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**THE IMPACT OF ENVIRONMENTAL DEGRADATION ON THE  
SOCIO-ECONOMIC ASPECTS OF COMMUNITY IN THE SIAK  
RIVER WATERSHED, RIAU PROVINCE INDONESIA**

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***Dampak degradasi lingkungan pada aspek social ekonomi masyarakat di daerah aliran  
Sungai Siak, Provinsi Riau Indonesia***

**ABSTRAK**

Sungai Siak di Provinsi Riau yang merupakan sungai terdalam di Indonesia mempunyai peranan penting sebagai prasarana transportasi dan memberikan kehidupan bagi masyarakat yang tinggal di sepanjang Daerah Aliran Sungai (DAS). Seiring dengan perkembangan ekonomi dan penduduk pemanfaatan sungai dan DAS Siak telah melebihi batas kapasitasnya sehingga terjadi kerusakan ekosistem. Kerusakan ini bersumber dari perubahan kegiatan manusia yang langsung mempengaruhi ekosistem sungai Siak dan kegiatan yang tidak langsung mempengaruhi ekosistem. Tujuan dari penelitian ini adalah untuk menganalisis dampak dari kerusakan ekosistem sungai Siak terhadap kehidupan ekonomi dan sosial masyarakat yang tinggal disepanjang DAS Siak. Untuk mencapai tujuan penelitian diatas maka dilakukan survey lapangan di tiga buah desa dan satu kelurahan untuk mengumpulkan data primer berupa data fisik dan kimia dan data ekonomi dan sosial. Ada dua variable yang diidentifikasi yaitu data kualitas air untuk melihat tingkat kerusakan ekosistem dan data ekonomi dan sosial sebagai variable terkena dampak. Penurunan kualitas air disebabkan oleh tiga faktor utama yaitu limbah yang dibuang oleh industri yang berdiri disepanjang sungai Siak, limbah domestik dari aktifitas manusia perkotaan dan limbah dari aktifitas pembangunan yang menggunakan lahan secara massive di daratan disepanjang DAS. Analisis data dilakukan secara kualitatif deskriptif. Hasil penelitian menunjukkan bahwa selama 10 tahun terakhir telah terjadi perubahan lingkungan pada DAS dan sungai Siak yang merusak jasa lingkungan yang selama ini diberikan oleh sungai Siak sehingga mempengaruhi kondisi ekonomi dan sosial masyarakat yang tinggal di DAS Siak. Dampak ekonomi dan sosial ini adalah penurunan pendapatan, penurunan tingkat kesehatan, perpindahan pekerjaan ke strata yang lebih rendah, dan pada tingkat tertentu terjadinya perubahan budaya masyarakat. Secara umum perubahan produksi jasa lingkungan yang selama ini diberikan oleh DAS Siak telah menyebabkan tingkat kesejahteraan penduduk menurun.

**Keyword:** *Ecosystem services, Siak river, environmental degradation, waste.*

## INTRUDUCTION

Siak river is the deepest river in Indonesia so that it has long been used as a main waterway transportation in Riau province. It has been a part of human life that provides the lively hood for community in the river basin. Economic activities were flourishing along the river as villages and small cities were growing along the river bank. Although land transportation has overtaken waterway transportation, the role of Siak river does not decline, but it even become more important in term of economy, social and culture.

As modern economy start to develop in the region, the use and the role of Siak river increase dramatically. The Siak river and its basin are then being used and exploited beyond its carrying capacity. It brings benefits as well as costs when the balance of its ecosystem has been disturbed.

Theoretically, ecosystem service is affected by direct and indirect drivers of change. These drivers of change are brought about by human being in their economic, social and cultural activities. Direct drivers of change are factors that directly affect the ecosystem - such as changes of climate, natural disaster, deforestation, production activities on land, etc. – These drivers will shape the ecosystem on which human being depend on for their lively hood. If the ecosystem is damaged or degraded it will not be able provide necessity and basic need for human being. Indirect drivers of change are factors that indirectly affect the ecosystem, such as change of sociopolitical circumstances, cultural, science, etc. The ecosystem service is defined as the benefits that people get from nature. Examples include fresh water, timber, climate regulation, recreation, aesthetic values, etc. (Ranganathan, et all, 2009).

The purpose of this study was to assess the impacts of degraded-ecosystem services of Siak river on social and economic of community living on the Siak river watershed. The pollution in the Siak river has caused the ecosystem services severely degraded which affect the welfare of community living along the river and its watershed. The pollutions are mainly coming from industrial waste and sludge that have been discharged to the stream since the industries were built along the river for the last 30 years. Other than industrial waste is the pollutant coming from urban waste. As economic activities and the number of dwelling along the river bank increase, the pollutant and the household waste also increase which further damage the ecosystem services. This eventually affects the lively hood and the welfare of the community. This research will evaluate the link between the ecosystem services and the welfare of human being.

## RESEARCH METHODS

This research is a collaboration work between the University of Riau and Bogor Institute of Agriculture. Data collection was carried out by a joint team of the two institutions. However, data analysis and report writing were done individually by separate team.

The field research was carried out in Siak regencies and in Pekanbaru city. The field research took for about 6 months to complete, starting from January until June 2010. Data were collected from sample of 30 people by interviewing each of them in three urban- and semi urban-affected villages. These villages are *Meranti Pandak* (close to *Pekanbaru* city),

*Meredan and Tualang in Siak Regency (close to and downstream of Perawang city, the capital of Siak Regency). The selection of these three villages is based on the possible impact of pollutant produced by industrial and city-dweller activities discharged to the stream and the subsequent impact on social and economic aspects of people in those villages (see the map).*



Source: Taken from map of Riau Province, CV. Inti Fajar Baru, Medan, Indonesia. The arrow indicate the location of field survey.

*Meranti Pandak* is an urban village as it is located in *Pekanbaru* city. As a city-affected village the type of pollution in this village is mainly household waste and traditional market garbage, untreated sewage, and other urban-type of effluent comes from city dweller activities such as oil and sludge and rubbish from sheep, ferry, boats and workshop. The other two villages, *Tualang* and *Meredan* are located further down the stream of Siak river, about 30 km, Northeast of *Pekanbaru* city. These two villages are close to a giant industrial complex of pulp and paper industries. Because of the industrial development, these villages have been transforming into semi-urban area. As an industrial affected villages, the type of pollution is mainly chemical substance and sludge, and waste from city-dweller activity like garbage and untreated sewage from household, oil and sludge from workshop, market waste, etc.

To achieve the goal of this research - the impact of environmental damage on social and economic aspects of community - two variables are identified together with their indicators. These two variables are, firstly, one that relates to water quality and the secondly, one that relate to the community welfare. Water quality is measured by some indicators; these are *biological oxygen demand (BOD)*, *chemical oxygen demand (COD)*, total dissolved solid,

number of *fecal coliform* and qualitative description of water quality in term of how far the water can be used by now and before the ecosystem service changed. Community welfare is measured by change of income and the job mobility which are both directly caused by the amount of fish catch. In addition to those is the health status and education. These two variables are analyzed descriptively to evaluate the correlation between the two.

Primary data and information about community welfare and the quality water of Siak river are collected through field observation and interview of respondents in *Siak* Regency. The sample respondents are fishermen living in those three villages (*Meranti Pandak*, *Tualang* and *Meredan*) which located in along the Siak river. Fishermen are defined as those who most of their income (more than 50%) comes from fishery activities and they still use river water for their daily washing and cleaning although they are not dependent solely on the river water. Secondary data was also collected from several offices and the relevant previous research. Data and information collected are analyzed by descriptive approach.

## **RESEARCH RESULT**

### **The health of Siak river**

According to our respondents, that some 30 years ago the water of Siak river can be used for drinking water as well as for bathing, washing clothes, cleaning, etc., however, as the water quality has been below the acceptable standard it can be dangerous to do so now. Even to wash the clothes is not possible any more as the dirt may stick to the clothes. There are three sources of pollution coming to the stream of Siak river; these are the waste from industrial, urban-activity, and waste driven by land development.

From the economic point of view, river side is the best site for industrial location. Industries need a lot of water and river is a reliable source of water while the waste they produced can be easily siphoned to the stream. Along the Siak river bank, there are 3 crumb rubber factories, one glue factory, and 13 of petroleum mining areas; and more importantly there is one big pulp and paper industry. All of these factories use chemical in their factory process and produced waste such as sludge and other toxic material and then discharged into the river stream. Based on information collected from people around the industries, it is allegedly that the waste is not treated properly before discharging to the stream.

The toxic waste has made the quality of water of Siak river to be severely degraded. The water quality is usually becomes worse after rainfall, because rainfall time is an appropriate time for the factories to release their waste as the rain water can hide the effluent they discharged. During the rainfall the volume of river body increases so that the waste will not be very significantly visible. This is a way to hide what is really going on under the water. However, at the first instance they discharge the effluent the concentration of chemical must be quite high before the effluent dissolve. As the water quality worsen the number fish catch declines. When the quality of water has been too far below the threshold the fish may be dying and floating. This has been the case just recently on November 16, 2010, when thousands of fish were dying and floating in the river near the port of IKPP (Indah Kiat Pulp and Paper) in the village *Tualang*. It was suspected that the effluent flowing to the river



contain toxic chemical substance from pulp and paper factory (Antara News Agency, 2010). People have been complaining and protesting to the company since the case has occurred many times; however, the practices of dumping the waste to the river still continue. What the factory do in order to reduce the impact of the waste is to adjust the amount of waste discharged below a certain level so that it does not cause a big impact on river. Consequently, the case of itchy and other skin diseases experienced by people in the village of *Meredan* and *Tualang*, still continue.

The second source of pollution flowing to Siak river is household and other urban-activities waste. For example, untreated sewage, garbage from households and traditional market, sludge from automotive workshops and garages, garbage and sludge from sheep, ferries, and boats. All of this waste is dumped off directly to the river. Although these activities are prohibited by law - as the notice board shows at the river bank and aboard the ferry - the practice still continue because the lack of control and lack of law enforcement from the authority. Untreated sewage is a big problem in the urban areas as there are no treatment facilities available to process the waste and the sewage since a sewage system is simply unavailable. The sewage is either released directly to the water stream or collected underground in the septic tank which eventually goes to the stream and contaminate the ground water.

The third sources of pollution are material from soil erosion derived by activities on the land in and around the river basin, such as logging, land clearing, plantation and development activities that required a lot of open land. Deforestation or logging (either legal or illegal) has been one of the main causes of environmental damage and has destroyed the area of primary forest substantially. In 1982 total forest area in Riau Province was about 6.4 million hectare which covers 78% of Riau province area. In 2005 the total forest area left is only about 2.7 million hectare, which covers 33% of Riau province area. The rate of deforestation is getting faster every year. During 2005 – 2005 the average forest lost is about 200,000 hectare per year increased from 160,000 hectare per year before that period. Large proportion of this forest area is then converted into plantation and industrial forest for feeding the pulp and paper industries. People who do not have access to forest are now turning to secondary forest, bush or whatever left as alternatives for economic sustenance. Consequently, there has been a massive forest conversion into palm oil plantation development and industrial forest. This conversion brings about a massive soil and organic material released into the stream (Riau Forest Recue Network, 2010). Siak is the deepest river in Indonesia; however, soil erosion has caused the river base shallower about 8 to 10 meters.

Natural resource-based activities explained above have put a heavy burden to the Siak river. As 2010 there are more than 19 palm oil plantations and Oil Palm Mills and 6 plywood processing (sawmills) along the river bank. Other than soil erosion oil palm plantation activities bring about residual from fertilizer and pesticide which affect the health of the river. Palm oil mill produce sludge from the process of fresh fruit bunch of palm oil. These residual, waste and sludge together with household waste and untreated sewage has increased the total organic material in water body, reduces the amount of oxygen dissolved in the water, inhibit the photosynthesis process, affect the food change for fish and finally reduce the fish stock. More over the low dissolved oxygen in the water can kill fish as the case in November 2004 when thousands of fish died and floating in village of *Meranti Pandak*. According to the

Environmental Research Institute of University of Riau, the causes of dying fish is lack of oxygen in the water after long period of drought and followed by heavy rain that washed out the residual and waste in land and at the river bed which lead to low oxygen dissolved in the water. The minimum standard of dissolved oxygen (DO) is 3 ppm, while at the time of fish floating the concentration is below 2 ppm (Detik.com, online news paper). The inland waste allegedly comes from palm oil mills.

As a result of the above three factors the quality of the Siak river water is severely worsen. The status of water quality of Siak river can be indicated by biological and physical parameter (as in Table 1). Table 1 shows the amount of *coliform* and the amount of total suspended solid (TSS) in the water. The average amount of *coliform* in the Siak river has been more than 2800, higher than allowable standard. This indicates that the water has been contaminated by household waste primarily untreated sewages. This bacteria can cause diarrhea and other stomach aches. This result is similar to what has been found by Husna, et al (2010) where they investigate the presence of macrozoobenthos in relation to the water quality of Siak river. Husna found the significant amount of the medium to very tolerance macrozoobenthos in all area of downstream of Siak river which indicate the lower part of the Siak river has suffered from moderate to high organic pollution and dissolve solid deriving either from human settlement or industries.

TSS indicates the amount of solid organic and inorganic material that are suspended in the water. It may consist of silt, plankton and industrial waste. TSS may also indicate the degree of erosion occurred inland and around the river stream. Suspended solid will lower the quality of water by absorbing light. Water becomes warmer and its ability to hold oxygen decline. The warmer the water the less the oxygen can be dissolved in the water. When oxygen is not enough photosynthesis decreases and less oxygen is produced. Less oxygen impedes further photosynthesis and makes it impossible for some form of life to exist. Subsequent effect is the food available for fish and other form of life declines and finally the fish stock declines or even diminishes.

Less dissolved oxygen may also indicate the excessive demand for oxygen by microbial decomposers which to break down the organic and inorganic mater in the water. The existence of organic and inorganic matter in the water further indicates the existence of waste and pollution in the water body. The amount of oxygen needed by microbial decomposers to break the organic matter is called biological oxygen demand (BOD). The higher BOD the worse the quality of water or the higher organic matter in the water to be broken down by the microbial decomposers. For optimal growth of fish and water activities, unpolluted natural waters need to have a BOD of 5 mg/L or less. Table 2 clearly show that BOD of the Siak river in 2009, has already been double than the standard threshold, that is 9.6 mg/L. This means that the organic matter in the Siak river has been significantly high.

### **Social and economic of Siak community**

This part will discuss the social and the welfare of community living in the Siak river basin which includes the change of their income, job mobility and health, before and after the change of water quality.

As the industries started to develop along the river subsequently the role of fisheries declined. Local modern economy started to grow as well. Supporting industries and services are also flourishing. However, this economic growth do not significantly affect those who are on the lower layer of population, particularly on local (indigenous) people who work in traditional sector like fisheries, agriculture and forest-dependent activities. Rather, their income and work opportunity are even eroded as fish catch starts to decline due to the declined quality of river water. For few years they enjoyed the economic fortune from selling the land and doing illegal logging. They do not have many alternative opportunities as they are not tune in to modern economic activities. They depend heavily on traditional works such as agriculture, forestry, fishery and other natural resource-based jobs. Because of lack of education and short future vision they were eventually and gradually marginalized and fell into poverty or a near poverty trap.

In the case of fish stock, the amount of fish catch has declined over the last 10 years, consequently the income of fishermen which comes from mostly the fish catch also decline. Ten years ago the amount of fish catch that a fisherman can get at the downstream of the river was about at least 15 kg per day, but now it declines substantially to around 4 kg per day, while in the middle and downstream it is even worse, downs to 2 kg per day from 10 kg per day ten years ago. The declining of the fish catch is a direct consequence of degraded water quality which make life for fish impossible. The decline of this catch has forced fishermen to leave their job and find other job opportunities. This structural change of job is not easy although it takes place within the same sector (between fishery and plantation).

The declining of fish catch has a direct consequence to community income. The average income of fishermen of villages *Tualang* and *Meredan* have been affected substantially. The average income of *Tualang* village is between Rp 100,000 – Rp 500,000 per month, down from that 10 years ago which was between Rp 500,000 – Rp 1,000,000 per month. The same figure for village *Meredan* is between Rp 500,000 – Rp 900,000 per month, down from Rp 1,000,000 – Rp 1,500,000 ten years ago before the degraded-water quality. After declining of water quality there is no more fishermen that can earn money more than Rp 1,000,000 per month from fish catch.<sup>1</sup> The case is a bit different for fishermen in the of village *Meranti Pandak* who have not been affected very much by the amount of fish catch as the two previous villages, because they do not depend on fishery activities. As a city-affected village, the main occupation of people in the *Meranti Pandak* is services activities.

Not only does it affect income of villagers but also the number fishermen are also reduced. During the last three years the number of fishermen has reduced to about 50% of the total. In 2009 the number of fishermen in the three villages was only about 105 people left or about 1% of total population of the two villages. In 2010, based on the interview, it is estimated that the number fishermen should have declined again of about 40%. We conclude that many of the fishermen moved to another available job as the amount of fish catch decline substantially. In village *Meranti Pandak*, closed to *Pekanbaru* city, there are no more fishermen left as they all move to another jobs, mainly service sector in the city (Village Profile, 2009).

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<sup>1</sup> The exchange rates was Rp 9,000 for US\$ 1.

It is expected that in the future the job mobility will likely increase and finally the fishermen in Siak river will disappear in a few years time to come, particularly those who live at the downstream part of the industries. At the very upstream of the river the number of fishermen will probably sustain as long as the water quality remains as it is now. As the fish income from selling fish is not enough anymore for living, they have to find some other alternative jobs; some of them become laborer at services sector, palm oil and rubber plantation and street vendor (small trader).

Another impact of downgraded ecosystem services on the community welfare is the health status. Data from survey indicates that in the *Tualang* village, there is 70% out of those who use river water for bathing, have once suffered or experienced skin diseases or itchy on their skin at some point of the time of the year. While the same figure in village *Meredan* is found about 80% out of those who use river water for bathing have once experienced or suffered the same skin diseases. The location of these two villages are quite close to pulp and paper factory in Siak regency, so it is likely that there is a strong relationship between the diseased incidence and the water quality. The case is quite different in village *Meranti Pandak* where the incidence of skin diseases is not as high as the case in the two other villages. Out of those who take a bath in the river, only about 40% of them say that they had experienced skin diseases. This is probably due to the location of this village is in the upstream of the river and far from source of pollution.

Although not directly related, there is an economic aspect should be considered in this analysis that is the “economic value” of the river. The forgone of clean water has put an economic burden on villagers. Because they cannot use the river water directly anymore, they have to buy water for their drinking, washing clothes, bathing, and other cleaning activities. For those who are not able to pay for clean water or to build a well for water sources they have to go through some inconvenience, such as skin diseases, itchy, and diarrhea. Ten years ago when the river water still clean they do not necessarily experience these inconvenience.

Another lost experienced by the fishermen is the fishery-related culture which they inherited from their ancestor which intertwine to the river. There is some routine ritual that missing in their life. Every morning or at a certain time of the day (depend on the river tides) they go down to the river with their canoes and traditional equipment to catch the fish. In few times to come this activity will disappear.

In conclusion, substantial changes of the environment in the last ten years, specially changes in water quality of the Siak river has directly degraded the ecosystem services and consequently affected the welfare and the livelihood of people who depend on that services. The effects include income, health, job mobility, and to some degree, culture of the community who live in the river basin of the Siak river. The income of the fishermen has reduced significantly and consequently forced them to find alternative job opportunities elsewhere. The contaminated water has caused the diseases that non existence at the first place ten years ago. The economic lost they experienced from the degraded ecosystem services has make their welfare is worse off.



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Table 1. Biological and physical indicators of Siak river in Siak Regency, Indonesia, 2009

Indicators	Unit	Standard threshold based on Governor rules	.Sampling Code																			
			SS 1	SS 2	SS 3	SS 4	SS 5	SS 6	SS 7	SS 8	SS 9	SS 10	SS 11	SS 12	SS 13	SS 14	SS 15	SS 16	SS 17	SS 18	Min	Max
Fecal Coliform	Amount/ 100mL	1000 - 2000	1,700	490	1,700	1,300	1,100	738	1,700	1,112	1,300	630	2,800	2,400	2,800	1,100	3,500	1,400	22,000	3,300	490	22,000
Total Dissolved Solid (TDS)	mg/L	1000	29	21	20	20	27	20	161	67	41	30	41	37	39	50	26	49	38	82	20	161
Total Suspended Solid (TSS)	mg/L	50	60	60	56	55	60	16	35	50	70	45	100	110	135	130	160	50	175	147	16	175

Table 2. Biological Oxygen Demand and chemical Oxygen Demand of Siak river in Siak Regency, Indonesia, 2009

Indicators	Unit	Standard threshold based on Governor rules	Sampling Code																			
			SS 1	SS 2	SS 3	SS 4	SS 5	SS 6	SS 7	SS 8	SS 9	SS 10	SS 11	SS 12	SS 13	SS 14	SS 15	SS 16	SS 17	SS 18	Min	Max
BOD	mg/L	3 – 6	3.0	8.0	5.0	6.0	10.0	12.0	2.0	7.0	0.70	10.0	10.0	5.0	8.0	12.0	9.0	20.0	16.0	29	0.7	29
COD	mg/L	25 - 50	15.0	35.0	30.0	30.0	40.0	60.0	9.84	24.60	4.83	34.4	34.44	14.76	19.68	34.44	34.44	98.40	54.12	103.42	4.83	103.42

Notes : SS = Sampling stations in Siak Regency

Source : Board of Environmental Affair, Siak Regency, Riau Province, Indonesia, 2009