THE CHANGES OF MANGROVE ECOSYSTEM IN MAHAKAM DELTA, INDONESIA: A COMPLEX SOCIAL-ENVIRONMENTAL PATTERN OF LINKAGES IN RESOURCES UTILIZATION[1]

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ABSTRACT

Mahakam Delta is a configuration of 46 small islands forming a unique fan-shaped lobate which stretches out into the coastal area of the Makassar Strait of East Kalimantan. Geologically the Mahakam Delta was formed through long term deposition of suspended solids from the 770 km long Mahakam River. Besides its high in biodiversity, and abundant in oil and gas resources.

The vegetation in Mahakam Delta is predominantly mangrove forests that consists of pedada zone, *Rizophora* zone, transition zone, *Nipa* zone and nibung zone. Prior to 1980, mangrove vegetation in Mahakam Delta was pristine and about 60% of the area was covered by *Nipa*. Considerable changes in the extent of mangrove ecosystem occurred between 1990-2002, with peak degradation between 1996-2000. Until 2001, about 63% mangrove areas was deforested mainly due to conversion for shrimp ponds. Loss of more than half the mangrove forests caused environmental impacts and affected aquatic productivity, social and economic condition and the livelihoods of communities living in Mahakam delta. Conflicts among various resource users were a frequent occurrence in the local communities, particularly related to land ownership and water pollution issues.

The factors affecting mangrove degradation in Mahakam Delta are linked to many drivers; described here as backward, forward, downward, and upward linkages. Important linkage factors are human migration in to East Kalimantan, the socio-cultural profile of migrants, condition of global economy, and the existing government policies, laws and regulations. Since 2002, partial efforts for restoration had been taken by both government and private companies in mangrove replanting at some sites in Mahakam delta. However, more integrated management is needed for ecosystem restoration in the delta, without affecting livelihood opportunities for communities living in the Mahakam Delta.

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INTRODUCTION

Mahakam Delta is on the eastern coast of Kalimantan island at the position of 117°15′ – 117°40′ EL and 0°19′ – 0°55′ SL and administratively includes the District of Kutai Kartanegara in East Kalimantan Province. The Mahakam Delta configures 46 small deltaic islands (**DKP, 2007**) forming a unique fan-shaped lobate and geologically it was formed by the long term deposition of suspended solids from 770 km long Mahakam River which passes through the delta and flows into the Makassar Strait (**Figure 1**).

Figure 1. Geographic position of Mahakam Delta (insert) located in East Kalimantan Province, Indonesia.

Geo-morphologically **Dutrieux (1990)** divided the delta into pro-delta, delta front and deltaic plain. Pro-delta is the deeper area bordering the delta with the Makassar Strait. Front delta is the deltaic fringe immerged at high tide and is a major area for sediment deposition. The deltaic plain consists of many small inlands separated by tributary channels where freshwater from the river and salt water from the sea are mixed. Considering the mixture between freshwater and salt water, four zones were found in the deltaic plain, i.e. apical zone, median distributary zone, river mouth zone, and central delta zone. Thick vegetation from various species of mangrove occupies the deltaic islands. Freshwater from the river strongly influences the apical zone and this zone is occupied by rain forest vegetation. The mangrovesin the median distributary zone are dominated by *Heritiera littoralis*. At the river mouth where the influence of

seawater is high, *Avicennia* grows predominantly. The central delta zone is mostly covered by mono-specific stands of *Nypa fruticans*, with scattered trees of *Rhizophora* and *Bruguiera*.

Several vegetation zones,namely pedada zone, bakau zone, transition zone, nypa zone, and nibung zone can be identified in these mangrove areas. The pedada zone is located closest to the delta front and is characterized by pedada (*Sonneratia alba*) and api-api (*Avicennia* sp.) that occur in a belt of about 100–150 m. The bakau (*Rhizophora*) zone is found mostly along the bank of distributaries of the lower delta area and on islands like Tunu and Selete. The transition zone is a mixed zone where many species of mangroves such as api-api (*Avicennia* sp.), pedada (*Sonneratia caseolaris*), bakau (*Rhizophora* sp.), tancang (*Bruguiera* sp.), nyirih (*Xylocarpus granatum*), and nipa (*Nypa fruticans*) grow together. Nipa covers the central area of the deltaand this zone is strongly influenced by freshwater flowing from the river. The nibung zone is in the upper most area of the delta and is characterized by species such as nibung (*Oncosperma* sp), dungun (*Heritiera littolaris*), mata buaya (*Gruguiera sexangula*), and buta-buta (*Excoecaria agallocha*) **(Prihatini, 2003**; **DKP, 2007)**

Biodiversity of estuarine ecosystem in Mahakam Delta is quite high. At least 7 families with 20 species of true mangrove species were identified from the area, excluding mangrove associated species in the upper zone of the delta. Faunal diversity in the delta too is considerable and this is the natural habitat of proboscis monkey which is endemic to East Kalimanthan. **Suyatna (2006)** reported 125 fish and shellfish species from 44 families from these estuarine waters.

Fishing gears commonly used by fishermen are gill nets, mini trawl nets, trammel nets, long line, lift nets and traps. Milkfish (*Chanos chanos*), mullet (*Mugil*), snappers (*Lutjanus*), groupers (*Epinephelus*), tiger shrimp (*Penaeus monodon*), white shrimp (*P. merguensis*), spotted shrimp (*Metapenaeus brevicornis*), and mud crab (*Scylla serrata*) are some commercially important species caught in the waters of Mahakam delta.

Besides its high biodiversity, the Delta had been recognized as the largest production zone for oil and gas in Indonesia. Three multinational companies, i.e. Total E&P Indonesie, Vico Indonesia Co., and Chevron Indonesia Co. are operating in the Delta. Total E&P Indonesie occupies the largest part of the Delta for oil and gas exploration and exploitation with the production of 70,000 barrels of oil/day and 200,000 barrel equivalent gas/day (**DKP, 2007**).

Communities living in the delta area consist of various ethnicities that have migrated from different provinces in Indonesia. They are generally engaged in activities related to fishing, shrimp culture, agriculture, gas and oil extraction and trading, and hey are settled in the mainland part of the delta. Mass migration to East Kalimanthan in general and to Mahakam delta in particular has led to the massive changes in mangrove ecosystems and the dependent livelihoods in the delta. This paper attempts to describe

the various factors linked to mangrove degradation, considering the demographic history, socio-economic condition, legal framework and institutional aspects in Mahakam Delta.

MANGROVE LOSS AND POND EXPANSION

Creocean (2000) estimated the size of Mahakam deltaic plain to be 150,000 ha including 100,000 ha total surface of vegetated lands. The central part of the delta was originally covered with dense *Nypa* (60,000 ha) representing one of the biggest expanses in the world.

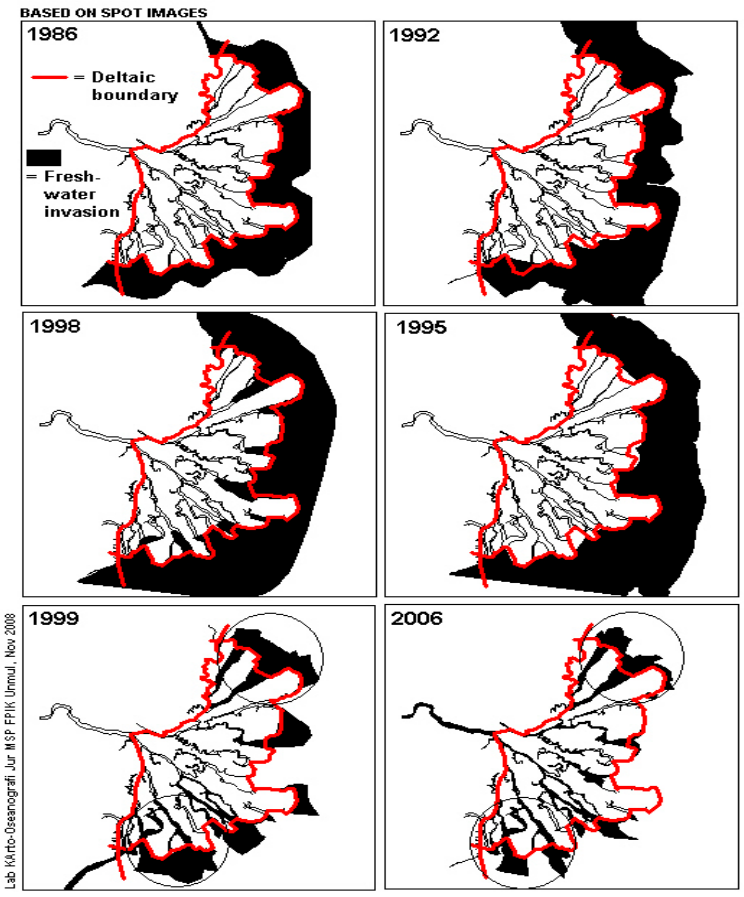
Information on the deforestation of mangrove ecosystem in Mahakam Delta has been already publicized widely. In recent years the main factor causing the deforestation of mangrove ecosystem in the delta, as also happened in Thailand and other ASEAN countries (**Barbier and Cox, 2002**) is the conversion for aquaculture ponds. **Hopley (1999)** stated that the area of ponds in Mahakam Delta in 1992 was recorded to be only 2,800 ha, but it increased up to 13,000 ha in 1998. Another source (**Bappeda Kukar, 2003**) mentioned that based on Land-sat imagery, the area of ponds in 1991 was estimated only 3,628 ha, but it increased to 14,480 ha in 1996 and to 69,454 ha in 2001. The fastest rate of conversion occurred between 1996-2000 (**Bourgeois *et al.*, 2002**) during the monetary crisis when the price of shrimp highly increased due to the weakening rupiah to US dollar. **Creocean (2000)** stated that until 1999, 76% of the mangrove area had been lost mainly due to conversion into ponds and about 80% of the lost mangrove was *Nypa* stands. The total area deforestated was estimated to be 85,000 ha representing about 80% of the total area of Mahakam Delta (**Dutrieux, 2001**).

Based on LANDSAT images, in 2003 the extent of deltaic islands of Mahakam Delta was estimated to be 108,152.5 ha including 60,818.4 ha mangrove forests, 45,297.4 ha ponds and 2,036 ha of ponds under construction (**Noryadi et al., 2006**). The latest interpretation from satellite imagery (Quick Bird 2007) showed that the size of Mahakam Delta was estimated to be 107,221.9 ha excluding the area of waters in distributaries. The number of ponds in the delta was recorded to be 10,645, occupying the total area of 57,912 ha (54%) with average pond size 5.4 ha, showing that pond system applied in the delta is traditional extensive. If the area for community settlements and other purposes is estimated at 129 ha in year 2001 (**Bappeda Kukar, 2003**), the loss of mangrove forest in the delta until 2007 can be estimated at 58,041 ha (54.13%). If the growth in settlements between 2001-2007 is estimated at ten hectares per year, the loss of mangrove until year 2007 does not exceed 55% from the initial mangrove covering. This is different from previous reports which stated that the loss of mangrove until 1999 was 76% **(Creocean, 2000**) and until 2001 was 63% (**Bappeda Kukar, 2003**). The differences are probably caused by different interpretations on satellite images or the mangrove left growing as thin green belts in between ponds were not counted.

ENVIRONMENTAL IMPACTS FROM MANGROVE LOSS

Seawater intrusion

The ecological and economical functions of mangrove ecosystem have been reported by many authors. The loss of mangrove stands in the coastal areas causing severe impacts on the environment has occurred in many tropical countries such as in Bangladesh, India, the Philippines, Vietnam and Thailand (**Karim, 2006; Gowing, *et al.*, 2006; Barbier and Cox, 2002; Barbier, 2006**). In the case of Mahakam Delta, the most significant impacts caused by the loss of mangrove forest and other vegetation in the upstream is the extension of salt wedge further upstream in the river. Figure two presents the temporal reduction in freshwater discharge into Mahakam delta, based on



SPOT images.

Figure 2. Maps showing the reduction of freshwater flow during the period 1986 - 2000 in the Mahakam Delta.

In the dry season, salt water intrusion has reached a hundred kilometres to the city of Samarinda and disturbed the drinking water supply. However, if seawater

intrusion takes place for a longer time and the freshwater flow is not sufficient to counteract the pressure of the intruding seawater, the characteristics of the biophysical environment in the deltaic plain could be affected. Gradual or long-term changes of the community structures of deltaic biota from dense vegetative to open environment and from low salinity tolerance to more saline environment will be promoted.

Sedimentation

Clear cutting of mangrove stands invites erosion and abrasion on the surface land of the delta leading to sedimentation in the bottom of river basin or at the front of the delta. The depth of tributary channels in the deltaic plain will become shallower, and the front delta will probably become wider and move forward in the future, since sedimentation will be continuous (**Figure 3**). Allen *et al*. (1979) ***in*** **Dutrieux (1990)** estimated that the discharge of Mahakam River was 1,000 – 1,500 m3/second and this flow contained $8x10^6$ m^3 solids per year with the composition of 70% mud and 30% sand. **Creocean (2000)** stated that the concentration of total suspended solids in the water column from the apex to the mouth of the deltaic area are ranged from 19.5 to 62 mg/l at the surface, and from 26.5 to 158 mg/l on the bottom, with a maximal average 178 mg/l in the middle part. These values are quite high as were the turbidity values.

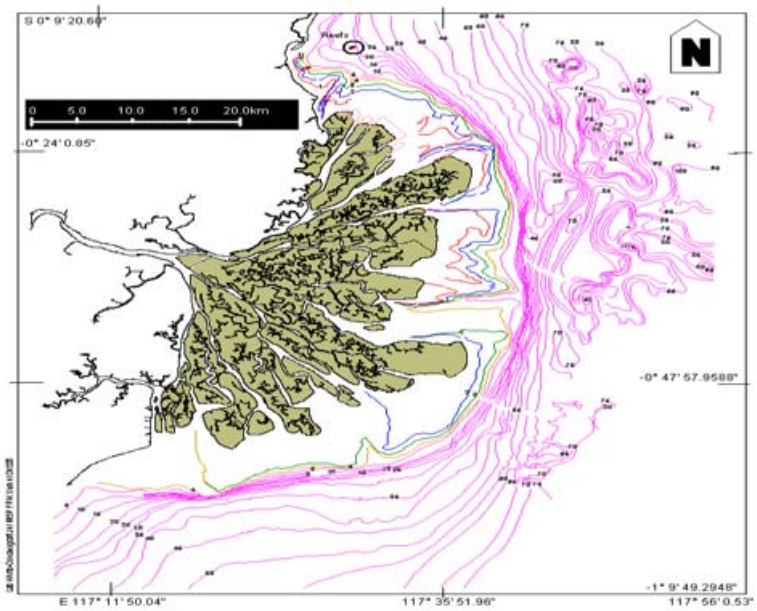


Figure 3. Bathymetric map showing the deposition of sediments in the delta front of the Mahakam Delta

The flowing water also contained high concentration of organic substances (**Creocean, 2000**) and debris which was deposited and accumulated in the bottom of river mouth. The debris consists of pieces of woods, leaves and charcoal, and plastic

goods. A large proportion of the mud, sand and debris flows down the river from upstream areas. Sedimentation in the deltaic plain and front delta led to sea level rise during high tide and pond farmers have to raise their pond dikes in recent years. **Bourgeois *et al.* (2002)** comparing the sedimentation, erosion and accretion which occurred in the delta during 50 years before and 5 years after 1996 concluded that the delta's inland morphology is stable.

Aquatic productivity

Based on data from fisheries statistical yearbooks, **van Zwieten, *et al*. (2006)** percept that no evidence is available that the fisheries and pond productivity declined following the loss of mangroves in Mahakam Delta. The increasing number of ponds and fishing gears stabilized the productivity of ponds and fisheries over years. However decreased stocks of wild shrimp (*Metapenaeus* sp.) was observed over the years with declining extents of mangroves.

The results of an extensive survey (**Noryadi *et al.*, 2006**) found that the average pond productivity of tiger shrimp (*P. monodon*) and wild shrimp was 42.5 kg/ha/year and 49.0 kg/ha/year, respectively. This productivity is far lower when compared to national productivity of 600-1,000 kg/ha/year in traditional ponds. High variability of production caused by many harvest failures and many abandoned ponds neglected by absentee owners are the possible reasons. The increased mortality of shrimp leading to harvest failures and pond abandoning had been identified by **Creocean (2000)**. Most ponds occupied the middle part of the delta where *Nypa* stands originally were. The soils in the ex-*Nypa* area are acid sulphate soils characterized with low pH, high concentration of organic matters and pyrite (**Sidik *et al.*, 2006**). The concentration of dissolved oxygen in these areas is also generally very low. In these conditions, shrimps are very susceptible to any diseases, and white spot outbreaks were a major cause of shrimp mass mortality in the delta. In addition, **Bourgeois *et al.* (2002)** stated that disease outbreaks and subsequent harvest losses that occurred in Taiwan, Thailand, the Philippines, China and Ecuador were the result of overloading capacity of the environment when pond-mangrove ratio exceeded largely the ecological footprint threshold.

Social vulnerability

Vulnerability refers to the sensitivity level of certain systems including societal, natural, ecological, biophysical or socio-ecological systems to threats, shocks and stress and the capacity of the systems to adapt to perturbations (**Adger, 2006; Gallopin, 2006**). In contrary, resilience refers to the ability of an ecological or livelihoods system to 'bounce back' from shocks, stress, or threats (**Adger, 2000; van Zwieten and Bosma, 2007**). Context factors influencing the vulnerability of certain systems are seasonal shifts, trends, and shocks (**DFID, 2008**).

The degradation of mangrove ecosystem in the Mahakam Delta leading to environmental deterioration, a reduction of fisheries catch and pond productivity, harvest failures and pond abandoning resulted in shocks and stress to the community and increased the vulnerability of their livelihoods. Social conflicts that frequently occurred were an indication of the appearance of social vulnerability in the delta area. **DKP (2007)** identified four kinds of conflicts that appeared in the delta; conflict of land ownership, conflict of authority, social conflict and conflict of identity. Conflict of land ownership usually occurred between members of the community on the land status. The different sectors of government have an authority on the management of Mahakam Delta and it raises conflicts of interest among government institutions. Social conflicts frequently occurred between fishermen or pond farmers with private companies mainly on the issue of compensation claims for land occupation, pollution and other disturbances. Conflict of identity usually refers to the opportunity for local people to be able to work in oil and gas companies operating in the delta. Conflict will appear if the companies employ only 'outsiders' and give less opportunities for 'local people'.

From the results of stakeholder analysis, **Bourgeois *et al.* (2002)** identified issues that stakeholders mostly want included in the future management of the delta i.e. avoiding the occurrence of conflicts related to land, preventing the occurrence of erosion and abrasion, increasing the sustainability of shrimp ponds production, setting aside areas for the reproduction of fishes and shrimps, increasing shrimp ponds productivity, preventing the occurrence of pollution, and developing and increasing the awareness of all stakeholders regarding the current conditions and evolution of the delta. Very clearly, the above issues are closely related to the vulnerability context of the community livelihoods in the delta.

WHY UNCONTROLLED?

Many analyses have attempted to address the question of why the cutting of mangroves and conversion for pond development in the Mahakam Delta can not be stopped and continues in an uncontrolled manner. According to **Bourgeois *et al.* (2002),** the mangrove areas are usually common property and have been considered for a longtime as low-value ecosystems or lands. As such, because nobody is in charge of their control, or because of the disinterests from public bodies in charge, various stakeholders feel free to gain or claim, legally or not, property rights. A laissez-faire attitude from ruling bodies or decision makers finally endorses this capture of resources and make difficult to challenge back its validity. However, **Simarmata (2008)** attributed the problems of mangrove degradation more to an unclear land tenure system, contradictive policies and regulations, and overlapping of delta management authority among different government sectors. Many rules and regulations on natural resources management were not operational at the level of implementation.

Prihatini (2003) described factors accelerated the opening of mangrove for ponds especially in 1997 as:

1. International shrimp market; increasing world consumption on shrimp stimulated the increase of shrimp price.
2. Regional economic crisis; economic crisis weakened the value of Indonesian rupiah to US dollar, and made the price of shrimp in rupiah were extremely expensive and the benefit margin received by farmers, collectors, and exporters increased.
3. Fishery policies; the ban for use of trawl issued by government in 1983 shifted some fishermen activities from fishing to pond culture.
4. Condition of environmental biophysics and *Nypa* covering; physically Nypa stands are easier to clearly cut than other species of mangrove, so then the initial cost for pond construction is cheaper.
5. Extreme climate in 1997; long dry season influenced by El Nino phenomenon increased the average water salinity in the delta to the level suitable for the optimum growth of shrimps.

More comprehensively **Prihatini (2003)** figured out the acceleration of mangrove loss in the delta in the problem tree below (**Figure 4**).

Furthermore, **Sidik et al. (2006)** stated that socioeconomic factors were very important determinants for mangrove conversion in Mahakam Delta with some reasons:

1. Shrimp culture system is still traditionally extensive and influenced by the access of information and technology derived from ethnic origin,
2. Economic organization patron-client supported the development of shrimp pond industry in Mahakam Delta, and
3. International market offered stable shrimp price, and good shrimp demands from developed countries particularly Japan, USA, and European Union.

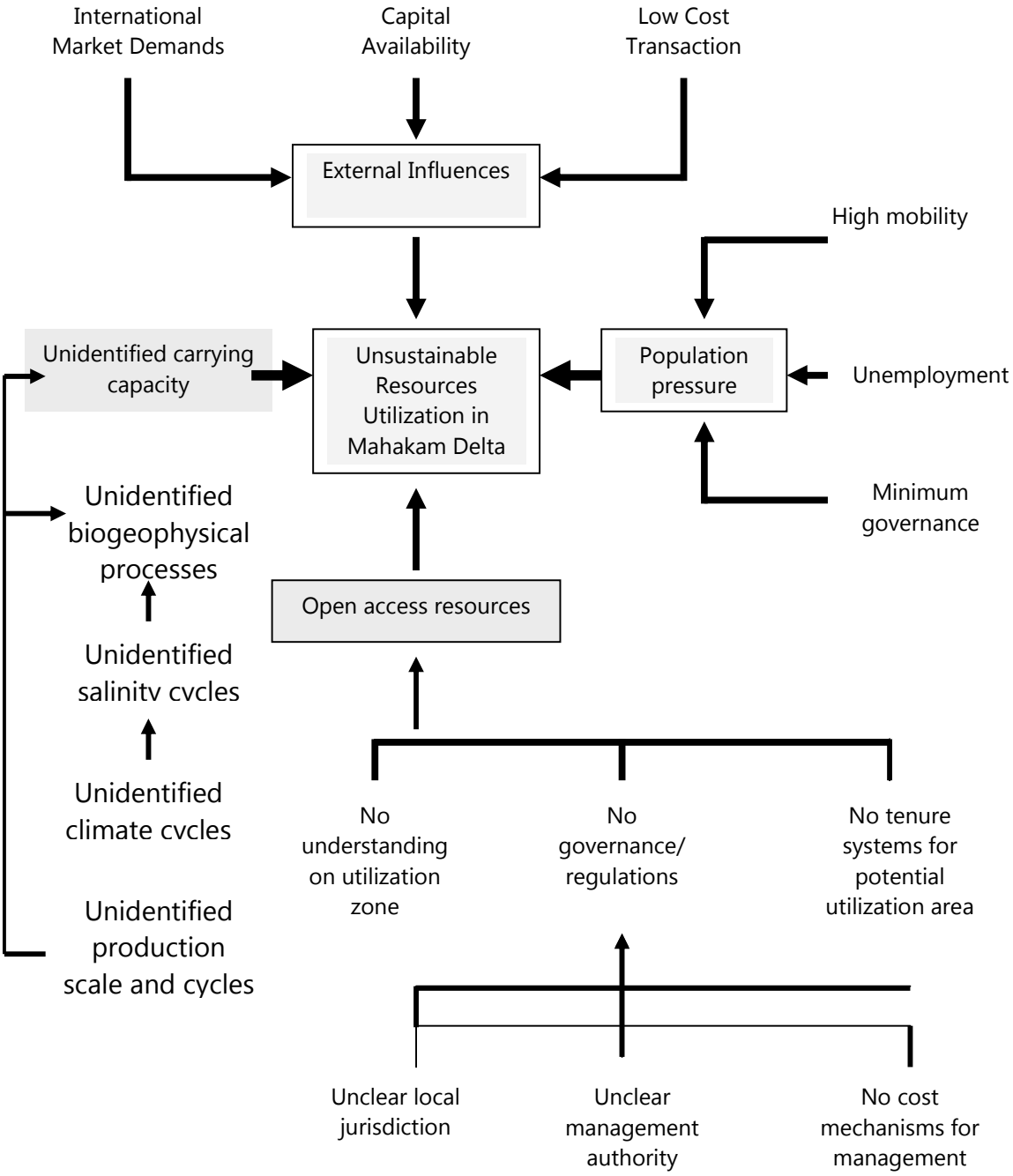


Figure 4. Problem tree identified in Mahakam Delta (**Prihatini, 2003**)

TRIANGLE NETWORK

There are two kinds of land ownership; traditional land ownership and legal ownership. In traditional ownership; anyone who cut the mangrove trees for the first time as wide as he can is the owner of the land. The land borders between owners were

agreed among community members. This kind of ownership is very strong even thought there is no legal proof. Legal ownership usually starts with traditional ownership. People in the community have to form a farmer group consists of minimum of 25 members. The farmer group then apply to the head of the village to get the land and an associated tillage permit for that land. Each member of a farmer group can get a tillage permit for 2 ha land. If this tillage permit is approved further by the head of sub-district, it is termed an SPPT (Surat Pernyataan Penguasaan Tanah Negara) or statement letter for occupying state land. Based on this rule, a household can control 2 ha of land, but at implementation it can be applied to each member of a household (**Simarmata, 2008**). So then, a household may have more than 10 ha as wide as the traditional land they have before dependent upon the number of household members.

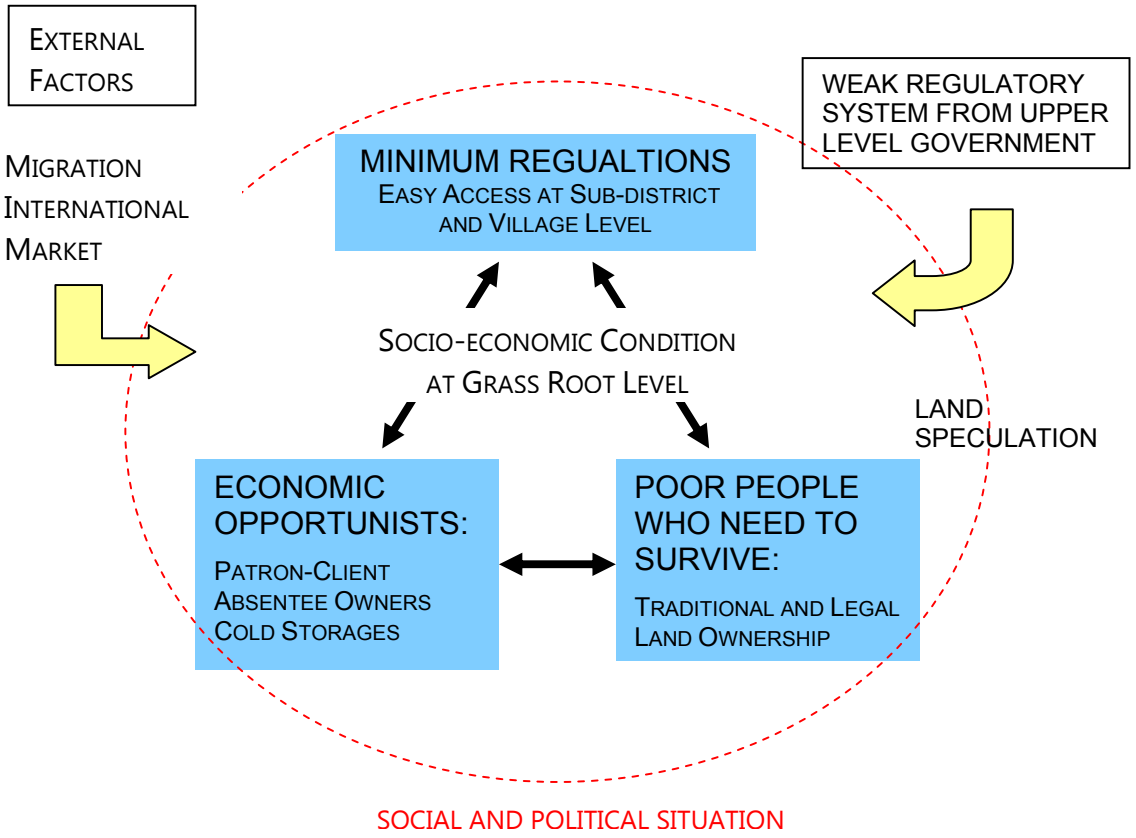


Figure 5. Triangle cooperation at grass root level influenced by external factors, weak regulatory systems and social and political situation, accelerated mangrove loss in the Mahakam Delta.

Legal ownership mainly is a way for farmers to change their traditional lands to legal status. The absentee owners get the land by buying traditional land or legal land from farmers. The easy access to land ownership, together with the economic

opportunists like ponggawa, absentee owners, and cold storage companies, and poor people who have land that need to survive are factors that have contributed to mangrove loss in the Mahakam Delta (**Figure 5**). This network of three factors resulted a means for people to convert mangrove forests for any purposes such as for shrimp pond development.

UNTOUCHED PERIOD

Mahakam Delta in the past

For about 12 centuries in the past, the Mahakam Delta area was under the jurisdiction of the Hindu kingdom, Kingdom Mulawarman (or another source called Kingdom Kutai Martapura). Kingdom Mulawarman ended in the mid 17th century when King Dharma Setia, the last king from the Kingdom Mulawarman was defeated in the war by the prince Sinum Panji Seta from the Kingdom Kutai Kartanegara in year 1636. Kingdom Kutai Kartanegara was founded in year 1300s by Aji Bhatara Agung Dewa Sakti, a warrier coming from the Kingdom Singosari in East Java in the period of King Kartanegara. The power centre of this kingdom was located in the upper river of Mahakam Delta in Tepian Batu (now called Desa Kutai Lama), before it was moved to Jembayan in the period of King Aji Dipati Tua, and then moved again in the period of King Aji Muhammad Muslihuddin to Tangga Arung (now called Tenggarong) (**Amin, 1975 *in* DKP, 2007**). At that time the Mahakam Delta was just used for transportation and the passage of traders from China, India, and Philippines to the kingdom centre in the upper river of Mahakam to buy gold, bird nest, and wood by barter with salt, tobacco, opium, clothes and gong (**Peluso, 1987, Magenda, 1991 *in* Simarmata, 2008**).

Migration and settlement

In year 1844, the Kingdom Kutai Kartanegara was occupied by a Dutch colonial authority and the king was forced to sign an agreement to surrender the power to the Dutch. The economic activities in Mahakam Delta slowly changed after J.H. Menten in 1902 found an oil field in Sanga-sanga just in the mainland of the delta and the King of Kingdom Kutai Kartanegara gave oil mining concession for oil exploration to Koetai Explotratie Maatscappij (KEM) until 1922. The first settlement in the delta was probably built by Bugis ethnic in Pemangkaran, Sepatin Village, Sub-district of Anggana in the beginning of 19th century. They migrated from Telake Village, Disrict of Paser following the surrender of Paser Kingdom to the Dutch authority. Some of them then moved to Muara Pantuan Village in the same sub-district in the middle of 19th century, almost at the same time with the Bugis ethnic migrating directly from Pangkajene, South Sulawesi to Muara Pantuan (**Lenggono, 2003 *in* DKP, 2007**).

Until 1942, many settlements were founded in many places in the delta area including at Muara Badak in 1917, Salo Palai and Saliki in 1925, Handil Satu in 1934, and

at Tanjung Adjoe in 1940s. The ethnic origin of people living in these villages was mostly Bugises mixed with small number of Banjarese. In the period of Japanese occupation, during the war settlements in Muara Jawa, Muara Pantuan and Muara Badak were burnt (**Bourgeois *et al.*, 2002**). Thus, people have lived in the delta before the 2nd World War, but the condition of mangrove ecosystem in the delta was still relatively untouched.

Soekarno Era

On 17 August 1945, Indonesia proclaimed its Independent Day, indicating the start of the Soekarno political era (1945-1965). The social and political situation in this era was still very turbulent. Soekarno struggled to keep independence and maintain the unity of Indonesia in the face of disturbances from many political movements, rebellions inside the country and the threat of re-occupation by the Dutch. Many rebellions occurred in this era like RMS in Maluku (1950), DI-TII Kartosuwiryo in West Java (1949) and Kahar Muzakar in South Sulawesi (1950), and PRRI-Permesta in Sumatera and Sulawesi (1958)[2](**Imron *et al.*, 2006**). The Kingdom Kutai Kartanegara unified with the Republic of Indonesia in 1950, and before founded in 1956, the province of East Kalimantan led by dual governments; the residency (republic) and the kingdom. However the authority to take royalty from oil mining since the unification in 1950 moved to the central government of Indonesia (**Magenda, 1991 *in* Simarmata, 2008**).

The condition of mangrove ecosystem in the delta in this era was still untouched, because the attention of central government to natural resource utilization was not yet a priority. The area of Mahakam Delta became a place and passage for smuggling activities. People brought home appliances such as household equipments, clothes, and electronic goods from Tawau (Malaysia), and they bought from Mahakam pepper, rubber, and coconut. In this era many Bugises from South Sulawesi migrated to the delta area running away from the military repression due to the occurrence of the Kahar Muzakkar rebellion.

THE PERIOD OF OIL, GAS AND FISHERIES

Soeharto era

The era of Soekarno ended with the communist rebellion G30S/PKI[3] in 1965, and Soeharto has held power since then. The development of the economy in the new era of Soeharto grew very fast. Natural resource exploitation became one of the main capital sources to support development but resultedin heavy impacts on the environment. The

[2] RMS – Republik Maluku Selatan (Republic of South Mollucas); DI/TII – Darul Islam/Tentara Islam Indonesia (*Islamic Country/Islamic Army of Indonesia*); PRRI/Permesta – Pemerintah Revolusioner Republik Indonesia/Gerakan Piagam Perjuangan Semesta (*Revolutionary Government of Republic of Indonesia/All People Struggle Movement*).

[3] G30S/PKI – Gerakan 30 September/Partai Komunis Indonesia (*September 30 Movement/Indonesian Communist Party*)

social and political policies set by the central government resulted in significant impacts and changes in the natural resources in East Kalimantan including to mangrove ecosystem in the Mahakam Delta area. The government political system was centralistic where regulatory systems were mostly top down.

Before 1970, in East Kalimantan there was a famous period called period of "banjir kap" or the flood of logs. The period lasted about three years from 1967 to 1970, where uncontrolled wood logging activities occurred. At that time, the Mahakam Delta became a 'voiceless witness' that so many logs were drifted down the river and transported through the delta. To more effectively control the logging activities, in 1970 the government issued Government Regulation No. 21/1970 and gave all authority on forest concession right only to central government. Many forest concession rights (HPH – *Hak Pengusahaan Hutan*) were then issued by central government to many timber companies for the area more than 500.000 ha per concession (**Simarmata, 2008**). Even though the "banjir kap" period had finished, the logging activities by many timber companies continued. Extensive logging activities led to forest degradation in recent years indicated among others by the increasing of water turbidity and sedimentation rate. No forest concessions have been granted in the Mahakam Delta, since mangrove forest in this area dominated with *Nypa* stands has low economic value.

Besides timber industries, oil and gas mining industries also developed well in East Kalimantan during this era. In 1970, Total E&P Indonesie a French company joined with Japex (Japanese company; now called Inpex Corporation) and won a production sharing contract for oil and gas mining in the area of Mahakam Delta. After exploration for two years, in 1972, Total E&P Indonesie found an oil field in Bekapai off-shore of Mahakam Delta, and began exploition in 1974. After operating for 21 years, in 1991 Total E&P Indonesie got the extension permit for production sharing contract until 2017 (**Simarmata, 2008**). Since 1970 East Kalimantan has been in the era of timber, oil and gas industries.

Industrial development attracted migrants from different parts of Indonesia to migrate to East Kalimantan. Many migrants from Sulawesi came to the Mahakam Delta to work in the fisheries sector. They supplied fisheries products to local markets in Samarinda and Balikpapan and to two newly built cold storage companies. In 1974, a Japanese Joint venture company built a cold storage industry PT Misaja Mitra in Sungai Meriam, District of Anggana, and one year later another cold storage industry PT Samarinda Cendana Cold Storage was established. The cold storage companies collected shrimps for export from fishing activities by fishermen along mid part of coastal waters of East Kalimantan, including the water of Mahakam Delta. In this period, migrants from Bugises ethnic introduced the organizational economy patron-client or "ponggawa system" in fisheries activities in East Kalimantan as practiced in their homeland (**Sidik *et al.*, 2000**).

On July 1, 1980, the government issued Government Regulation No. 39/1980 to ban the use of trawl in fishing activities which effectively implemented since January 1, 1983. The production of shrimps from fishing declined after this ban and reduced the supply for cold storage. The first opening mangrove for pond construction probably began in 1974 for milkfish culture in Muara Jawa and Anggana by Bugises migrants (**Bourgeois *et al.*, 2002**). However the shrimp pond culture probably started in 1985 after some fishermen shifted their activities from fishing to shrimp culture following the trawl ban. From satellite imagery, it was found that until 1992 the area of ponds in the delta reached to about 2.8 to 3.6 thousand ha.

Acceleration of mangrove conversion

The success of intensive shrimp pond culture in Japan and Taiwan, and the success of breeding tiger shrimp in hatcheries by eye-stalk ablation method in Indonesia in 1980s enhanced the development of intensive shrimp pond culture in Indonesia, especially in the north coast of Java, South Sulawesi and South Sumatera. The success of shrimp culture in Java and Sulawesi then influenced very much to the development of shrimp culture in Mahakam Delta. In 1990s, cold storage companies encouraged ponggawa to construct the ponds by means of excavator. The ponggawa system shifted from fisheries to shrimp pond culture and then the conversion of mangrove ecosystem for shrimp pond culture in Mahakam Delta entered an uncontrolled phase.

The acceleration of mangrove conversion for ponds started from 1996 until 2001 at the time when Indonesia was experiencing a heavy economic crisis. The Indonesian rupiah fell to a very low level against US dollar which made the price of shrimp in rupiah incredibly high and accelerated the expansion of shrimp pond development in Mahakam Delta. This economic crisis then brought Indonesia into reformation era following the fall of Soeharto on May 21, 1998.

Reformation era

After the end of the Soeharto era, the economic crisis continued and expanded into a more multidimensional crisis. The political system in Indonesia was reforming to a more democratic system and moving from centralization into decentralization. In this transition period, transformation euphoria brought Indonesia into a highly turbulent social and political situation. In seven years until 2005, four presidents had been elected to lead the government. Governmental control on natural resources utilization weakened, and in this situation, uncontrolled mangrove conversion for ponds in the Mahakam Delta was accelerated (**Figure 6**).

The peak of mangrove conversion for shrimp ponds was reached in 2001 after more than 50% of mangrove ecosystem in the delta was degraded. After 2002 the opening of mangrove for ponds stagnated, since the government succeeded to stabilize rupiah to US dollar and by 2000 many harvest failures for tiger shrimp culture occurred

caused by the disease outbreaks or by the degrading environmental condition due to the construction of ponds had passed over the environmental carrying capacity. Many ponds were neglected by the owners and abandoned, particularly in the case of absentee owners. Most shrimp pond farmers depended only on the production of wild shrimps (*Metapenaeus* spp.) that entering the ponds during high tide for subsistence livelihoods.

The awareness of ruling bodies enhanced after realizing that the mangrove ecosystem degradation in Mahakam Delta had reached a worse condition resulting in many problems such as water pollution, harvest failures, and social conflicts. Since year 2000, thoughts to the need for Mahakam Delta restoration have been developing.

EFFORTS TO INTEGRATED MANAGEMENT

The mangrove replanting program initiated in 2001 in ponds and degraded areas by both government and private companies started the era of delta restoration. In the period between 2001-2005 for example, Total E&P Indonesie had replanted 3,549,997 trees covering 646 ha of the delta (**Simarmata, 2008**). In addition, **Waridin (2008)** stated that in the period between 2002-2007, the Department of Forestry, District Kutai Kartanegara had also replanted mangrove plants in 819 ha area, especially in the ponds to develop an integrated mangrove pond management (silvofishery). The species planted by both Total and Department of Forestry was mostly *Rhizopora* spp., even in the area originally covered with *Nypa* stands. *Rhizopora* and *Bruguiera* are more easily planted in watery lands as in ponds and no information that *Avicennia* or *Nypa* were used for mangrove replanting program in Mahakam Delta (**Bourgeois *et al.*, 2002**). In the future the mangrove replanting program will possibly change the composition of mangrove stands in Mahakam Delta and make it far different from the original ecosystem (**Figure 7**).

Figure 7. Mangrove pond integrated system (silvofishery) as one of possible restoration methods in the degraded mangrove ecosystem in Mahakam Delta.

The local government together with Total E&P Indonesie initiated efforts for more integrated management of the delta. In 2001, the District government formed the Integrated Delta Mahakam Management Council composing various stakeholders which had concerns in relation to delta management. In the same year, the district government produced a document, Detailed Spatial Planning of Mahakam Delta Area as basis to regulate the restoration management of the delta. Other important documents produced or being drafted as a legal basis for the delta management are Land Use Planning 2005-2025, Draft on Spatial Planning for Coastal Zone 2008-2027, and Draft of Strategic Planning for Integrated Delta Management 2008-2013. The District government in cooperation with Department of Interior, Total E&P Indonesie and UNDP since 2006 has also been developing a multiyear community empowerment program called PMD Mahakam or Pemberdayaan Masyarakat Delta Mahakam (Mahakam Delta Community Empowerment). PMD Mahakam coordinates various stakeholders and finds out ways to restore the delta and promote an alternative income sources for local community to build their livelihoods.

During implementation, many problems have been encountered. The area of the delta to be restored is so wide that it will take time and be very costly. It will need a strong political will from the government, especially as natural conservation programs are usually assigned a low priority. Silvofishery is a possible solution, but it needs more efforts to convince pond farmers to apply this system in practice. Stakeholder interests and efforts concerning restoration diverge in different ways, therefore socially and politically acceptable restoration program should be developed, using for instance, soft system methodology.

LINKAGE FACTORS

No single factor governs the loss of mangrove ecosystems in the delta. Interactions between man and environment always produce a complex 'building of factors' linked and influencing each other. The interactions not only link each other today, but they are also link with the past and are pushing continuously to the future and never set back. And man has central roles in these interactions where the future depends on. Thus, the changes of mangrove ecosystem in Mahakam Delta in last two decades are linked 'backward' with the history of the delta and the people involved in the past. The current situation links 'upward' with the local governance or regulatory systems and the influencing external factors and 'downward' with the social, economical and cultural condition of the people living in the delta.

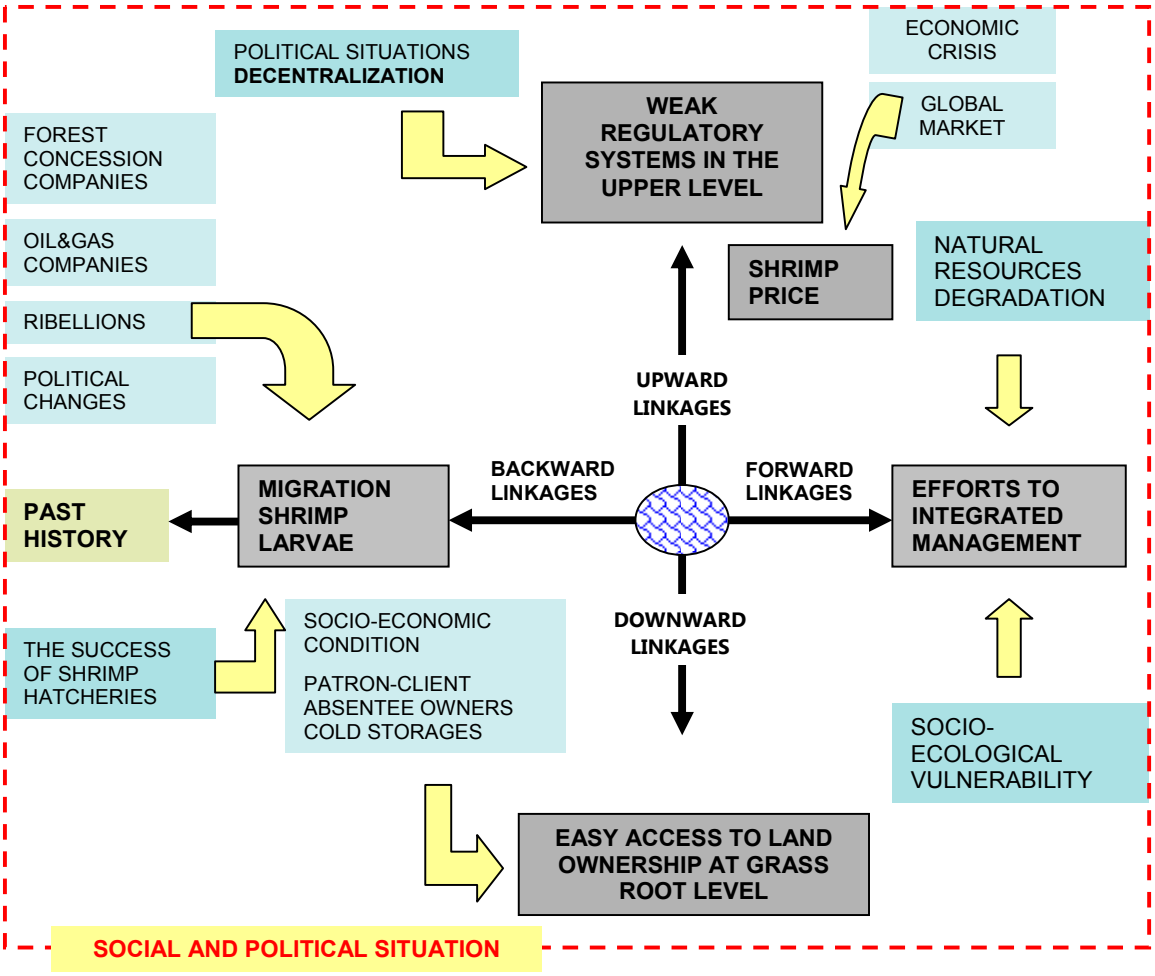


Figure 8. Linkage factors of mangrove loss and shrimp development in the frame of social and political situation in Mahakam Delta.

Problems emerging from the loss of mangrove ecosystem have forward linkages in the form of environmental degradation and socio-ecological vulnerability and people should learn a lesson as to how to manage the delta in a more sustainable manner for a better life in the future. All factors are influenced by the framework of social and political situation of the country over time. Factors that linked to the changes of mangrove ecosystem in the delta are illustrated in the figure below (**Figure 8**).

The loss of mangrove ecosystem in the Mahakam Delta or even elsewhere in this planet 'is not a problem of environmental biophysics', but it is really a social problem. Therefore, all governance and regulatory systems set up in order to regulate the sustainable use of natural resources should be in the framework of 'social development' or social transformation to a higher understanding, awareness and consciousness.

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