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The effect of anthropogenic changes on the sustainability of eastern sumatran floodplain fisheries resources

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Abstract. Every human (anthropogenic) activity along a river system has potential to influence on quantity and quality of aquatic environment and its organisms. Few studies have been conducted to evaluate the effect of these activities on fisheries resources. This paper examines the effect of anthropogenic changes on floodplain ecosystem of Eastern Sumatran fisheries. Fisheries data presented in this paper are derived from a desk study and multi-year field surveys conducted in three provinces; these were Giam Siak Kecil (GSK), Riau Province, and Batanghari River, Jambi Province (2010 to 2016) and Lempuing River, South Sumatra Province (2011-2013, 2016). In GSK, the results showed that there was a tendency for fish size to decrease along the river with decreasing riparian forest and increasing fishing intensity. In the Lempuing floodplain, fisheries degradation had occurred as a result of human activities such as conversion of land area for plantation, unpredictable flood pulses due to the Perjaya irrigation dam, high fishing intensity, and the use of un-friendly fishing gear. The number of fish species, here, decreased dramatically from 90 species in 1981 to 32 fish species in 2011, a decrease of 60% over three decades. In addition, total fish production decreased from 60 tonnes per year before 1996 to 12 tonnes per year in 2012, while the number of uneconomical and small sized fish caught increased. Decreases in fish diversity, size and catch rate were found in Jambi. Fish composition was dominated by small size blackfish (snakehead, climbing perch and Asian redbtail catfish). Anthropogenic activities contributed significantly to the degradation of floodplain fisheries resources, especially in relation to a decrease in forest cover due to fires that occurred between 1996 and 2000. An integrated management plan should be considered in the long term to support the Sustainable Development Goals for floodplain fisheries.

1. Introduction

Various types of habitat form along meandering rivers. These include pools and riffles in the main river from the upstream to downstream, and floodplain areas located along the middle to the downstream sections [1] [2]. The floodplain area, known as an ecotone zone, is a transition area between ecological communities [3] in long and large meandering river systems. The floodplain, itself, consists



of several ecosystem types, including river channels, floodplain savanna, floodplain forest and floodplain pit or pool [1].

In Indonesia, especially in South Sumatra Province, natural floodplain is known locally as *lebak lebung*. It consists of various ecosystems including main rivers, floodplain pits (*lebung*), floodplain savanna (*lebak*), floodplain forest (*rawang*) and upland (*talang*) [4] [5]. With the exception of upland, most of these ecosystem types are influenced by the progress of the flood cycle. Seasonal pulsing of river flows, or flood pulsing, has an important role in the biogeochemical cycle [6] and affects the productivity of fish and other aquatic organisms in river floodplain systems [7]. In addition, it provides shelter, spawning grounds, and *refugia* during the dry season, for the resident floodplain fish [1]. Fish production in Indonesian floodplain habitats is four times higher than that in the main river [8], and these fish resources have been exploited through the *lebak lebung* auction system since 1630 [9].

Floodplain fish resources are more vulnerable than other aquatic systems because of their higher fish production and exploitation [10]. As a result, the fish resources of inland waters, including floodplain ecosystems, have tended to decrease in several places [11]. Degradation of floodplain fisheries is not only a result of fisheries activities, but also a result of pressure from other human (anthropogenic) activities such as land conversion [12] and the construction of reservoirs in the upper parts of floodplains [7][10][13]. Some changes have led to alterations in the flood regime [13][14] and the extensive ecological degradation of aquatic systems, making them no longer able to sustain the provision of goods and services. Such changes include water quality degradation, intense flooding, and variations in the distribution and structure of aquatic biota [7] [14]. A previous study [6] indicated that the damming of rivers induced vegetation changes in the floodplain towards more woody plants and phytoplankton production because it added nitrogen-rich organic matter to the river system downstream.

At present, there is limited information on the effect of anthropogenic activities, such as ecosystem regime shifts, dams, reservoirs and channelisation on fisheries resources especially in floodplain areas. However, this information is needed to support the sustainable management of floodplain fisheries as part of the implementation of Sustainable Development Goal (SDG) number 14 (Life Under Water) and, in relation to this, Indonesia Presidential Regulation Number 59 Year of 2017, which aims to protect, restore, and increase the sustainable use of terrestrial ecosystems, manage forests in a sustainable way, stop desertification, restore degraded land, and halt biodiversity loss on dry land in line with obligations based on the international agreement. The objective of this study was to obtain information on anthropogenic changes and their effect on floodplain fisheries in the rivers that flow into the estuary of Eastern Sumatra.

2. Methodology

2.1. Data collection

This study was focused on floodplain areas of large, meandering rivers that flow into the estuary of Eastern Sumatra. These rivers are located in three provinces; Giam Siak Kecil (GSK), Riau Province; Batanghari River, Jambi Province; and Lempuing River, South Sumatra Province (figure 1). Data on anthropogenic changes, such as shifts in water regime, damming and channelisation of the floodplain, were compiled through a desk study and interviews with local people who had more than 5 years experience as fishermen.

Data on the effect of anthropogenic change on fisheries, in terms of fish diversity, exploitation, and catch were collected through a desk study and field surveys conducted in 2011-2013 and 2016. To determine the rate of fish exploitation, biological data such as fish weight, length and gonad maturity were collected from several dominant fish species in each river in 2016. Fish collected from Lempuing River, Batanghari River and Siak River were Asian redbtail catfish (*Hemibagrus nemurus*), sheathfish (*Kryptopterus* sp) and kissing gouramy (*Helostoma temminckii*).

In Jambi Province, the fish comprised snakeskin gouramy (*Trichopodus pectoralis*) and snakehead (*Channa striata*), while in the Musi River they comprised snakeskin gouramy (*Trichopodus pectoralis*), Asian redbtail fish (*Hemibagrus nemurus*) and climbing perch (*Anabas testudineus*).

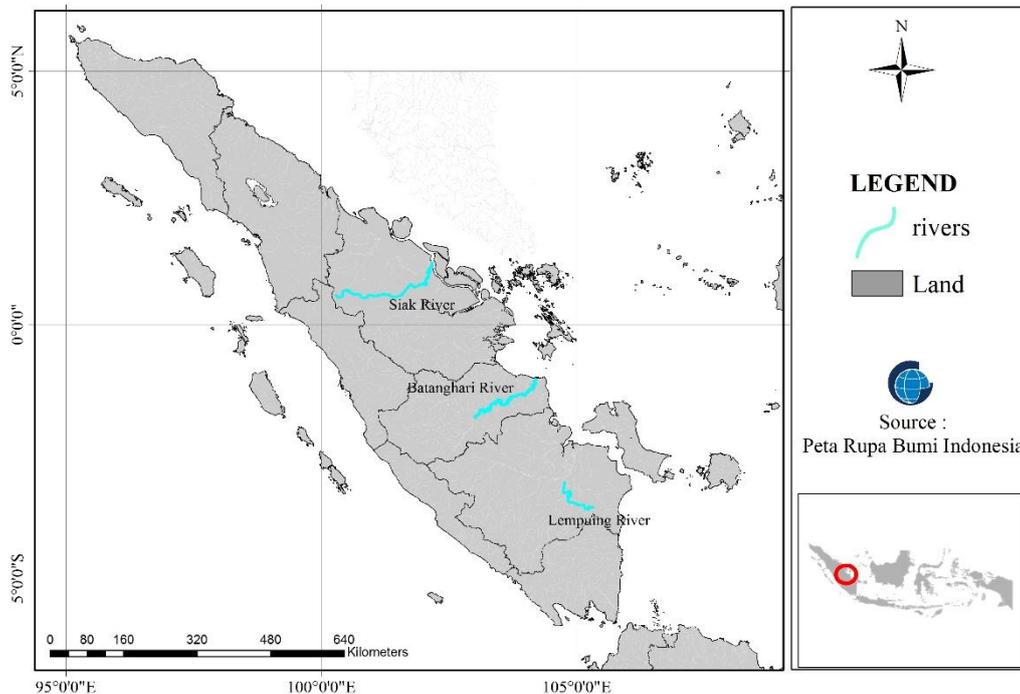


Figure 1. Map of study area showing rivers flowing to the eastern part of Sumatra

Fisheries biology data (length-weight; gonad maturity level), fish species composition, fishery activities and habitat were also obtained through field survey as primary data. Secondary data was collected from universities and research institutions.

2.2 Data analysis

Information on anthropogenic change were analysed descriptively, while fisheries data (e.g. exploitation rate) were analysed using Spawning Partial Ratio (SPR) [15]. SPR is one of the tools that is used to determine fish resource management needs. It is calculated from the length frequency distribution, weight and gonad maturity level of the fish.

3. Anthropogenic Changes in Eastern Sumatran Floodplain Areas

Activities identified as the causes of deforestation included more intensive felling of natural forests during timber concession; the conversion of forest areas for use by other sectors such as agricultural expansion, mining, plantations and transmigration. This results in unsustainable forest management, illegal logging, encroachment and illegal land occupation. The peak in deforestation occurred between 1996 and 2000 shown in Figure 2 resulted from forest fires [16].



Figure 2. Indonesia deforestation trends, 1990-2017 [16]

In Riau Province, approximately 363,554 ha, or 67.8%, of the forest in the Siak watershed had been converted to other forms of land use over a period of 15 years (figure 3). This change in land use is significant, because this equates to a rate of forest conversion of about 2020 ha per month. The significant shift in land use within the watershed of this river affects water availability, decreases its areas of forest and increases its areas of plantation [17]. A decrease in peatland forest also occurred in the Giam Siak Kecil-Bukit Batu area, except the issues of environmental pollution [18], at least 1500 ha of peatland forest were completely converted to bare land between 2002 and 2008 [19] (figure 3).

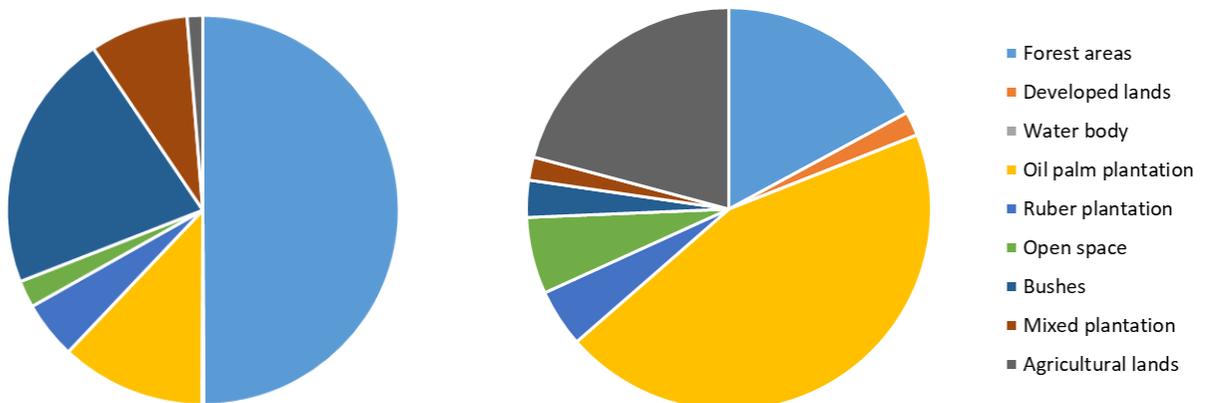


Figure 3. Land use changes in Siak Watershed between 1990 (left) and 2005 (right) [17]

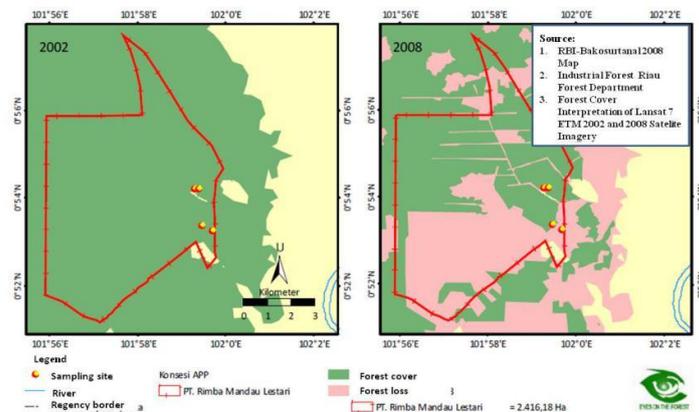


Figure 4. Change in peatland forest cover of Giam Siak Kecil-Bukit Batu Riau between 2002 and 2008. Modified from a published map [19]

In the Kampar River, land-cover changed between 1990 and 2016 [18]. The largest land-cover change occurred in agriculture/plantations (11.58 ha/year), building/settlement (48.11 ha/year) and scrubland (30.88 ha/year) (table 1). Other types of land cover, such as bare land and areas of sediment deposition, varied every year. These changes in land cover caused changes in the river corridor additionally. Even though the main contribution of the changes of river corridor caused by erosion and sedimentation that is not stable in the middle of the river or further downstream [18].

Table 1. Land cover within the catchment of the Kampar River and Estuary

Land cover type	1990	2007	2010	2016	Total	Rate (ha/year)
Agriculture/plantations	0	82.88	92.85	125.3	301.03	11.58
Scrubland	281.36	180.99	188.89	151.69	802.93	30.88
Bare land	14.36	15.73	24.23	27.23	81.55	3.14
Settlements	152	173	513	413	1251	48.11
Sedimentation area	12.83	2.87	1.58	3.29	20.57	0.79
Bodies of water	24.02	31.13	36.4	36.55	128.1	4.93
Frame/empty data	11.84	30.65	0	0	42.49	1.63

Source: Landsat imagery [18]

In Jambi Province, the floodplain area spreads along the middle of the Batanghari River from Teluk Kayu Putih, in Bungo Tebo Regency, to Suak Kandis, in Tanjung Jabung Regency. Deforestation in the Batanghari River drainage area has been on-going since 1985 [20]. High levels of deforestation within critical watershed areas has caused high frequency and intense flooding events during the rainy season. In contrast, during the dry season, there is insufficient water in this area for irrigation and water supply. Deforestation also causes increased rates of erosion, sedimentation and siltation [21].

As in Riau and Jambi Province, changes in forest cover were recorded in the Lubuk Lampam floodplain area of the Lempuing River (a tributary of Komering and Musi River) (figure 5). Landsat TM 5 and TM 7 satellite imagery from 1989 to 2001 showed that forest cover in Lubuk Lampam fell from 1153 ha in 2001 to 74 ha in 2013. The most affected ecosystem in the floodplain was forest, which was decreased to 60.2 ha; the next most affected area was floodplain savanna and floodplain pool, with reductions of 11.2 ha and 3.2 ha, respectively [22]. The establishment of oil palm factories

and river channelisation by oil palm companies are also likely to have influenced changes in water level [23].

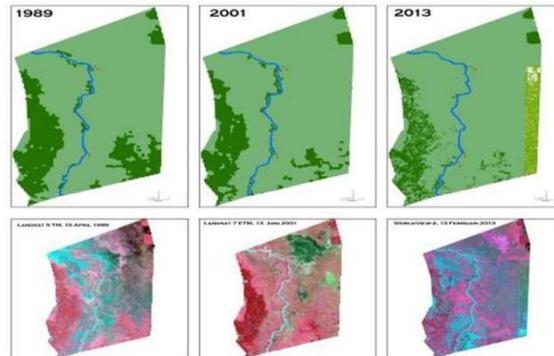


Figure 5. Changes in forest cover on the Lubuk Lampam floodplain of the Lempuing River in 1989, 2001, 2013 [22]

In addition to forest fires, global climate change has also caused changes in rainfall patterns in the Province of South Sumatra. Between 1979 and 2008, the number of wet months (rainfall > 100 mm) has tended to increase, almost there are no dry phase in 2008 (Figure 6). In 2013, the Lubuk Lampam floodplain was negatively affected by the Indian Ocean Dipole (IOD-) which resulted in floods occurring through the year [22].

Physical modification of the Siak Watershed has been affected by two processes, namely the construction of drainage channels for oil palm plantations and the abrasion of the banks of the Siak River due to commercial water transportation activities. The rate of scouring by waves generated by passing ships was $0.01 \text{ m}^3/\text{m}/\text{day}$. Many sources of pollution were found within the Siak Watershed, including oil palm, pulp and paper, rubber remilling, glue factories, docking ports, water transportation, and domestic waste. Oil palm processing factories are located in the upper reaches of the river, at Tapung Kanan and Tapung Kiri River, and these and a pulp-paper processing plant generate waste that greatly affects the water quality of the Siak River. Evidence of this includes increases in total suspended solids (TSS), total dissolved solids (TDS), dissolved oxygen (DO), chemical oxygen demand (COD), and increases in biological oxygen demand (BOD) in June and in TSS, TDS, hardness, alkalinity and COD in August [24]. A significant increase in three parameters (TSS, hardness and conductivity) was found in areas upstream and downstream of the pulp and paper factory. Periphyton were abundant near the pulp and paper factories, where the diversity index of 1.0-2.5 indicated that the Siak River was degraded. In contrast, the abundance of macrozoobenthos in these areas was high ($2000\text{-}6000 \text{ ind. m}^{-2}$), but the dominant species were those with a high tolerance to polluted conditions (*Tubificidae* such as *Aulodrilus plurisetia*, *Aulodrilus paucichaeta*, and *Bothrioneurum vej dovskyanum*).

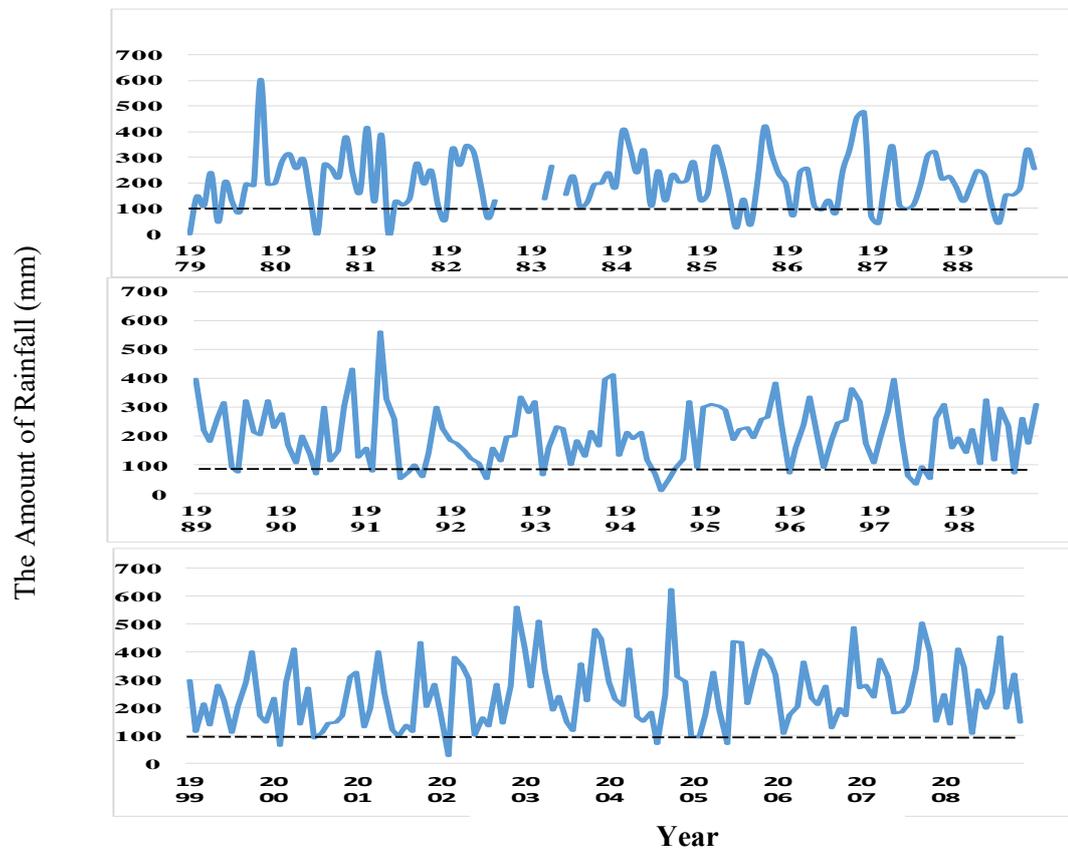


Figure 6. Rainfall pattern in the Province of South Sumatra between 1979 and 2008. Wet months (Y-axis value above the dash line) and dry months (y-axis value below the dash line)

Environmental pollution was also found in the Batanghari River. Here, un-authorized gold mining (PETI) discharges mercury (Hg) into the water, threatening the aquatic animals. Concentrations of Hg ranged between 0.17-0.66 mg/kg), indicating that the Batanghari River is exceeding its water quality standard of 0.3 mg/kg [25]. In addition to intensive fishing, pollution and deforestation have caused other environmental damage, such as loss of riparian vegetation, and this has contributed to the decline of the fish populations [26].

4. Fisheries Resources of the Eastern Sumatra Floodplain

On Eastern Sumatra, the largest decline in fish production was found in South Sumatra Province, where it reached 10.48% (1597 tonnes) of the total production of Sumatra Island. The dominance of small-sized and less economic species is an indicator of pressure on the aquatic environment [27].

Based on catch data, 60 fish species from 12 families and one crustacean (*Macrobrachium rosenbergii*) were found in the lower part of the Siak River [27]. Fish abundance was dominated by Cyprinidae and Engraulidae, and most of the Cyprinidae found were small Cyprinids.

In some rivers with floodplain systems, degradation of the aquatic environment has caused a decline in fish biodiversity. In the Siak River, for example, at least 123 fish species were recorded in 1997 [28]. However, this number had declined progressively to 60-89 species by 2009 [29] and only 26 to 36 species by 2012 [30]. Decrease in fish diversity in the Siak River has been attributed to intensive small-scale fishing and the use of non-selective fishing gear (a filtering device, known

locally as *Gumbang*). The catch by *Gumbang* are dominated by economically important larvae and juveniles of *Pumpus* sp., *Plotasus canius*, *Scomberonomos commersoni*, *Lepturacanthus savala*, etc., almost 58% of the total catch categorized as discards [27].

Similarly, species diversity in the Kampar River has also decreased. In the Kampar Kiri River tributary, only 86 fish species were found [31], while in the Kampar Kanan River tributary only 58 species were found [32], decreasing to 36 species by 2014 [33]. The number of fish in the Koto Panjang Reservoir was lower than in the Kampar River, with only 26 species being recorded [34].

Fish diversity in the peatland floodplain of the Siak Kecil River, GSK, in Riau Province was low and comprised 37-39 species belonging to 12 families [35] [36]. However, a more recent study (2017) has indicated a decrease in the number of fish species to 35 belonging to 17 families [37]. A decline in the populations of *tapah* (*Wallago attu*), *dragon fish* (*Scleropages formosus*), *asian redtail catfish* (*Hemibagrus nemurus*), bronze featherback fish (*Notopterus notopterus*) and *Lepidocephalichthys hasselti* (locally named as *silok*) is also recorded [37]. There are indications that the scarcity of the population is due to intensive fish capture and the use of unfriendly fishing gear and methods, such as stow nets (known locally as *tuguk*), which have mesh sizes of less than 5 cm. Changes in catch per unit effort (CPUE) over the past 10 years has been very significant. One third of fishermen were able to catch 30-100 kg of fish per month in 2005, but by 2015, almost half of these fishermen could catch <30 kg per month. Overfishing has occurred in several areas of the core part of GSK since 2008 (*Tasik Serai Timur*, *Tasik Serai*, *Tasik Betung*, *Tasik Serai Barat* and *Tasik Tebing Serai*).

The floodplain of the Batanghari River in Jambi was a nursery area for the eggs and juveniles of 90 species of fish [38]. However, changes in seasonal flood pattern have affected the number of fish species caught significantly, with the number of species caught in the dry season now 50% lower than in the rainy season. Of these 90 species, *Hampala ampalung* (known locally as *sebaro lalat*), has a high market demand and seems already to have been overexploited, it is now rarely found in fishermen's catches [39]. Other fish species seem to be in a similar situation, with backfeather fish (*belida*), *Pangasius* sp. carp (*lampam*) and wallago (*tapah*) are now difficult to find in the Batanghari River [39]. Declining fish resources in the Batanghari floodplain may be related to the presence of a water gate (regulation dam) that has disconnected the Batanghari River from the Danau Teluk (an oxbow lake). It may also relate to increasing levels of pollution and the loss of riparian vegetation (table 2).

Decreases in fish diversity have also been found in the Lubuk Lampam floodplain of the Lempuing River, a tributary of Komering and Musi River. Between 2008 and 2011, the number of fish species decreased from 48 to 32 species [25]. A diversity index based on the total abundance and relative abundance of aquatic organisms (periphyton, macrozoobenthos, and plankton) indicates that Lubuk Lampam has suffered a medium level of degradation.

The synergistic effect of forest fires, conversion of forest to oil palm and rubber plantation, construction of the Perjaya Dam on the upper Komering River and irrational fishing practices, have reduced fish production and diversity in the floodplain of Lubuk Lampam. Before a significant deforestation event occurred due to forest fires in 1996, fish production in this floodplain during the fishing season, which coincides with the dry season (April to October), ranged from 5 to more than 30 tonnes per year. During the wet season it ranged from one to 10 tonnes per year (figure 7). During the forest fires (1996-1997), fish production, especially during the wet season, was less than that recorded before the forest fires and total fish production decreased from 60 tonnes per year to 12 tonnes per year. Before the 1995-1997 big phenomenon of forest fires in Indonesia, most of the fish production was derived from floodplain savanna and river segment, while after 1997, most fish production was derived from the floodplain savanna and then was followed by floodplain pool, floodplain forest and river segment.

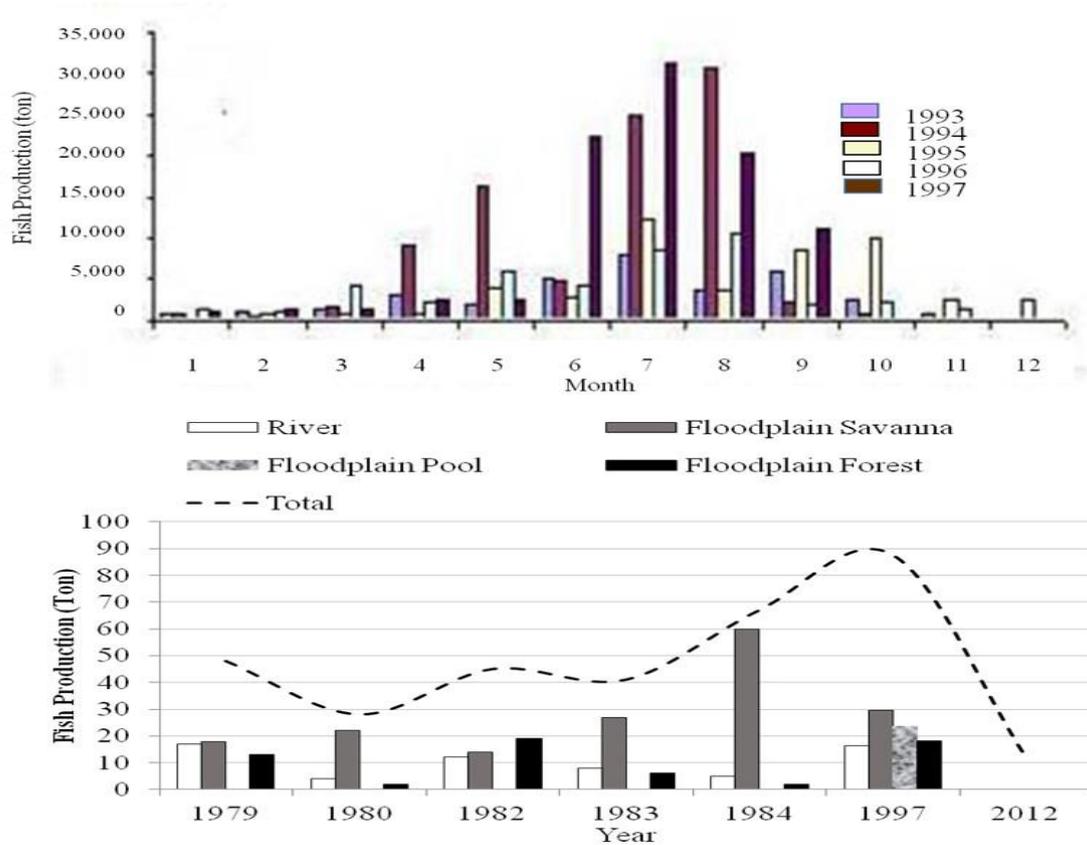


Figure 7. Total and ecosystem type based fish production in the floodplain of Lubuk Lampam, 1979 to 2012. Data are reanalysed from studies undertaken between 1984 and 1997.

In addition to fish production, the composition of fish in the Lubuk Lampam floodplain was affected by other anthropogenic activities, such as the construction of the Perjaya Dam in 1991 and the use of un-ecological fishing techniques (destructive fishing gear and fishing methods). In 1984, most of the fish catch was dominated by snakehead, kissing gourami and snakeskin gourami. However, in 1997, after the Perjaya Dam had been constructed and operated, the composition of fish catches changed. They became dominated by less economically important fish species such as snakeskin gourami, followed by snakehead, three spot gourami, kissing gourami, Asian redbtail catfish, bronze featherback fish, Indonesian snakehead, mixed small fish, mixed small Cyprinids and other fish.

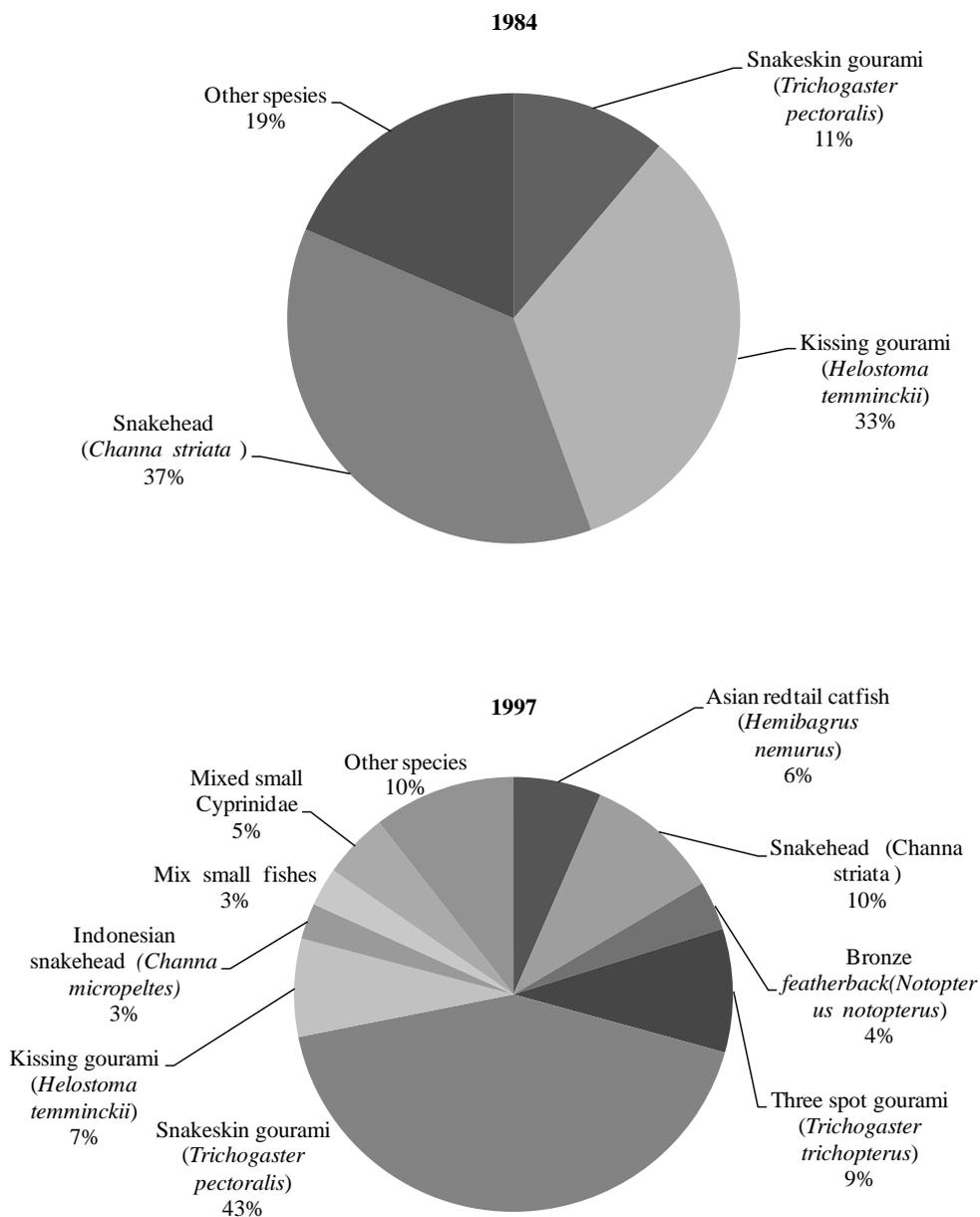


Figure 8. Fish composition of the Lubuk Lampam floodplain before the forest fires (1984) and during the forest fires (1997) (Data from studies undertaken in 1984 and 1997 re-analysed)

Changes in the composition of fish community in 1997 are thought to have been related to the use of the more and different types of fishing gear, the conversion of 66.7 ha of floodplain forest to floodplain savanna, and the decline of floodplain pool habitats between 1989 and 2001 [22]. Unpredicted flood pulses also influenced floodplain hydrology, biological behavior and the successful

reproduction within the floodplain savanna, which subsequently influenced fish catch and productivity in the Lubuk Lampam floodplain.

Most floodplain fishery activities and changes in level of production are related to water level fluctuations (e.g. as associated with flood pulses during the dry and rainy seasons. In addition, [40] states that fishing intensity (number and type of fishing gear) influenced the fishing activity in the Musi River. Furthermore, fishing activities in inland waters are influenced by the dynamics of fish stocks [41]. Although recruitment continues throughout the year, seasonal changes, especially at high and low water levels, can affect the life of larvae and the survival of juvenile fish. Over-exploitation is indicated by the value of the exploitation rate index (E) being greater than 0.5; this value has already been recorded for climbing perch (*Anabas testudineus*) in Lubuk Lampam floodplain [42].

Table 2. Impact of water gates on fish catch in Teluk Lake, Jambi

Type of fishing gear	Number of respondents	Average catch (kg/trip)		Catch condition
		Before dam construction	After dam construction	
Lift net (<i>tangkal</i>)	9	10-50	2-5	80% decline
Seine (<i>pukat</i>)	11	8	2	75% decline
Mini seine (<i>pukat mini</i>)	1	5	4-2	20-60% decline
Hand and Line (<i>tajur</i>)	5	10	1.5-3	65% decline
Tubular trap (<i>gerugu</i>)	3	0.5-1.0	0.3	30-60% decline
Liftnet (<i>Kelong</i>)	2	10	3	70% decline

Source: [35]

In general, fisheries resources in Riau, Jambi and South Sumatra have been over-exploited (as shown by a SPR value of < 30%), apart from snakehead (*Channa striata*) in Jambi Province. The SPR values recorded for the dominant fish in Kampar River, such as Asian redtail catfish (*Hemibagrus nemurus*), sheathfish (*Kryptopterus* sp) and kissing gouramy (*Helostoma teminckii*), are 1%, 2% and 11%, respectively. A very low SPR value indicates that the fish are relatively small in size and have never spawned previously (length at fish captured > length at fish maturity, L_m). Fishing activities have led to a decline in the reproductive ability of grey river catfish and sheathfish (table 3).

Table 3. Exploitation rate of dominant floodplain fish in the Kampar River (Riau), the Batanghari River (Jambi), and the Lempuing River, South Sumatra Province

Fish species	Exploitation status	F/M	L _{m50}	L _{m95}	SPR	SL ₅₀	SL ₉₅
Kampar River							
<i>Hemibagrus nemurus</i>	<i>Over exploited</i>	2.64	36	47	1	12.7	16.2
<i>Kryptopterus</i> sp	<i>Over exploited</i>	5.13	20.2	28.8	2	15	18.6
<i>Helostoma teminckii</i>	<i>Over exploited</i>	4.59	7.8	15.1	11	13.8	16.7
Batanghari River							
<i>Trichopodus pectoralis</i>	<i>Over exploited</i>	6.06	12	18.5	16	14.4	16.3
<i>Channa striata</i>	<i>Moderately exploited</i>	0.48	36.1	61	37	15	18.1
Lempuing River							
<i>Trichopodus pectoralis</i>	<i>Over exploited</i>	4.45	15.8	21.2	4	13	15.2
<i>Hemibagrus nemurus</i>	<i>Over exploited</i>	1.73	39	50	2	17.1	22.6
<i>Anabas testudineus</i>	<i>Over exploited</i>	7.89	13.7	23.9	2	10.8	14

Note: L_{m50} and L_{m95} are fish lengths at 50% and 95% maturity; F/M is the instantaneous rate of fishing mortality; SL₅₀ and SL₉₅ are the standard fish lengths of 50% and 95% of the catch

The ecological and fisheries resources issues that are developing in the Eastern Sumatra floodplain are related to the fact that many sectors compete, here, for aquatic and land resources. From a government perspective, the role of fisheries sectors in generating gross domestic product (GDP) is low and this puts the fisheries sector into a weak negotiating position within the national development program. In fact, inland water resources are more important to the food security of rural people than the GDP of the country. Also, Indonesia is an archipelago country where inland fisheries are scattered and their resource management is habitat specific. So, inland fisheries resources management needs to be supported by good coordination and synergistic relationships between all sectors at national and local government levels to be successful. However, the main issue that affects inland fisheries management as it currently exists is the opposite of this, as in the case of GSK, Riau [36]. For this reason, achieving sustainable inland fisheries in the future requires the strengthening of network, coordination and synergies within inland resources development programmes to become a high priority at national and local level.

5. Conclusion and Suggestion

The degradation of aquatic ecology and fisheries resources of the Eastern Sumatran floodplain relates to natural disturbance, and anthropogenic activities associated with fisheries and non fisheries sectors and global climate change. Anthropogenic activity that has contributed to the degradation of floodplain fisheries includes decreased forest cover as a result of forest fires that occurred between 1996 and 2000. The subsequent conversion of floodplain forest to floodplain savanna reduced floodplain pools and create unpredictable flood pulses within the floodplain hydrology. Decreases in fish diversity, fish composition, fish size and fish production have been recorded in the three main river floodplain of Riau, Jambi and South Sumatra Provinces. The creation of an integrated management plan should be considered for this area to support the global SDGs associated with floodplain fisheries.

6. References

- [1] Welcome R L 1985 *River Fisheries* FAO Technical paper **262** Rome: FAO
- [2] Cowx I G and Welcomme R L 1998 *Rehabilitation of rivers for fish* FAO and Fishing News Books Ltd
- [3] Kark S and Renburg B J 2006 Ecotone: marginal or central areas of transition *Israel Journal of Ecology & evolution* **52** 29-53
- [4] Arifin Z 1978 Beberapa aspek penangkapan ikan di perairan umum Lubuk Lampam *Simposium Modernisasi Perikanan Rakyat* p 31
- [5] Utomo A D 2016 Management strategies for fisheries reserve in Sumatera and Kalimantan floodplain (in Bahasa) *J.Kebijak.Perikan.Ind.* **8** 1 14-20
- [6] Zuijgeest AL, Zurbrugg R, Blank N, Fulcri R, Senn D B and Wehrli B 2015 Seasonal dynamic of carbon and nutrients from two contrasting tropical floodplain system in the Zambesi River basin *Biogeosciences* **12** 7535-47
- [7] Husnah, Wijaya D and Arsyad MN 2007 Bendung Perjaya (Upper Komering): Peran dan Masalahnya Terhadap Sumberdaya Ikan di Sungai Komering Prosiding Kongres Ilmu Pengetahuan Wilayah Indonesia Bagian Barat C101-108 (in Bahasa)
- [8] Utomo A D and Ondara 1987 Pendugaan parameter pertumbuhan ikan sepat siam (*Trichogaster pectoralis*) di Lubuk Lampam Sumatera Selatan *Bull. Penel. Perik. Darat* **6** 1 37-41
- [9] Firdaus M and Huda HM 2009 *Karakteristik sosial ekonomi pemanfaatan sumber daya perairan sungai dan rawa banjir di Sumatera Selatan* (Balai Besar Riset Sosial Ekonomi Kelautan dan Perikanan)
- [10] Nizar M, Kamal M K and Adilaga E M 2014 Komposisi jenis dan struktur komunitas ikan yang bermigrasi melewati tangga ikan pada bendung Perjaya, Sungai Komering, Sumatera Selatan *Depik* **3** 1 27-35

- [11] Nurdawati S, Wiadnyana N N, Muflikhah N, Said A, Ali M and Rais A H 2010 Dinamika populasi ikan rawa banjiran di DAS Musi bagian tengah *Laporan Teknis Balai Riset Perikanan Perairan Umum Palembang*
- [12] Husnah 2008 Potential threat to the floodplain ecosystem of Lempuing River, South Sumatera, in: Hartoto D I, Koeshendrajana S, Kartamihardja E S, Utomo A D and Nasution Z (ed) *Fisheries Ecology and Management of Lubuk Lampam Floodplain Musi River, South Sumatera* (Palembang: Research Institute for Inland Water Fisheries, Ministry of Marine and Fisheries Affairs) pp 149-155
- [13] Agostinho A A, Gomes L C, Pelicice F M, Souza-Filho E E and Tomanik E A 2008 Application of the ecohydrological concept for sustainable development of tropical floodplains: the case of the upper Paraná River basin *Ecohydrology & Hydrobiology* **8** Issues 2–4 205-223
- [14] Poff N L, Allan D, Bain M B, Karr J R, Prestegard K L, Richter B D, Sparks R E and Stromberg J C 1997 The natural flow regime A paradigm for river conservation and restoration *Bioscience* **47** 769-784
- [15] Hordyk A, Ono K, Sainsbury K, Loneragan N and Prince 2014 Some exploration of the life history ratio to describe length composition, spawning-per-recruit, and the spawning potential ratio *ICES Journal of Marine Science* Doi: 10.1093/icesjms/fst235
- [16] Agung R et. al 2018 The state of Indonesia's Forests 2018 Nurbaya S, Efransyah and Awang S A (eds) (Ministry of Environment and Forestry Republic of Indonesia) 157
- [17] Sandhyavitri A, Sutikno S and Iqbal M 2015 The changes of land use pattern affect to the availability of water resources in Siak Watershed, Riau Province, Indonesia *International Symposium on Civil and Environmental Engineering* **8**
- [18] Putra A, Wisna U J and Kusumah G 2017 Spatial analysis of the river line and land cover changes in the Kampar River Estuary: the influence of the Bono Tidal Bore Phenomenon *Forum Geografi* **31** 2
- [19] Anonymous 2011 Ecosystem lansekap Giam siak Kecil-Bukit Batu terancam karenan PT rimba Mandau Lestari, Perusahaan afiliasi dengan APP/SMG, melanjutkan penebangan hutan gambut di zona transisi Cagar Biosfer UNESCO GSK- BB *Laporan Investigasi –Eyes on the Forest (RoF)* pp 21
- [20] Bapedalda Kota Jambi 2003 *Basis data lingkungan hidup daerah Kota Jambi, Propinsi Jambi*
- [21] Mujiyani, Hidayati D and Nugraha B 2004 *Degradasi pengelolaan DAS Batanghari permasalahan dan tantangan Pusat Penelitian Kependudukan-LIPI* p 99
- [22] Prianto E Reproductive Aspect and Dynamics of Fish Larvae as Fundamental Fisheries Management in Lubuk Lampam Floodplain, South Sumatera Province (in Bahasa) *Dissertation* (Bogor Agricultural Institute) 141
- [23] Muflikhah N, Marini M, Marson, Burnawi and Syamsul B 2011 Inventarisasi sumber daya ikan di rawa banjiran Ogan Komering Ulir dan Muara Enim *Laporan akhir Balai Riset Perikanan Perairan Umum*
- [24] Husnah 2008 Potential threat to the floodplain ecosystem of Lempuing River, South Sumatera, in: Hartoto D I, Koeshendrajana S, Kartamihardja E S, Utomo A D and Nasution Z (ed) *Fisheries Ecology and Management of Lubuk Lampam Floodplain Musi River, South Sumatera* (Palembang: Research Institute for Inland Water Fisheries Ministry of Marine and Fisheries Affairs) pp 149-155)
- [25] Kaban S, Asyari, Fatah K, Marini M, Nanda T, Burnawi, Nasution D H and Mersi 2015 Kajian tingkat degradasi dan potensi sumber daya ikan di Sungai Batanghari, Jambi *Final report Inland Fishery Resources Development and Management Department*
- [26] Nurdawati 2008 Fauna ikan di perairan rawa banjiran Sungai Batanghari, Jambi *Prosiding Seminar Nasional Ikan* V 65-76
- [27] Rupawan, Prianto E, Fauzi M, Herlan, Suryaningrat S and Herman 2009 Kajian pemanfaatan sumberdaya ikan di perairan umum estuari Sungai Siak dan rawa pasang-surut selat Panjang

Provinsi Riau *Final report Inland Fishery Resources Development and Management Department*

- [28] Salim E 2005 Pembangunan Daerah Aliran Sungai Siak Pekanbaru *Makalah Seminar*
- [29] Husnah, Kaban S, Fatah K, Makri, Ali M, Sudrajat A, Dwirastina M and Juniarto R S 2009 Penentuan tingkat degradasi lingkungan perairan di Sungai Siak Bagian Hilir dengan Benthic Integrated Biotic Index (B-IBI) *Laporan Teknis Balai Riset Perikanan Perairan Umum Badan Rist Kelautan dan Perikanan* 32
- [30] Iskandar J and Dahiyat Y 2012 Keanekaragaman ikan di Sungai Siak Riau *Bionatura-Jurnal Ilmu-ilmu Hayati dan Fisik* **14** 1 51-58
- [31] Simanjuntak C P H, Rahardjo M F and Sukimin S 2006 Ichthyofauna in Floodplain of Kampar Kiri River *Jurnal of Ikhtiologi Indonesia* **6** (2) 99-109
- [32] Fithra R Y and Siregar Y I 2010 Fishes biodiversity of Kampar River an inventory from Kampar Kanan River *Journal of Environmental Science* **2** (4) 139-147
- [33] Aryani N 2015 Native species in Kampar Kanan River, Riau Province Indonesia *International Journal of Fisheries and Aquatic Studies* **2** (5) 213-217
- [34] Warsa A, Nastiti A S, Krismono and Nurfiarini A Fisheries resources in Koto Panjang Reservoir *Bawal* **2** (3) 93-97
- [35] Kasim K, Prianto E, Husnah and Triharyuni S 2017 Fisheries resources management through ecosystem approach in Giam Siak Kecil floodplain (in bahasa), *J.Kebijak.Perikan.Ind.* **9** (2) 115-124
- [36] Husnah, Ditya Y C, Marini M, Koeshendrajana S, Samiaji J and Juniarto R S 2013 Identifikasi komponen penyusun pengelolaan perikanan di rawa banjir Giam Siak Kecil, Provinsi Riau *Laporan Akhir Balai Riset Perikanan Perairan Umum* 69
- [37] Titisari P W, Syamsudin T S, Sjarmidi A, Elfis Zen I S and Hendrayani Y 2018 Potential of sustainable fishery resources at Giam Siak Kecil-Bukit Batu Biosphere Reserve, Riau Province, Indonesia *IOP Conf. Ser.: Earth Environ. Sci.* **298** (012025) p 18
- [38] Nurdawati S 2007 Keanekaragaman dan distribusi benih ikan di beberapa tipe habitat Sungai Batanghari, Jambi *Jurnal Penelitian Perikanan Indonesia* **13** (2) 71-86
- [39] Ambaran A 2016 Faktor-faktor yang mempengaruhi eksistensi nelayan Sungai Batanghari di Kecamatan Maro Sebo Ulu Kabupaten Batang Hari Provinsi Jambi *Swara Bhumi* **1** (1) 75-82
- [40] Nurdawati S, Husnah, Asyari, Prianto E, Abidin M, Herlan and Sudrajad A 2005 Inventarisasi kelimpahan dan keanekaragaman sumberdaya hayati perikanan di perairan bersifat asam *Laporan Akhir Balai Riset Perikanan Perairan Umum* p 87
- [41] Gaffar K, Fatah K and Hidayah T 2005 Perikanan Di Perairan Rawa Banjiran Sungai Musi *Laporan Akhir Balai Riset Perikanan Perairan Umum* p 33
- [42] Nurdawati, Fahmi Z and Supriyadi F 2019 Population parameter of *Anabas testudineus* (Bloch, 1792) in floodplains ecosystems of Musi River, Lubuk Lampam (in Bahasa) *Berita Biologi* **18** (1) 25-35

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