in the shallow seas off the coast often do not understand the important role of mangroves in making their catch possible and are less willing to support mangrove restoration (Walton et al. 2006). Therefore, awareness programs are essential in order for everyone from farmers, to fishermen to fully understand the value of these important forests in order for them to support mangrove restoration efforts. Needless to say, for fisheries to benefit the best from mangroves it is essential that the fisheries are managed to prevent overfishing (Figure 3). Fishes need to grow to adulthood in sufficient numbers to reproduce in order for a fishery to be able to sustain itself (Debrot et al. 2022).

Figure 3. *Left: oysters harvested in a morning from the mangroves of Surodadi, Demak, Java. Shellfish can't swim away which makes them especially vulnerable to overharvest. Right: mangrove-dependent barramundi (Kakap-puthi) caught in a mangrove-restoration area at Timbulsloko, Java. In both cases, management regulations to prevent overharvest is critical (Photos: A.O. Debrot).*

4 Mussel culture

The green mussel, *Perna viridis,* is an excellent source of protein, fat and carbohydrates (Chakraborty et al. 2016), and has long been cultured at a subsistence scale in Indonesia. It is a popular source of food throughout South-East Asia. Because it reproduces year-round, does not need supplemental food input, is ready for harvest in about six months (Litasari 2002) and requires no mangrove removal for pond construction, it is very promising as a sustainable seafood product on erosion-sensitive mangrove coasts (Litasari 2002), as long as its culture can be made profitable. Mussel culture does not require complex or sophisticated techniques, knowledge or equipment, making it ideal for small-scale artisanal use (Bin Sallih 2005). While mussel culture has greatly advanced and grown in importance in many areas of Asia, in Indonesia its use lags far behind (Lymer et al. 2010) and with few exceptions (e.g., Noor et al. 2019), innovation has largely stagnated (Lovatelli 1988).

To help facilitate the use of the potential that mussels represent to coastal communities, Rejeki et al. (2020) studied and developed new methods that allow profitable mussel culture using long-lines. The use of longlines is a simple, low-cost and easily adopted source of income for households in areas where other means of income generation have been lost or are limited. Also, longlines are a mangrove-friendly alternative livelihood and can be placed alongside mangrove channels, in lagoons, inside abandoned ponds and in shallow marine areas seawards mangrove forests without any need to cut mangroves or excavate ponds. Thanks to that work, in Indonesia, mussel culture can serve as an economic incentive to preserve mangroves so the latter can be left intact to fulfil their many other important ecosystem functions (Romañach et al. 2018). Mussel culture is a fully gender-compatible source of supplemental income and can easily and safely be conducted by women and children to provide food for the table (Kripa & Surendranathan 2008, Mohamed 2015, Rajagopal et al. 2006, Tan & Ransangan 2016, Vipinkumar et al. 2015). Additional research towards methods of scaling up production, improved site selection and greater efficiency in the market value chain (e.g., Bin Sallih 2005) is advised to further icrease green mussel culture profitability, and thereby make it even more effective as a commercially viable livelihood option for mangrove communities

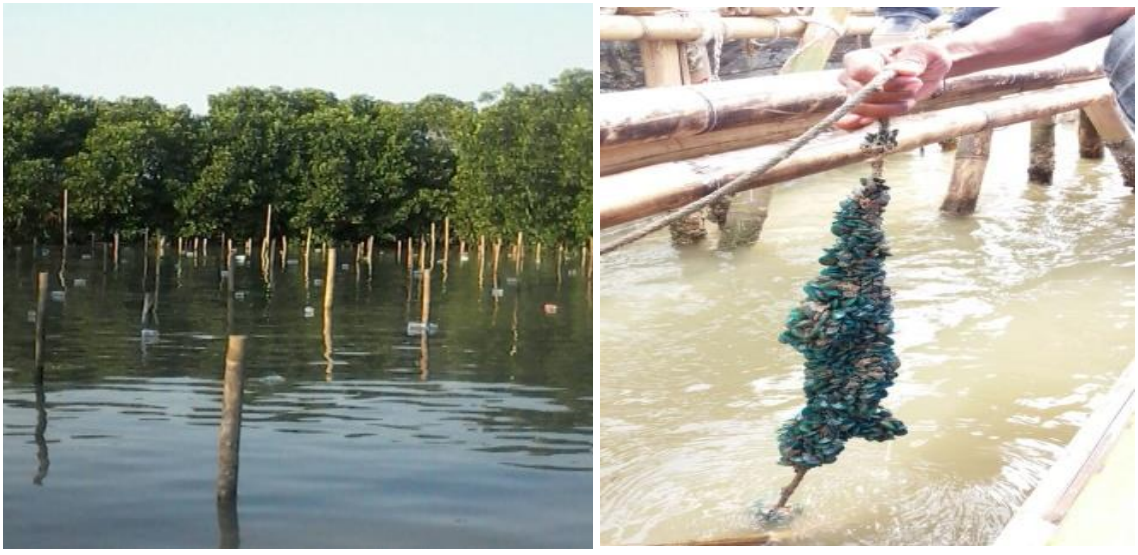

Figure 4. *Left: green mussel culture on bamboo poles in an abandoned broken dyke pond in Kaliwlingi village, Brebes, Java. Right: spat collected on a longline collector (Photo: Sri Rejeki).*

5 Agroforestry-related options

There is a growing body of solid research that shows the potential of agroforestry for increasing or maintaining system economic productivity while protecting natural resources and environmental services at the same time. Hence agroforestry is a key tool for "sustainable economic intensification" (Muschler 2016) and this is also the case for mangrove forest systems. Agroforestry can be defined as "the intentional integration of trees and shrubs into crop and animal farming systems to create environmental, economic, and social benefits" (Muschler 2016). The concept originated in the 1970 but the practice in which trees, crops, and animals are combined is ancient and much older than the idea of monoculture. In agroforestry, trees or woody shrubs are combined into production systems with annual or perennial crops, grazing animals, or non-grazing animals like bees, fish or shrimp (Muschler 2016). A few examples follow.

Associated Mangrove Aquaculture (AMA)

In the beginning of the 21st century over 2 million people were working in the aquaculture sector in Indonesia alone. However, intensive aquaculture ponds lose profitability after a few years due to environmental degradation (Avnimelech 2006, Primavera 2006). This leads to a collapse of aquaculture productivity as well as damage to agricultural crops further inland (Marfai 2011, Primavera 1998). Mangrove trees play a critical role in maintaining ecosystem integrity and their reintroduction into the aquaculture system can help heal the damage done as long as there are sufficient mangrove areas left (Figure 5). Therefore, use of monoculture production systems, such as the common fish or shrimp pond culture, should be limited in surficial extent. Recent research suggests that such mono-culture systems should be limited to less than 25% of total land surface area to be sustainable. Different studies show how mangroves can even provide many benefits to the pond culture of fish and shrimp (Rahman et al. 2020, Alam et al. 2021, 2022). The mangroves are used to manage pond water quality and by associating mangroves to pond aquaculture can be a promising alternative for full pond reversion to mangrove (Primavera et al. 2014). In the AMA being developed, the mangroves stand outside the culture pond and along the banks of the connecting waterways.

Ideally in AMA, all waterways would at both sides have a band of at least 20m of mangrove. However, before farmers can give up part of their ponds, the benefit of aquaculture needs to increase. The project assisted about 150 fish farmers in Demak regency to restore part of their pond, along the waterways, into mangrove. For Indonesia this is a new type of silvi-aquaculture. In the past, farmers were stimulated (by others) to plant *Rhizophora mucronata* mangroves on the pond bunds. The latter has not helped aquaculture production significantly and has also not appreciably contributed to coastal protection or biodiversity. The new type of AMA offers more ecosystem services and opportunities to manage pond water quality (Bosma et al. 2020). By means of Low External Input Sustainable Aquaculture (LEISA), farmer's benefits can be multiplied by 300% in a sustainable way (Ariyati et al. 2019). These improvements create livelihood incentives and make it financially interesting to apply AMA, that will also even increase fish production for the coastal fisheries.

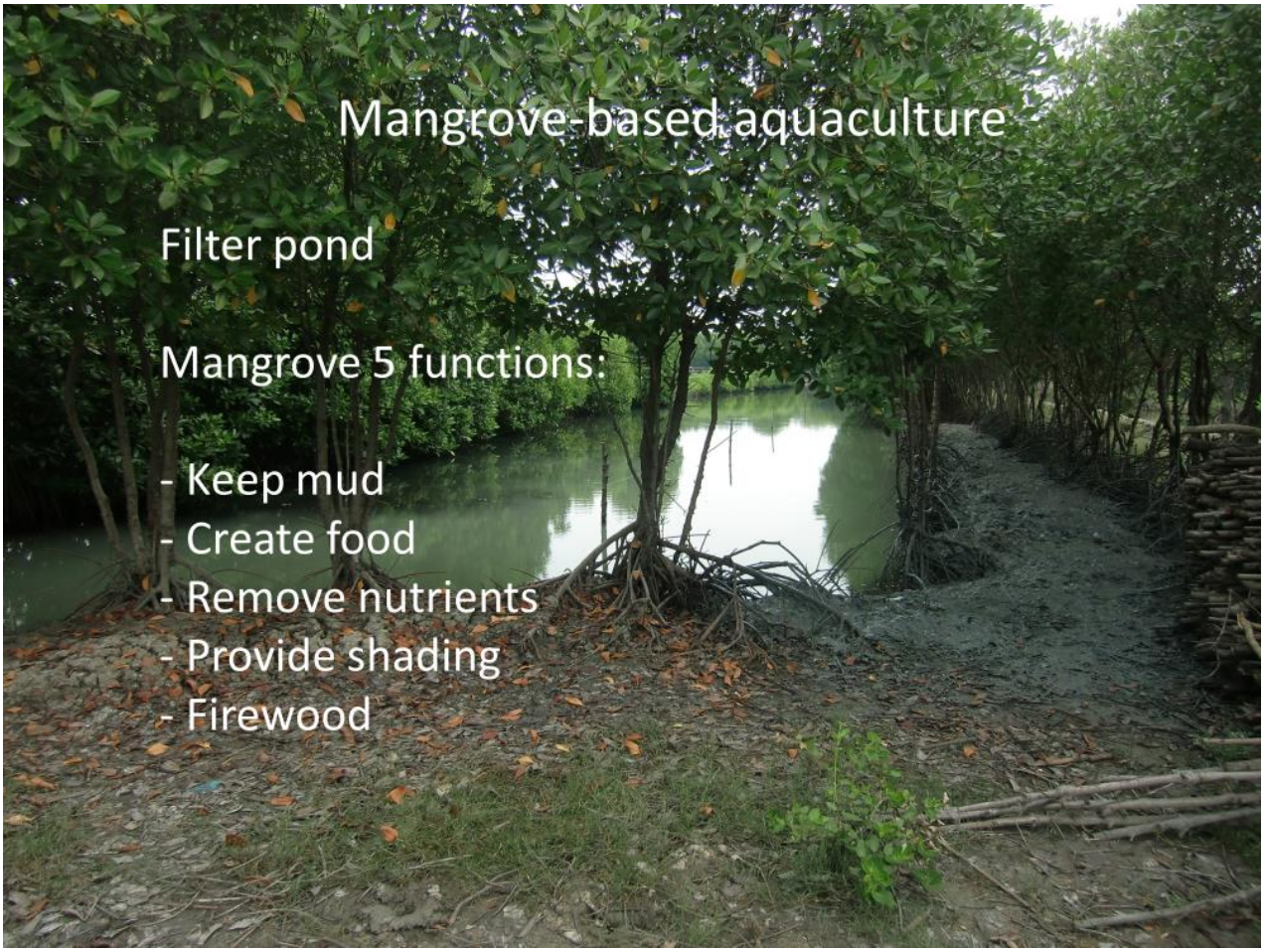

Figure 5. *Overview of stated benefits from Mixed Mangrove Aquaculture as practiced by Pak Abdullah Ahsin of Purworedjo, Demak, Java (Photo: A. Debrot).*

Plant-based Non-Timber Mangrove Forest Products

Mangrove plant materials have been used since time immemorial for many purposes. These include fuelwood, wooden poles, Nipa palm (*Nypa fruticans*) materials, vegetables, fish, and plants with medicinal properties (Feurer et al. 2018). Debrot et al. (2020) provide an extensive listing of 409 sustainable non-wood uses for 203 Asia-Pacific mangrove forest plants. Of these, 117 were food-related uses; 33 livestock and fish feed uses; 126 were domestic uses for crafts, as materials (including dyes and resins) or as ornamental plants; and 133 were medicinal uses. In Indonesia, more than 100 traditional uses have been documented from 39 mangrove and mangrove-associated species. Human food uses along with many recipes are provided by Priono et al. (2010). However, practically all uses remain at local subsistence levels (Kusmana 2018, Islam et al. 2020). Scalable commercialization of mangrove products is dearly needed for these to serve as true livelihood options. Simard et al. (2019) discuss the challenges and opportunities for livelihood development from artisanal handicrafts based on mollusc shells, which also abound in the mangrove habitat. In light of the global trends towards bio-economy, today mangrove products represent a major business opportunity for forest communities to produce high value-added end-user products. Notwithstanding considerable preliminary work on recipes and product development (Figure 6), creating sustainable economic activities in mangrove systems through market and product development (e.g., Islam et al. 2021) is really needed before it will be possible to tap into the many economic riches made possible by the mangrove forest (Tamrin et al. 2018).

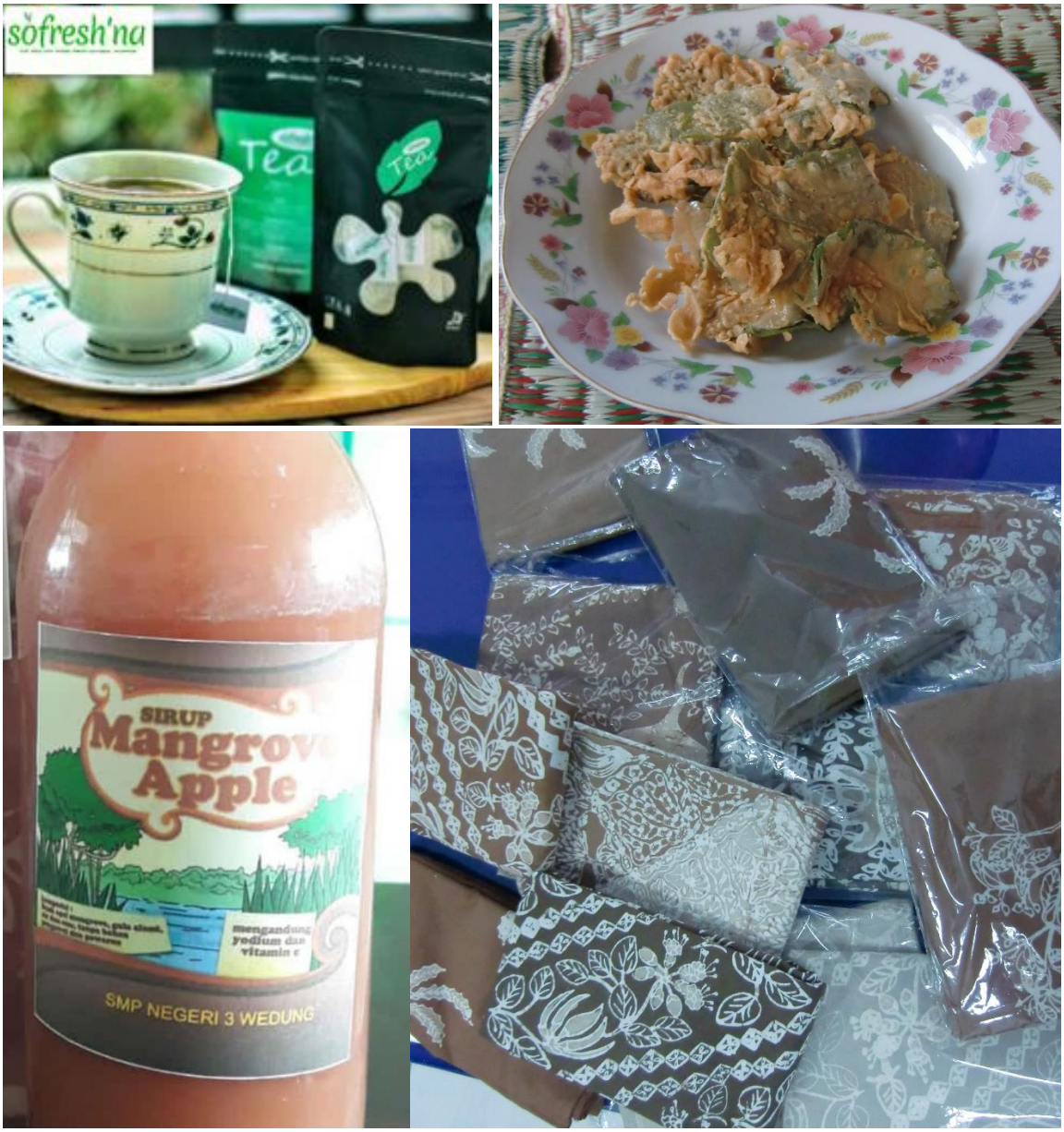

Figure 6. *Examples of high quality, added-value consumer end products produced at the village level. Clockwise from top left: herbal tea, delectable mangrove leaf chips, batik fashion fabrics, mangrove apple juice (Photos: E. Damastuti, A.O. Debrot and Y.R. Noor).*

Mangrove Apiculture (Beekeeping)

Mangrove apiculture is one of the many income and food provisioning services provided by vegetation. In several areas of the tropics, awareness of this value provides additional economic incentive for communities to preserve forest habitat as a source of nectar for bees (e.g., Sande et al. 2009, Baines and Whittaker 2016). Beekeeping yields several high-value products including honey, beeswax, royal jelly, bee pollen and propolis. Mangrove vegetation is also a valuable source of nectar for bees and several recent initiatives link apiculture with mangrove conservation as a way to provide alternative livelihoods for coastal villages and as an economic incentive to protect and/or restore mangrove forests. Bees kept in mangrove areas visit a large number of trees bushes and herbs including the mangrove trees themselves (Barth and Pinto Da Luz 1998, Upadhyay et al. 2014). In Indonesia the potential for apiculture has so far been little utilized, largely because of prejudices against bees and beekeeping (Gratzer et al. 2019). For Central Java additional challenges to beekeeping include a possible shortage of bee forage, capital, technical extension support and technical training. However, bee products are highly suitable to specialty products markets and with proper support can contribute to sustainable livelihoods for mangrove areas.

Sustainable fuel and fodder for goats and sheep

In many areas mangroves have been destroyed by excessive cutting for wood and fuel. However, research in Bangladesh shows that sustainable fuelwood production in mangrove forests is possible as long as principal branches are not harvested. By harvesting only small, non-essential branches (as in Figure 7), such firewood production can already recover the costs for mangrove reforestation (Chow 2015).

Figure 7. *Sustainable fuelwood from mangroves. Left: Purworedjo; right: Timbulsloko, Demak, Java (Photos: A.O. Debrot).*

The mangrove habitat is hot, muddy and salty which presents important challenges for the production of meat from typical large ruminants: they can sink into the mud, damage pond dikes with their hooves and are generally not adapted to high salt contents in the forage and/or water. Exceptions are some sheep and goat races that are well-adapted to high salt levels in the fodder (Dunson 1974). Many mangrove forest plants are good as fodder for such smaller ruminants which are often kept penned (Figure 8).

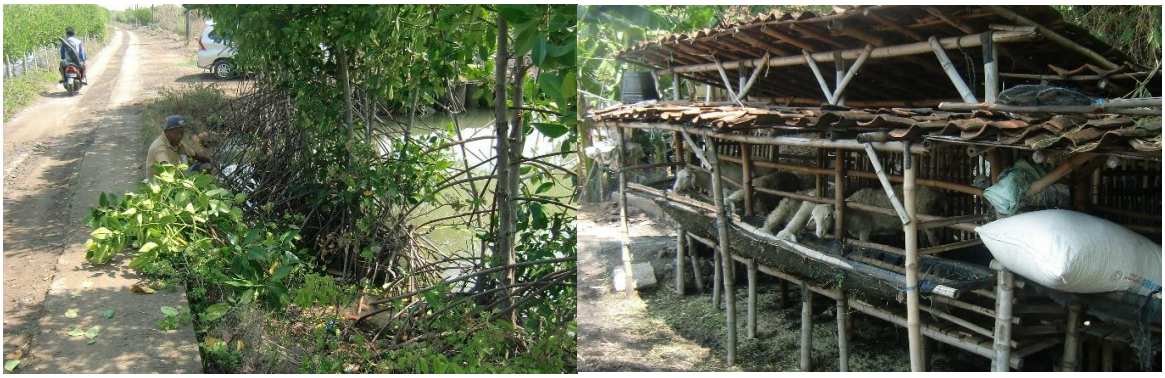

Figure 8. *Left: collecting Rhizophora mucronata fodder for goats, Timbulsloko. Right: penned sheep, a common way of keeping livestock in the coastal areas of Surodadi, Demak, Java (Photos: A.O. Debrot).*

Mangrove tourism

A great example of a successful community-based mangrove tourism project as a source of alternative livelihoods in a mangrove area comes from Kaliwlingi village in Brebes district (Fig. 9). The village has suffered much from coastal abrasion such that many shrimp ponds have been lost and shrimp and fish culture are no longer feasible. This has made it necessary for the village to seek alternative livelihood options that are compatible with mangrove conservation. Mangrove replanting efforts started in 2007, and since then a total of 145 ha have been planted. The Kaliwlingi community mangrove tourism project was begun in 2014 by initiative of Pak Mashadi of the "Mangrove Tracking" project (Desa Wisata Mangrove Pandansari Tracking Mangrove dan Pulau Pasir; "Village Tourism Mangrove Guide to Tracking Mangroves and Sand Islands). This project was started based on a combination of local community, international NGO and government support in 2014. At present several NGO's such as OISCA, Indonesian Rainforest Foundation and Toshiba still provide annual support. Since it started, the project has grown dramatically. In 2017 it booked 85,000 visitors while in 2018 it booked 120,000 visitors. It generates finances based on an entry fee of IDR 15,000 per visitor plus sales from many locally owned souvenir shops, food stalls ("warung") and boat trips. Local shop entrepreneurs rent space from pond owners and also pay a monthly community tax of IDR 300,000 for support of the project. The shops sell high quality locally produced mangrove end-products to the visitors (Fig. 10). In this fashion the financial benefits of the project are widely spread in the community with a high multiplier effect. Promotion is based on social media, a website and ticket-online booking. As of yet there are only two other comparable projects on Java, one in Banten west Java and one in Situbonto, East Java.

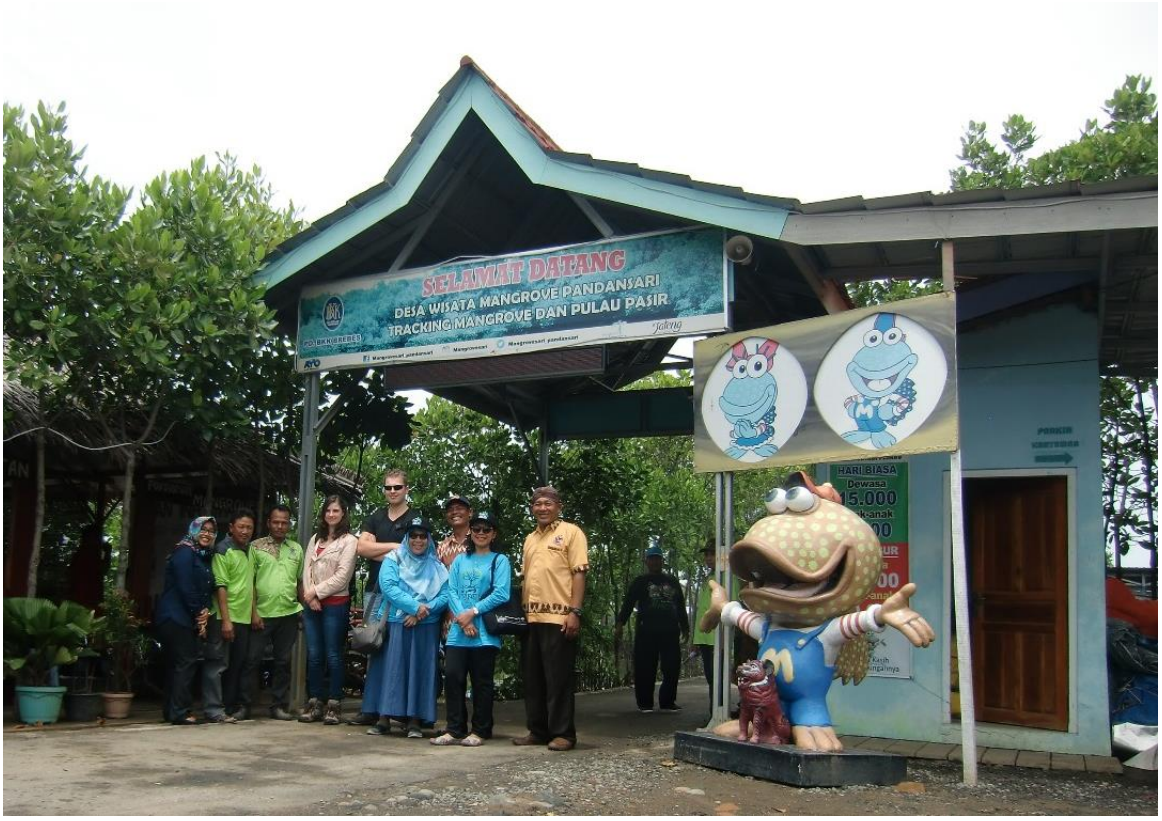

Figure 9. *The entrance to the Kaliwlingi (Brebes, Java) community touristic "Mangrove Tracking" project in Brebes district that currently receives over 120,000 (largely local) tourists per year (Photos: A.O. Debrot).*

Mangrove sport fishing

A good example of successful development of mangrove sport fishing industry comes from the village of Sigempol at Randusanga Kulon in Brebes district. There, Pak Masdori and Pak Suradi pioneered the development of a community sport fishing project in an area where pond culture no longer is feasible due to coastal abrasion. In contrast to the mangrove tourism project of Kaliwlingi village discussed above, this project has been totally independent from NGO or government financial sponsorship. It is supported based on informal local government zoning excluding commercial net fishing in the prescribed area and voluntary cooperation by the community and fishermen. For 25,000 IDR per day, fishermen are provided transport to any of a number of mangrove fishing vantage points including either one of many fishing huts (Fig. 11, left; "ranggon"), or one of two fishing islands; Pulau Ikan and Pulau Hantu. These islands are not true islands but basically consist of two larger vegetated remnant pond bunds that persist in the otherwise-eroded former pond landscape. Unwritten community project rules of no net fishing and no electric fishing are well abided to by the fishermen. The project started in 2007, and currently receives about 36,000 largely local anglers per year. Species caught by angling consist primarily of high-value predatory species like barramundi, catfish, snapper, and grouper. Daily catches of more than 10kg of fish are not unusual which yield a middleman sales value of 200,000 IDR per angling day (Fig. 11, right). The project has no website or organized promotion and largely receives free publicity based on blogs and other social media by visiting fishermen. The initiative is community-based and self-regulated.

Figure 10. *Part of the entrance food court/boulevard with ample food stall and souvenir shops at Sigempol, Brebes, Java, selling locally-produced consumer food end-products like local salt and fried shrimp crackers (Photos: A.O. Debrot).*

Figure 11. Left: one of many fishing huts (ranggong) at Sigempol, Brebes, Java, built to provide sport fishermen fishing vantage points. Right: visitor posing with a nice sports-caught barramundi (Kakap puthi) catch (Photos: A.O. Debrot).

6 Requirements for successful product development and marketing

Value chain management and technology

Apart from those mangrove products harvested for own use, all mangrove natural products pass along the value and supply chain before reaching the end user. At each stage, the price of the product increases and a profit margin is realized. This means that completing more of the value chain within the community is an opportunity to retain jobs and profit within the community. That is of much greater benefit than selling fresh harvest to city middlemen but is a major challenge for poor coastal communities where most processing is done manually and with minimal technology. This equates to high labour production costs, inconsistent quality, high perishability and unreliable supply. Therefore, aside from being very promising, the international marketing of forest goods can also be very challenging (Shanley et al. 2016). Different scholars have discussed the high perishability of many products, difficulties in marketing products at both the local and international levels (Pendelton 1992), poor pricing estimations, poor predictability of supply and the local community's lack of experience with the market economy, high-quality-control standards of importing countries and that many products can be in one day and out the next (Shanley et al. 2016). In addition, commercialization for international markets also requires several critical preconditions, among which a favourable law and policy environment, well-developed and accessible markets, and a well-managed resource (Shanley et al. 2016). Hence for many mangrove natural products to become more widely marketable and to go significantly beyond subsistence use, the development of market plans and intermediate-scale production technology for application at the village level is essential. For very many mangrove products with high potential, efficient production processes have yet to be developed in addition to effective marketing.

Finances

Even in cases where such technology has been developed, finances are needed to be able to realise technological improvements. Finances can be obtained in many ways but for cash-strapped communities this will largely come down to subsidies from NGOs or some form of micro-credit arrangement which today are widely provided by financial institutions. For instance in the Ayeyarwady Delta in Myanmar as many as 59% of households make use of microfinance (Feurer et al. 2018). In addition, group saving clubs are possible but are generally only suitable for more limited capital expenditures (Rim and Rouse 2002).

Regulations and enforcement

Availability of non-timber mangrove forest products can provide important incentives to coastal communities to conserve mangroves for socio-economic benefits such as livelihoods, food, and health security (FAO 1999, Harbi et al. 2018). Allowing wise use and harvest of mangrove forest products can contribute to sustainable forest management and conservation strategies (Arnold 2002), but this alone is not enough. Without regulations and enforcement, communities that live in or near wooded areas such as mangrove forests will ultimately reduce the forest cover for both short- and long-term benefits (Nurrochmat et al. 2017). Therefore, effective limits to deleterious types of use, such as removal of trees and overharvest are critical to keep mangrove forest use sustainable (Birgiantoro and Nurrochmat 2007; Roslinda et al. 2012; Adalina et al. 2014; Harbi et al. 2018).

7 Concluding remarks

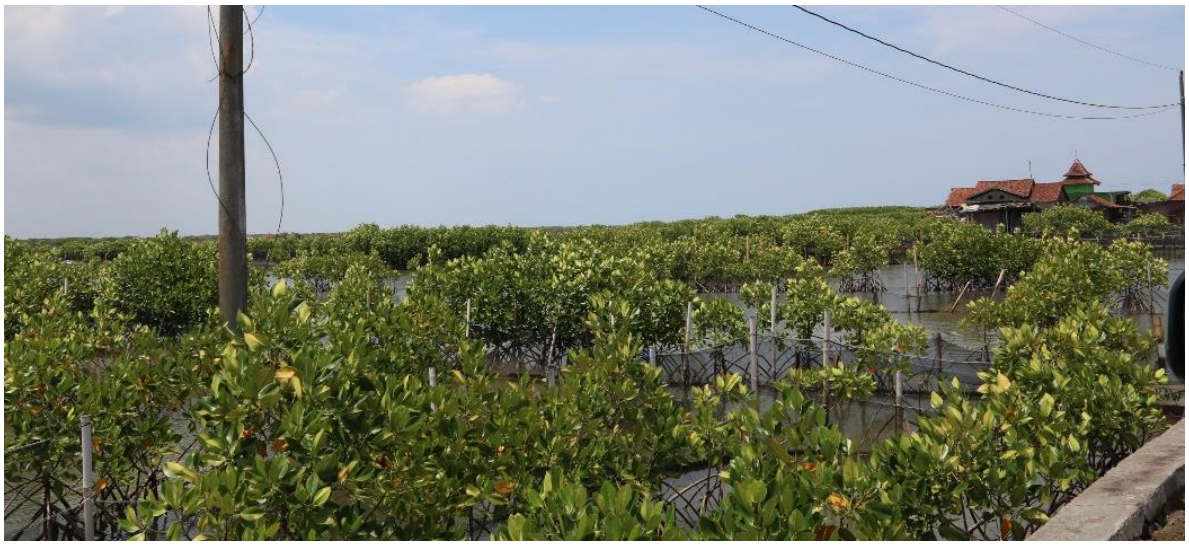

Figure 12. *Healing the landscape at Timbulsloko, Demak, Java. Thanks to planting, a mangrove forest emerges from what were totally barren shrimp ponds. (Photo: A.O. Debrot).*

Mangrove rehabilitation can be achieved in different ways, with or without planting(Bijsterveldt et al. 2022), depending on the local constraints (Fig. 12). Whether it will be supported by the local communities in the long-term depends most importantly on fair and equitable economic incentives in the form of clear sustainable livelihood provision for the local communities. Integrating human livelihood needs into mangrove ecosystem conservation is essential to achieve long-term sustainability for mangrove forests (Romañach et al. 2018). Mangrove forests provide many options for sustainable livelihoods based on their many non-timber forest products such as fish, shellfish and many plant-based forest products. However, because of their complicating biological characteristics the development of such forest product resources for sustainable livelihoods has long been neglected. As a result, the inhabitants of mangrove areas have often been forced to continue with unsustainable practices that usually end up in the destruction of the mangrove forests. Only by developing sustainable, mangrove-friendly livelihood options, will it be possible to develop strong and lasting local support for mangrove rehabilitation. We have briefly discussed a number of promising options for mangrove-compatible livelihoods and highlight a few of the most critical requirements to their successful development.

8 Acknowledgments

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9 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2015 certified quality management system. The organisation has been certified since 27 February 2001. The certification was issued by DNV.

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Justification

Report C053/22
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The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

Approved: René J.H.G. Henkens
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