Investigation of the Steps Needed to Rehabilitate the Areas of East Kalimantan Seriously Affected by Fire

GTZ-PN: 38.3021.3 – 11.000
ITTO: PD 17/87 (F)

Effects of the Forest Fire 1982/83 in East Kalimantan on Fishery and Hydrology

Sarwono
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Preface

The present report has been compiled for the project entitled "Investigation of the Steps Needed to Rehabilitate the Areas of East Kalimantan Seriously Affected by Fire". This project was carried out by the Indonesian Ministry of Forestry and Balai Penelitian Kehutanan (Forestry Research Institute) of Samarinda and financed by ITTO (International Tropical Timber Organization) and the Government of Indonesia.

The Deutsche Gesellschaft fuer Technische Zusammenarbeit (GTZ) GmbH, was charged by the Indonesian Government with the implementation of the technical assistance. On behalf of the GTZ the DFS Deutsche Forstinventur-Service GmbH carried out the study.

The present report was revised and supplemented by W. Schindele, team leader of the above mentioned project.
1. Introduction

In 1982/83 a serious drought related with the southern oscillation of El Nino, affected the southeast Asian region. East Kalimantan, one of the four Borneal provinces in Indonesia, was seriously affected and extensive forest fires burned about 3.2 million ha of which 2.7 million ha were forest lands.

The Middle Mahakam Area, which was very badly affected by fire (see Figure 1: Location of the 1982/83 forest fire), is the most important region for freshwater fish production in East Kalimantan. About 20 000 to 35 000 tons of fish have been landed annually since the 1970's. Fishery is a very important source of income in this region; out of the 240 000 inhabitants of Mahakam Tenga, Kutai District, 40 000 are fishermen.

Both drought and fire influenced the hydrology of the rivers and lakes, which in turn affected fishery. In 1983 a considerable drop in the fish catch was observed, which was definitely related to the low water level during the drought as well as the change in water quality through infiltration of ash and humin acids with the first rains.

The present study is an attempt to compile the informations available on the effects of the drought and fire on hydrology and fishery.
Fig. 1: Location of the 1982/83 forest fire
2. The Study Area

The Middle Mahakam Area was selected as the study area for several reasons. First, it is the main producer of fresh water fish; secondly, it was the only area where reliable information was available; thirdly, this area was very badly affected by drought and fire. To a limited extent the results are representative of the other areas of East Kalimantan affected by fire.

The Middle Mahakam Area is the central partition of Kutai and has an area of about 18 000 square kilometers. Of these 1.8 million ha, about 500 000 ha are seasonally inundated swamp forests, about 50 000 ha are permanent swamp lands, 36 000 ha are seasonal lakes and about 13 000 ha are rivers, meaning that about one-third of the area is either permanently or seasonally flooded. (Christensen, et al, 1985). This is the area that is of interest to fishery, being the maximum flooded area of the Middle Mahakam, i.e. its floodplain.

According to Christensen, et al (1986), the following ecotypes can be distinguished:

Swamp Areas

Swamp areas are those areas which are either seasonally or permanently flooded. Generally they have thick peat layers beneath thick stands of trees and/or swamp grasses and are generally fairly inaccessible. The constant presence of decaying plant matter results in high humic acid levels in the water. PH and oxygen levels are thus generally very low. Productivity is also low, predominantly amongst air-breathing blackfish (Welcome 1979), e.g. biawan, gabus, keli, penang, pepuyu, sepat and sepat siam. These swampy areas can be subdivided again as follows:

- permanent swamp forest: Typically very black water with a very low nutrient load, low pH (5-6) and a high humic acid content. The water is often stagnant, especially in the dry season and has low oxygen levels. It is difficult to access, except during very high flood periods.

- annually inundated swamp forest: During the first flooding, the water colour is "white"; oxygen levels are high yet pH levels are normal. These levels change within a short period of time (2-4 weeks), however, when blackwater conditions prevail. During highwater periods, access is often possible by canoe, as the undergrowth is submerged below water.
- **permanent swamp**: Typically extremely poor quality blackwater, with even lower pH and oxygen levels than in the swamp forests, such areas being covered by various floating grasses, water hyacinth, salvinia etc., which clog them up. Access is often very difficult yet canals into these areas can be and are cut, to permit access to open areas (either natural or man-made), where fish congregate as they come to the surface to breathe.

- **annually inundated swamp**: The same pattern of change in water quality is observed here as it is for the seasonally inundated forests. Access is similar to that of the permanent swamps.

**Open lakes:**

There are many lakes in the area, ranging in size from the largest Lake Jempang, with a total area of 14 600 ha, to some that only are a few hundred hectares in size. They are seasonal in character with maximum water depths of between 7 and 8 meters at peak flood conditions. They exhibit a variety of physical conditions, but can broadly be classified as follows:

- **blackwater lakes**: Blackwater lakes have normal oxygen and slightly lower than normal pH levels in spite of their getting their water from swampy areas. The largest is Lake Melintang (8 900 ha). As in all lakes, salvinia and water hyacinth can become problematic at times, choking off waterways, but this only generally occurs when the flood season has been too long and the weeds have not been "swept out" by the falling water as water levels recede.

- **mixed water lakes**: Most of the lakes belong to this category, e.g. Lake Semayang (10.300 ha). The water quality varies between being almost pure blackwater to being almost pure whitewater, depending on the season (white when the water level rises and black when it falls), or on the amount of river and swamp water entering the individual system. Almost pure blackwater and pure whitewater conditions are often found in a single lake, corresponding to nearby rivers/swamps. This type of lake generally tends more and more to being blackwater as the flood season progresses, as little or no water enters from the rivers flooding their banks. Plankton levels are generally low, but blooms can be observed, at the interfaces between white and black waters.
- **oxbow lakes**: These are old riverbeds or "arms" of rivers that have been cut off from the main river. They are small, mainly whitewater to mixed-water in character in the upper river reaches or blackwater in the lower river reaches and generally productive with many young/larval fishes.

**Rivers:**

These are medium productive, dominated by whitefish, e.g. belinda, jelawat carp, lempam carp, patin etc. and can be subdivided as follows:

- **slow-flowing, large rivers**: The main river Mahakam and the lower reaches of the Belayan and Kedang Kepala rivers belong to this ecotype. Water colour is generally "white", with a high sediment load and stable physical conditions. The water turns "red" and oxygen/pH levels fall off during the end of the flooding conditions, when water levels fall and the blackwater lakes and swamps are drained. Driftwood is common and sometimes floating vegetation (water hyacinth and grass mats), when flushed out of lakes and swamps, is observed.

- **fast-flowing large rivers**: This ecotype includes the upper reaches of all main rivers. Currents are strong, water levels rise and fall very rapidly (sometimes as much as 3 m in 36 hours) and oxygen/pH levels are good. Riverbanks are often steeply undercut and sandbanks are commonly observed.

- **blackwater rivers**: These are rivers draining catchment areas primarily composed of swamps and, as such, have physical conditions very similar to swamps, although fish are more common probably due to the higher oxygen levels. Floating mats of vegetation are often observed, with large numbers of birds using these to prey on young fish sheltering under them, e.g. Javanese swamp herons and giant egrets. As this is usually not found under similar conditions in whitewater rivers, then it may be that juvenile and/or small species of fish occur in this ecotype in larger numbers than usual - preliminary catches with the fish larvae net back this up.

- **small rivers**: These do not play an important role, due to their small size and their infrequency in the Middle Mahakam area. Therefore, they will not be further considered.
3. Source of Information

Information was obtained from various reports as listed in the references. Additionally, numerous interviews with fishermen, farmers, boatmen and officials of fishery were conducted based on questionnaires (Mayer, 1989).

4. Effects of Drought and Fire on Hydrology

Drought and fire have influenced the hydrology of the Middle Mahakam Area directly and indirectly. Drought creates fluctuations in the water table through lack of precipitation as well as decreased inflow of water from tributaries. Fire has completely changed the vegetation cover and the water retention capacity of the forested areas. Also, by exposure of the soil in burned areas, the erosion rate was considerably increased during the initial years after the fire, thereby increasing the sedimentation rate considerably in lakes and rivers.

4.1 Drought

Although East Kalimantan is located in the equatorial zone (its capital city, Samarinda, is situated almost exactly under the equator) and is marked by a tropical climate, there are seasonal changes in precipitation. Especially during the period from July to September there is much less precipitation (see Figure 2: Mean annual rainfall versus rainfall 1982/83 at Kota Bangun) causing fluctuations in the water table of rivers and lakes.

In addition to these seasonal dry spells, drought occurs periodically every 3 to 5 years in connection with the southern oscillation of the El Nino, a current of the Pacific Ocean. These droughts, however, are not very severe and the ecosystems are very well adapted to such changes. Yet, there is another periodicity in droughts, also related to the El Nino Southern Oscillation which occurs every 90 to 100 years. These droughts are very severe. During the 1982/83 drought only 33 % of the average annual precipitation was measured at Kota Bangun (see Figure 2). Figure 3 shows the fluctuation of the Mahakam River at Kota Bangun Station for the period 1980 to 1985. The low water level during the 1982/83 drought is significant.
Fig. 2: Mean annual rainfall versus rainfall 1982/83 at Kota Bangun

Rainfall (mm)

Month

Mean annual rainfall
Rainfall 1982/83
Fig. 3: Fluctuation of the Mahakam River at Kota Bangun

Bankfull level
In areas close to the Mahakam River, the fluctuations of the water table remained lower than in the upper part and the tributaries. In many of the smaller rivers, the water table sunk considerably, making sometimes even local transportation by Kentinting impossible (Mayer, 1984).

Many lakes also dried out completely, such as the Jempang lake, and it is reported that people used motorbikes to cross the river instead of boats.

The fluctuation of the lakes and rivers is related very closely with precipitation levels in the upper regions.

The decline of the water table in the swamp areas also affected the forest vegetation. In large areas the peat became dry and combustible and huge areas of swamp forests burned.

4.2 Fire

Tropical rainforest ecosystems have a very high impact on the hydrology of rivers and lakes; they retain precipitation and release it slowly and continuously. Swamp forests, in particular, act like a sponge. During dry spells, the retained water from the forest ecosystems helps to equalize fluctuations in the water table. Also, the soil is protected from erosion and the rinsing away of nutrients and organic matter is prevented as rainwater never falls directly on the bare soil.

The forest fires following the 1982/83 drought destroyed 2.7 million ha of forest land. Especially logged over forests and peat swamp forests were very seriously affected. The total forest cover was destroyed, while former primary forest areas were just lightly disturbed.

After the fire, the bare forest soil was covered by ash, carbonized twigs and branches and rotten debris. The first heavy rains eroded the exposed forest soil quite heavily. Remaining topsoil, ash, twigs, branches and rotten debris were washed away and drained into the river. During the first month after the fire the colour of the river changed into a black-brown (personal communication) and water quality was affected.
The water in peat swamps became black, but remained clear in the burned areas which can be explained because after the fire active carbon was formed which absorbed dissolved organic carbon. Oxygen levels decreased and the pH value of 1983 was higher compared with 1982 or 1989 (but less than 1987). Table 1 compares the water quality of the Mahakam River over several different years.

**Table 1: Water quality of the Mahakam River at Kota Bangun**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>May 1981 (TAD)</th>
<th>Febr.1982 (Sarwono)</th>
<th>1983 (Christensen)</th>
<th>June 1989 (Sarwono)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air temperature (°C)</td>
<td>33</td>
<td>31</td>
<td>32.5</td>
<td>33</td>
</tr>
<tr>
<td>Water temperature (°C)</td>
<td>34</td>
<td>30</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>Transparency (cm)</td>
<td>32</td>
<td>60</td>
<td>-</td>
<td>60</td>
</tr>
<tr>
<td>Conductivity (cm)</td>
<td>35</td>
<td>-</td>
<td>-</td>
<td>18</td>
</tr>
<tr>
<td>pH</td>
<td>7.4</td>
<td>6.4</td>
<td>7.1</td>
<td>6.6</td>
</tr>
<tr>
<td>Oxygen (mg/l)</td>
<td>6.9</td>
<td>7.5</td>
<td>6.1</td>
<td>7.2</td>
</tr>
</tbody>
</table>

According to fishermen, the river surface was more fully covered by waste and debris in the period from 1984 to 1986 than before, while the disturbance by Iilia was less.

The continuous erosion during the first years after the fire lead to an increase in the sedimentation rate from the normal 10 - 12 cm per year to 13 - 17 cm per year in lakes like Tempatung Ma’au, Sirau and Seguntur, while in lakes such as the Semayang and Melintang the sedimentation rate remained stable. According to the opinion of local fishermen muddy water flows out of these lakes during heavy rains, while in the other lakes, like Jempang, this is not the case. This is due to the intensity of water circulation. Also, village people observed that the sedimentation rate increased in lakes with shrubby shores. The water depth in smaller rivers, however increased. This is due to the use of motorboats which increases turbidity.

Undisturbed tropical rainforests have a high water retention capacity. The multi-storey structure of the rainforests retains most of the precipitation in the canopy, only a part reaches the forest floor. Via evapo-transpiration much of the received precipitation is released into the atmosphere. The rainwater which reaches the forest floor infiltrates
the soil and is drained off slowly into the rivers. Thus, the forest is able to act as a buffer. During heavy rains, water is retained and during droughts water is released. The effect of the swamp forest in particular can be compared with a sponge. The uniform, one-storey secondary forests have much lower water retention capacity; a great share of precipitation is washed away superficially. The buffer effect is almost lost.

After the fire, the period of low water table levels in rivers and lakes was extended to about 5 month. Also, the fluctuations of the water table reacts more quickly on precipitation. High and low water peaks are much more common (personnel communication). For the lakes the infiltration rate was decreased after the fire for about 50%. This might be due to the fact that in the burnt area the precipitation is drained off quickly into the lower areas, thus increasing fluctuation.
5. Effects of Drought and Fire on Fishery

Fish populations in the Middle Mahakam Area are adapted to seasonal drought conditions. When the water table of the lakes and small rivers declines during the period July to September blackfish flee into the peat swamp forests. They survive in holes under large trees, which are covered with water even during dry spells (see Figure 4) and are easily caught when the tree is felled. This catch method has become very popular through the advent of the chainsaw. Catches weighing 50-100 kg per tree are very common (Christensen, et al, 1986).

The severe drought of 1982/83 also affected the peat swamp forests. The peat dried out down to a depth of up to 1 m and thus affected the refugium of blackfish. Forest fires damaged 385,000 ha of swamp forests and, today, 110,000 ha have to be classified as open swamps. It can be assumed that all the blackfish in the burned areas were exterminated.
Fig. 4: Blackfish surviving drought under tree trunks in peat swamp forest
Whitefish, in contrast to blackfish, fled into large rivers when the water table became too low. During and after the drought, fishing pressure was considerably increased as people were forced to search for other food sources, as rice, cereal and vegetable harvests were partly lost by the effects of the drought. As a result whitefish represented the favoured catch during the 1982/83 drought.

The 1982/83 drought and fire, as well as the overfishing in the Middle Mahakam area which began in 1983, created considerable changes in fish species diversity and population structure (Christensen, et al, 1986). Some fish species like the Notopterus (belinda) and the Pangasius (patin) disappeared completely from the market, while other species started to breed at much smaller sizes, like the Thynnichthys (kenida) and the Puntius schwanefeldii (lempam). Overfishing is mainly due to the introduction of gillnets. Figure 5 reflects the production of fish in the Middle Mahakam area from the early 50's to 1986. Fish catches were reduced when many fishermen entered the timber industry during the 1960's. The marketshare of nine out of 15 fish species declined dramatically.

While the production of blackfish declined in 1983, it has remained steady since then. This can be explained by the fact that in inaccessible and isolated unburned parts of the peat swamp forests, residual blackfish populations survived. The production of whitefish however declined steadily (see Figure 6).

Fig. 5: Fish production in Middle Mahakam Area from 1952 to 1985

(Source: Christensen, 1986)
Fig. 6: Production of blackfish and whitefish at central landing stage in Samarinda for the period 1980 to 1985

Production of blackfish

Production in tons

Production of whitefish

Production in tons

Year

- Baung
- Jelawat
- Lempam
- Pahat
- Patin
- Belida

(Source: Christensen, 1988)
Due to the continuous overfishing the catches per man-hour and man-year decreased considerably.

Table 2 shows the production of various fish species at TPI Samarinda Sebarang for the period 1980 to 1984.

<table>
<thead>
<tr>
<th>Fish species</th>
<th>Production in tons</th>
<th>Percentage of species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gabus</td>
<td>478</td>
<td>210</td>
</tr>
<tr>
<td>Biawan</td>
<td>133</td>
<td>122</td>
</tr>
<tr>
<td>Sepat Siam</td>
<td>72</td>
<td>84</td>
</tr>
<tr>
<td>Jelawat</td>
<td>50</td>
<td>79</td>
</tr>
<tr>
<td>Lempam</td>
<td>27</td>
<td>72</td>
</tr>
<tr>
<td>Puyau</td>
<td>6</td>
<td>51</td>
</tr>
<tr>
<td>Baung</td>
<td>32</td>
<td>67</td>
</tr>
<tr>
<td>Pahat</td>
<td>10</td>
<td>51</td>
</tr>
<tr>
<td>Patin</td>
<td>21</td>
<td>54</td>
</tr>
<tr>
<td>Pepuyu</td>
<td>35</td>
<td>63</td>
</tr>
<tr>
<td>Belida</td>
<td>17</td>
<td>50</td>
</tr>
<tr>
<td>Betutu</td>
<td>0</td>
<td>41</td>
</tr>
<tr>
<td>Keli</td>
<td>25</td>
<td>32</td>
</tr>
<tr>
<td>Lais</td>
<td>33</td>
<td>55</td>
</tr>
<tr>
<td>Others</td>
<td>19</td>
<td>61</td>
</tr>
<tr>
<td>Total</td>
<td>958</td>
<td>1092</td>
</tr>
</tbody>
</table>

In the TPI area of Samarinda Sebarang, the production of peat swamp fishes like Sepat Siam and Pepuyu was significantly decreased in 1983, while the production of the lake fishes Jelawat, Lampan, Belida and Pahat were successively decreased since 1982.

Besides the destruction of the peat swamp forest habitat, which affected the blackfish population solely in 1983, drought and fire affected the breeding of all fish species through reduced water table and a change in water quality. Fish ponds, which depended on surface water, completely dried out.
In 1984, a bacterial fish disease infected all fish species except the Baung hitam. Most heavily, however, those species were infected which were cultured in floating cages like the Gabus, Keli, Penang and Sebat. The disease was almost certainly imported from Java, where a similar outbreak occurred in 1980/81 (Christensen, et al, 1986). A correlation between the outbreak of this disease and the incident of drought and fire cannot be identified, however, the fish population had already been weakened and the bad water quality, perhaps, led the fish population to become less resistant.
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