



A historical analysis of the drivers of loss and degradation of Indonesia's mangroves



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ABSTRACT

Mangroves have been systematically exploited in Indonesia since 1800, especially for the development of brackish water shrimp aquaculture (called '*tambak*') and for timber harvesting. By the end of the 1960s, Indonesia is estimated to have lost more than 200,000 ha of its mangroves mostly in Java and Sumatra. The rate of mangrove loss started to dramatically increase in the 1970 when exploitation shifted to new areas outside Java, particularly in Kalimantan and Sulawesi, encouraged by government policies to boost timber production, followed by policies to expand *tambak* in 1980s and large scale *tambak* development triggered by increased shrimp price during Asian financial crisis in 1997. The result has been the loss of nearly 800,000 ha of mangroves in only 30 years, mostly now in the form of low productivity or abandoned *tambaks*. In recent years, timber harvesting activities in Indonesia's mangroves appear to have become more sustainable. Our analysis suggests that aquaculture will continue as the main driver of change in mangrove ecosystems in Indonesia followed by palm oil plantation. Failure to deal with the current low productivity of shrimp aquaculture in many parts of Indonesia will force shrimp producers to clear an estimated 600,000 ha more mangroves to make way for shrimp farms over the next two decades. However, with improvements in brackish water aquaculture productivity, halting palm oil concession to utilise mangroves, along with maintaining other mangrove use pressures at moderate levels, the net loss of mangroves in the next two decades could be reduced to around 23,000 ha.

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1. Introduction

Indonesia is home to over 20% of the world's mangrove areas and possesses a higher number of mangrove species than other countries (Giri et al., 2011; Spalding et al., 2010). The latest extensive inventory gathered by Indonesia's Geospatial Information Agency found that the country has around 3.2 million hectares of mangroves (Geospatial Information Agency, 2012), slightly larger than the 3.1 million hectares suggested by Giri et al. (2011) for 2000.

Mangroves protect Indonesia's coastlines from storms, storm surges, and even tsunamis (Gedan et al., 2010; Hashim and Catherine, 2013). Mangrove habitats are important for shrimp production, worth around US\$ 1.5 billion annually, contributing over 45% to the total fish exports from Indonesia, making shrimp

the most important species in the fishery sector (Ministry of Marine Affairs and Fisheries, 2014b). In 2014, over 1 million people worked in coastal fisheries businesses that were directly or indirectly related to shrimp production (Ministry of Marine Affairs and Fisheries, 2014b), highlighting the importance of mangroves for community livelihoods, as well as for the national economy.

Mangroves also play an important role in the global environment, most notably due to their high effectiveness in storing carbon compared with other types of forests (Alongi, 2012; Donato et al., 2011; Murdiyarso et al., 2015). Indonesia possesses more mangroves, in terms of number of species and areas, than other countries arguably making it the most important mangrove habitat in the world.

Indonesia's mangroves have been in decline over the last 6 centuries. Some of the losses, such as in Java, were very widespread, but went undetected and unmitigated by policy makers, leading to the loss of more than 70% of the original mangrove area. In other regions, such as the east coast of Sumatra, mangrove timber exploitation was rampant but information about the extent of

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the exploitation was either not recorded or simply included in data for an array of forest products (Burbridge and Koesoebiono, 1982; Choong et al., 1990).

The destruction of mangroves, particularly with the absence of woody vegetation, is always followed by changes in soil and hydrology that increased the risks of soil acidification and coastal erosion. The damage sometimes is irreversible (Alongi, 2002; Di Nitto et al., 2013) as suffered by many communities and landscapes, especially on the north coast of Java, these modified landscapes are exposed to coastal erosion, wave inundation, and storms, with limited opportunity to restore mangroves to re-establish their function as an ecological barrier.

Understanding the history of mangrove management is crucial for understanding the major drivers of deforestation, and for developing management plans. There are few studies, with limited scope and from widely spaced locations, about the history of Indonesian mangrove management and future trends. Although Alongi (2002), Duke et al. (2007), and Crooks et al. (2011) discuss the future of mangroves on a global scale, there have been no specific studies about projections for Indonesia. This paper is the first attempt to construct a timeline for Indonesia's mangrove management, provides critical information about the loss of mangroves over time, and offers scenarios for the fate of these mangroves over the next two decades.

2. Past changes

There are no comprehensive estimates of the initial area of mangroves in Indonesia, although some estimates of between 4.2 and 7.7 million hectares, are largely based on extensive land system mapping carried out in 1985–1989, as proposed by Giesen (1993) and Ministry of Forestry in Geospatial Information Agency (2012). Giesen's estimation, 4.2 million hectares, seems to be fairly accurate when his work is compared with the current data and events that led to the loss of mangroves.

Monitoring mangrove deforestation in Indonesia is difficult even with the use of satellite imagery as cloud cover limits most optical sensors of remote sensing technologies. Other challenges are: difficulties in delineating the boundary between mangroves and freshwater swamps; the relatively fast recovery of mangrove vegetation, which means that exploitation is not easily detected; the rapid expansion of mangroves in newly formed mudflats, which makes it difficult to determine the original areas of mangroves, and the large spatial resolution of past satellite imagery that does not register small patches of mangroves a significant area in total. Government of Indonesia through its *One-map Policy* is currently unifying its mangrove status information that is scattered across different institutions. It is expected that in the coming year, a far accurate data for Indonesia mangrove areas would be available.

The changes of mangrove area presented in this paper were reconstructed from numerous sources as early as 1817 (Raffles, 1817) especially from records relating to brackish water pond development and mangrove timber exploitation—two activities that dominate mangrove deforestation in Indonesia. From literature we found that mangrove exploitation in Indonesia started as early as 1400 during the Majapahit Kingdom era. However, the first date for figures of mangrove exploitation areas is 1820 (Schuster, 1952), thus we back-extrapolate from the information in these sources to the starting date of our historical analysis to 1800 (Fig. 1). The most recent estimations of Indonesia's mangroves area widely used in Indonesia are 3.2 million hectares (Geospatial Information Agency, 2012) and 2.8 million hectares (Ministry of Forestry, 2013). This would indicate that the loss of mangroves since 1800 has been around 1 million hectares (Table 1).

In general, the history of Indonesia's mangrove management in this paper is dividing the activities into four eras, based on the most dominant driver of mangrove loss during those years (summarized in Table 2). The eras and milestones are presented as follow.

2.1. Early tambak (brackish-water pond) development, the first known exploitation (1800–1900)

Development of brackish water ponds in Java was the first indication of mangrove deforestation in Indonesia. This was identified from penal codes about punishment for stealing fish from brackish-water ponds (*tambaks*), which were written around 1400 during the Hindu Majapahit Kingdom in Java (Schuster, 1952). Inclusion into the code shows that the *tambaks*, which were converted from mangroves, covered significant areas and played a significant role in community livelihoods. Since then, the coastal communities along the north coast of Java have been converting thousands of hectares of mangroves into permanent brackish-water ponds. Apart from the code, there was no written record of the mangroves exploitation event until Raffles (1817), reported in his book that *tambaks* were widespread along the coasts of Gresik, Java Island. He also deduced that the *tambaks* in Gresik of East Java were first built during the visit of the *Wali Sanga* (Islam saint), around the 15th century, although he did not provide any supporting evidence.

Schuster (1952) suggested that, by the end of the 1900s, communities along the north coast of Java had converted around 50,000 ha of mangrove into *tambaks* (Fig. 1b). During this period, records about forest exploitation gathered by Goor et al. (1982) did not indicate major mangrove exploitation in other parts of Indonesia. Therefore, the first wave of activities that contributed to the significant degradation of mangroves in Indonesia was development of brackish-water fish farms, mainly in Java with some in Southern Sulawesi. Schuster (1952) reported that, after 1900, the pressure to convert mangroves for *tambaks* slowed down. Instead they were built on the newly accreted lands from sediment deposition along the north coast of Java, as verified by various maps compiled by Bird and Ongkosongo (1980).

2.2. First episodes of mangrove timber exploitation: setting the standards (1900–1949)

Commercial mangrove timber exploitation commenced during the Dutch Trading Company VOC (*Vereenigde Oostindische Compagnie*) operations in Indonesia (then Dutch East Indies) in the 1700s. However, large-scale exploitation started at the end of 1800s, along with the flourishing international trade between Indonesia, Europe, and the US, and with Singapore as the main port.

During this period, communities along the coasts of Aceh, North Sumatra, Riau, and British Borneo, logged mangroves for: tannin exports to Europe and US (de Neve, 1918 Wind, 1924); charcoal; construction and fuel wood exports to Singapore; rail sleepers for northern Sumatran tram development (Bodegom, 1929; Luitjes, 1923); and for fishing industries on the east coast of Sumatra (Boon, D. L. as cited in Goor et al. (1982)).

Many of the mangrove timber management concepts that are applied by the Indonesian Government today were developed in this period. These can be seen in reports about mangrove timber exploitation regulation imposed in Langkat Regency, Sumatra in 1923 reported by Hiemstra, J.L. in Goor et al. (1982) and the management plan proposed by de Haan cited in Goor et al. (1982) to exploit the mangrove areas of Cilacap Regency of Central Java for the period of 1930–1939—all had advocated clear-felling. The Cilacap plan involved defined production zones and allowed clear felling of mangroves in sub-blocks using a 20-year rotation. This was followed by similar plans in Bengkalis in Sumatra in 1937,

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