

River Health and Community Health: A Collaborative Action-oriented Social-ecological Analysis

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Abstract: We assume that social and ecological systems are closely connected. Within the conceptual framework of Social-Ecological Systems (SES) analysis we focus on poverty, health and sustainable development within the Siak River catchment area in Riau Province (Sumatra). Substantial environmental changes in the last ten years, especially the degraded water quality of the Siak River, have directly affected the Siak ecosystem services and consequently the welfare and the livelihood of people who depend on these services. Impacts occur on income, health, job mobility and, to some degree, community culture for those who live in the Siak River basin. The income of fisher families has been reduced significantly forcing them to look for job alternatives elsewhere. The contaminated water has caused diseases that were not reported ten years ago.

Local village inhabitants, women specifically, are aware of the social-ecological nexus, i.e. the connection between river pollution and people's health in the riverside village communities. The economic disadvantages people experience from the degraded ecosystem services differ between villages but have severely lowered the standard of living and quality of life in riverside settlements.

Conclusions are drawn on the role of poverty, and the chances of alleviating health risks and pursuing sustainable development for the Siak river basin are explored.

Key words: Riverside communities, water pollution, health risks, women's role, poverty and social injustice.

Global and Indonesian Public Health in Relation to Water

UN Goals

Even over 150 years ago it was known that polluted water can create and spread diseases. And over 20 years ago the United Nations initiated the "International Drinking Water Supply and Sanitation Decade (1980-1990)". But still many people in the world live with inadequate access to clean water and sanitary facilities

and hence are exposed to high risks of illness (Whiteford and Whiteford, 2005). Poor hygiene standards add to the problem. In 2003, polluted water, lacking sanitary facilities and poor hygiene caused 4.6% of global diseases, and 1.6 million deaths resulted from these problems (Hutton and Haller, 2004). The United Nations included these topics as their seventh "Millennium Development Goal": to provide access to clean water and adequate sanitary facilities to all people in the world by 2015 (United Nations, 2008).

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The Rio WCED 1992 discussed the social-ecological nexus, the global consequences of human behaviour on the environment and needed counter-measures (Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen, 1993). Particularly in the developing world, people face poverty and health risks as a consequence of environmental degradation. They often do not have the means to access adequate sanitary facilities or to provide sufficient clean water. Knowledge about hygiene is often lacking.

The Situation in Indonesia

Twenty percent of the rural population in Indonesia lives close to the national poverty line. Seven percent of its total population lives on less than 1 US\$ per day and 52% on less than 2 US\$ in 2002 (Asian Development Bank, 2006b). Sanitary facilities are out of reach for these people.

Indonesia is unlikely to reach the seventh Millennium Development Goal until 2015 (Asian Development Bank, 2006a). In 2006, the country faced 89 million diarrhoea cases, caused by lack of sanitary facilities and by polluted drinking water and poor hygiene. Inadequate sanitary facilities and poor hygiene are estimated to create an annual economic loss of about six billion US\$, equivalent to 2.3% of the Indonesian GDP. Would appropriate measures be initiated, these diseases could be reduced and 53% of the cost be saved (Water and Sanitation Program, 2008a). Poor rural communities, in particular, have reduced access to clean water and sanitary facilities and use polluted drinking water daily (Water and Sanitation Program, 2008a). Although measures have been taken, the situation has not changed very much over the last 30 years (Water and Sanitation Program, 2008b).

Water is polluted by domestic waste, industrial effluents and agriculture. In rural areas of Indonesia 53% of faeces, in urban region 52% of urine and effluents flow untreated into the ground or surface water (Water and Sanitation Program, 2008a; Tejalaksana, 2007).

Domestic effluents are major causes for the spread of diseases and child mortality (Water and Sanitation Program, 2008b; Semba et al., 2009). In addition, medium to heavy industries (about 9600 companies) pollute the water. It is estimated that 89% of the urban and 71% of the rural population in Indonesia have sustainable access to improved drinking water

sources. Improved sanitation coverage is estimated at 67% in urban and 37% in rural areas (World Health Organisation, 2008). In other regions, people do not have access to tap water and—if no other clean water resources are provided—have to use river water for drinking and for daily hygiene. It is still unknown to what extent increasing industrial waste levels and other environmental changes affect the health of these populations.

Implementation Obstacles

Politicians initiated measures to tackle these problems, like “Law 7 in 2004 describing the water quality management and water pollution protection in terms of enduring and recovering water resources” or Article 24 (Law 7 in 2004): this regulates “...that people and business organisations are prohibited to do any activities that may degrade the water resources.” Also the “Company Environmental Performance Rating Assessment Program” (PROPER) and the “Clean River Program (PROKASIH)” were set up in 2002. To reach the Millennium Development Goal in 2015 the Ministry of Public Works and the Ministry of Health created the “National Policy for Community Based Drinking Water Supply and Environmental Sanitation and Institutional Based Drinking Water Supply and Environmental Sanitation”. Further the Ministry of Public Work published the ‘The National Action Plan for Wastewater’ and the Ministry of Health the ‘National Planning in Environmental Health 2005-2009’. But unwillingness of local governments to spend money on these programmes¹, poor management, lack of defined procedures and little awareness on a local level as to the importance of the water-public health nexus perpetuate the problems. The offer of assistance and financial support from some foreign organisations seems to have made little difference (Roosmini and Rahmawati, 2007; Tejalaksana, 2007). Siak River in Riau Province (Sumatra) is perceived as an example of heavy pollution. There are 25 medium to heavy industrial bases and many small industrial enterprises that potentially pollute river Siak (Tejalaksana, 2007).

The health care system was improved in recent years, and the government attempted to reach the poorest and marginalised people. Still, until today not everybody is able to pay for health services or eligible to receive benefits through the social insurance scheme. Those

¹ Such a programme is not a priority for them as it has a long-term impact while the politicians prefer an immediate impact to raise their image and win votes; similarly in education.

who work in the informal sector are excluded (Hidayat, 2005).

Even if measures to clean up the environment, to improve public health and to reduce poverty were a political priority and finances were available, their implementation would still face obstacles. Vested interests prevail and environmental awareness is low. It is often not sufficiently understood that riverside residents' behaviour contributes to water quality and human health outcomes. According to international experiences, the following key aspects need to be considered: Communities need to be willing and able to participate in projects to improve sanitary facilities, clean water and hygiene. They need to be involved and adequately informed from the beginning (Foley et al., 2007; Mukherjee and Josodipoero, 2000; United Nations Economic and Social Commission for Asia and the Pacific, 2006, 2007). In particular, opinion leaders, such as teachers, religious leaders and other local key people, should be involved. This includes school children as they can bring knowledge to their families. In education and community management, cultural aspects need to be considered as part of the communities' needs. Theoretical knowledge about water quality and hygiene is often not fully understood and needs to be complemented by hands-on training (Mukherjee, 2000; Mukherjee and Josodipoero, 2000; United Nations Economic and Social Commission for Asia and the Pacific, 2006; World Bank, 2006).

Individual willingness to contribute to the installation of sanitary and water facilities and drinking water resources depends on age, gender, education and number of family members. In rural areas there is lower willingness to pay for the installation of these facilities than in urban areas (Mukherjee and Josodipoero, 2000; Foley et al., 2007; Harahap and Hartono, 2007). Such payment for sanitary services is, however, not common yet. There were some sanitary and waste processing programmes in Java and usually financed by foreign aid or the government.

In general, women should be involved more in projects to optimise hygiene behaviour in communities and drinking water and sanitary facilities because they play a key role in daily domestic life. Since they care for the family, provide water, cook meals and clean they often understand the importance of these topics better than men (Foley et al., 2007). According to the WHO, fifty percent of the girls and boys in the rural areas of Indonesia leave school after primary school (World Health Organisation, 2007). This low level of education needs improvement. Local experiences

with health care services are needed to develop health promotion projects.

River Siak in Sumatra: A Social-ecological System

Conceptual Framework

To allow for an integrated analysis of the social-ecological co-evolution of human-nature systems, a *social-ecological system* may be defined as consisting of a spatially explicit bio-geophysical unit, and its associated social actors and institutions in relation to a specific issue or problem (Glaser et al., 2010). A social-ecological system is thus complex, adaptive and delimited by the spatial or functional boundaries surrounding an ecosystem or combination of ecosystems in a specific territory in a particular problem context. We applied this concept to develop our conceptual framework for the analysis of Siak river water quality-human health nexus. On the issue of water quality, the Siak river region is linked to various local social systems. These include the users of Siak river water and of fishery resources, a range of riverside industries and a range of non-local decision makers in the government, market and civil society spheres. Water users and fisherfolk, and a number of industries are physically situated in riverside locations, other relevant decision-makers, such as government health and fisheries offices are not.

Siak river has long provided the livelihood for the human communities resident in the river basin. Economic activities have flourished as villages and small cities grew along the river bank. Land transportation has overtaken waterways but Siak River has become more important in economic, social and cultural terms.

As the modern economy started to develop in the region, the importance and the role of the Siak increased dramatically. The river and its basin were used and exploited beyond its carrying capacity. Both benefits and costs accrue as the balance of its ecosystem is disturbed.

Ecosystem services are the benefits that people receive from nature. Examples include fresh water, timber, climate regulation, pollution filtering recreation, and aesthetic pleasure (Ranganathan et al., 2008). Drivers of change—such as changes of technology, climate, natural disaster, deforestation—continuously (re)shape the ecosystem on which human beings depend for their livelihood.

In the following, we take a closer look at the link between ecosystem services and the welfare of human

beings, in the social-ecological system of the Siak basin. Pollution in the river has negatively affected the watershed and the welfare of the communities along the river. Pollution stems mainly from industrial waste and sludge that have been discharged into the stream since the industries were built along the river for the last 30 years. In addition to industrial waste, there is pollution by urban waste. As economic activities and settlements along the river bank increase, industrial and household waste also increase to cause further damage to the ecosystem and its services. This process eventually affects the livelihood and the welfare of the communities.

During recent years, different branches of industry have gained increasing importance in Indonesia. Along Siak River, the palm oil, pulp and paper, rubber, plywood and petroleum industries are predominant. Deforestation of the tropical rain forests and the creation of monocultures, the change of the ecosystem and the increasing industrialisation together with unsatisfactory urban sewage systems created adverse developments affect both people and nature.

Effluents of pulp and paper mills, for instance, are heavily loaded with organic substances. A high biochemical oxygen demand (BOD) and chemical oxygen demand (COD) are found as well as suspended solids (mainly fibres), fatty acids, tannin acids, lignin, sulphur and sulphur compounds and chlorinated compounds (measured as absorbable organic halides). The latter show a tendency to accumulate and some are proven carcinogens or mutagens (Ali and Sreekrishnan, 2001; Savant et al., 2006). Many of these contaminants are acute or even chronic toxins. Moreover, the effluents contain organic and inorganic residual nutrients, which may possibly lead to the growth and bloom of a variety of pathogenic micro-organisms (Chandra et al., 2006). Even when the pulp and paper mills have installed effluent treatment facilities, the effluents are still highly polluted and improvements are needed to increase their efficiency for treating discharged wastewaters (Tiku et al., 2007).

The sewage of petroleum processing industries is highly loaded with organic and metallic pollutants such as phenols, oil and fat, sulphides, ammonia nitrogen and polycyclic aromatic hydrocarbons. This sewage, due to leakage and infiltration of oil, untreated sewages or insufficient waste management systems, may also affect the ground water (Ritter et al., 2002). Polycyclic aromatic hydrocarbons are toxic, mutagen and/or carcinogenic and could lead to skin diseases like contact allergy and skin cancer (Anderson et al.,

1995; Hollender et al., 2002). They were found to be highly concentrated in the Siak River, the estuary and the coastal waters, a fact that indicates the presence of pyrogenic sources, particularly biomass and petroleum combustion (Lukman, 2010).

According to the reports so far available, the main health problems in the area of those rivers which have been polluted by pulp and paper mills are skin diseases and symptoms like scaly skin, mycosis, pruritus and purulent inflammations as well as cough and breathing difficulties, which may be caused by chlorine gas emerging from the river. In addition, the pollution of the river (and the ground water) has led to a reduction of fruit and vegetable crops (which may even contain pesticides or other pollutants). The intoxication and reduction of fish stocks is a further likely consequence of river pollution (Happe, 2001; Hewitt et al., 2008; Aglionby, 2001).

Research Goals, Sites and Methods

This contribution is based on three research papers in Riau province, written by Fitria Devita (2010), Katrin Prueter (2010) and Eva Suhren (2010). These papers were compiled by Bernhard Glaeser (supervisor to Katrin Prueter and Eva Suhren), Marion Glaser (Coordinator, SPICE Cluster 6; supervisor and examiner for Katrin Prüter) and Suardi Tarumun (supervisor to Fitria Devita). The research papers are listed under the references (Devita, 2010; Prüter, 2010; Suhren, 2010).

I Research—Suhren/Glaeser

The study purpose was to assess health impacts, depending on varying Siak water qualities. The following research questions were posed: How and for what purpose do people use the water of the river? Do they have health problems or problems in their everyday life, which they trace back to the insufficient water quality? Which factors affect the residents in their behaviour regarding the use of the river water?

In addition to the residents' health assessment, a secondary (non-descriptive, non-analytical) objective was to increase public awareness as to the importance of environmental health and ecosystem services relating to public health. Despite reports on increasing amounts of industrial waste flowing into the Siak and on fish stock depletion in that region (Tejalaksana, 2007; Aglionby, 2001) the real impact of these environmental changes on the residents' health still remains unclear.

Fifteen standardised in-depth interviews with women were carried out in three different Siak vicinity regions, five in each one. These regions were—pertaining to

industrial waste or urban sewage disposal—differently affected by pollution. Kotagaro in Tapung Regency was assumed to be polluted only to a small extent. Okura village in the Pekanbaru region was heavily polluted by urban sewage. Buatan II village in the Siak Regency was assumed to be polluted by both industrial and urban sewages (see Figure 4).

The interview guide included 13 questions about changes of the river water quality and subsequent changes of personal behaviour and subjective health status from past to present times as far as they could be related to the river water. It also included prospects regarding the future of the river and the subjective health status as well as wishes, chances and abilities to influence the environmental conditions of the river. In addition, personal data including age, family status, ethnic group, place of birth, children, profession, vaccinations, allergies as well as chronic and previous diseases were collected.

The interviews were analysed and interpreted by means of the summing-up model of qualitative content analysis according to Mayring (Mayring, 2008). Ten different categories with 22 variables were designated to which the statements of the interviewees could be assigned.

II Research—Devita/Tarumun

The purpose of this study was to assess the impacts of pollution and degraded ecosystem services of river Siak on social and economic features of community living in the Siak vicinity. This research was a collaborative effort between the University of Riau and Bogor Institute of Agriculture. Data collection was carried out by a joint team, involving both universities, whereas data analysis and report writing were done individually by separate teams.

The field research was carried out in Siak regencies and in Pekanbaru city. The field research took about six months to complete, from January to June 2010. Data were collected from a sample of 30 people by interviewing each of them in three urban and semi-urban villages. These villages were 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 was based on the possible impact of pollutants produced by industrial and urban activities, discharged into the stream and the subsequent impact on social and economic aspects of people in those villages (see Figure 4).

To achieve the goal of this research—the impact of environmental damage on social and economic aspects of community—two variables were identified, together with their indicators. These two variables were, first, one that relates to water quality, and second, one that relates to the community welfare. Water quality was measured by the following indicators: biological oxygen demand (BOD) and chemical oxygen demand (COD) (see Table 1), total dissolved solid, number of fecal coliform (Table 2) and qualitative description of water quality in terms of to what extent the water could be used: at present, and before the ecosystem services changed. Community welfare was measured by change of income and job mobility which are both directly caused by the amount of fish caught. In addition to those, health status and education were measured. These two variables were analysed descriptively to evaluate the correlation between the two.

Primary data and information about community welfare and Siak water quality were collected through field observation and interviews in Siak Regency. The interview sample consists of fishermen living in those three villages (Meranti Pandak, Tualang and Meredan) which are located along the Siak River. Fishermen were defined as those who earn most of their income (more than 50%) from fishery activities. Secondary data was also collected from government offices and relevant previous research. Data and information collected were analysed by a descriptive approach.

III Research—Prüter/Glaser

The study purpose was to prepare a literature-based synthesis on water pollution and health in Indonesia, focussing on Sumatra and the Siak river. The research emphasised national health policy and health status and the social, political and administrative aspects of national health policy and status. Originally, it was also planned to conduct an empirical interview-based survey to assess the regional and local health system in Riau Province. Since Katrin Prüter was unable to obtain a research visa and clearance from the Indonesian authorities this was not done. Instead, a conceptual “health project” was developed, linking science and health practitioners to implement the design in Riau.

Three specific research questions were posed. How can the current state of water provision in Indonesia be described and which problems does it entail? Under what conditions could a health promotion project, connecting water pollution, hygiene and human health, be feasible? How could such a concept be implemented

Table 1: 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	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	Max
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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
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

Notes: SS = Sampling stations in Siak Regency.
Source: Board of Environmental Affair, Siak Regency, Riau Province, Indonesia, 2009.

Table 2: Biological and physical indicators of Siak River in Siak Regency, Indonesia, 2009

Indicators	Amount/ Unit	Standard threshold based on Governor rules	Sampling Code																	
			SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	Max
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Fecal Coliform	100 mL	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	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	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	175

Notes: SS = Sampling stations in Siak Regency.
Source: Board of Environmental Affair, Siak Regency, Riau Province, Indonesia, 2009.

for the people in the Siak river basin? The hypothesis was that riverside residents do not understand the relation between polluted environment and impacts on health.

River Pollution as Observed by Local Informants

Focused interviews with five women respectively were carried out in three different regions of the Siak River, which, due to industrial waste or urban sewage, were assumed to be differently affected by pollution: In *Kotagaro* in the region of Tapung, which was assumed to be polluted to only a small extent; in *Okura*, a village in the region of Pekanbaru, which was assumed to be mainly polluted by urban sewages; and in *Buatan II*, a village in the region of Siak, which was assumed to be polluted by both industrial and urban sewage (see Figure 4).

All women in *Kotagaro* regarded the river as clean and the water as of good quality. They did, however, remember that it had once been polluted, caused by the palm oil industry, but this happened quite long ago. All women in *Okura* and *Buatan II* perceived the river to be heavily polluted and the water as too dirty to be used as drinking water. The women in both villages pointed out that the pollution was not always at the same level. Even though there were always pollutants in the river, heavy pollution occurred once every two to six months (*Okura*) or once in three months (*Buatan II*). The women reported to be able to smell and taste the pollutants in the river and in the air during those periods. One woman in *Okura* said that about twice a year she saw large amounts of dead fish and unnatural looking lobsters.

The reasons for pollution, as suspected by the women, were manifold. In the first place, they blamed the pulp and paper industry “*Indah Kiat*” as well as the palm oil industry and their effluents. The women assumed there were pipes breaking or tanks flooding inside the production plant so that the effluents floated into the river. Other reasons mentioned were rubbish in the river, dead animals, public toilets by the riverside, oil from boats, domestic waste from *Pekanbaru* city and effluents from other industries, such as rubber and plywood. The women in *Buatan II* sometimes felt harassed by air pollution. It remained, however, uncertain whether they felt air pollution or the bad smell of the river. The most remarkable changes of the river mentioned by the women were reductions of the fish stock.

These statements regarding the fish stock coincide with and are confirmed by environmental studies (Aglionby, 2001; Glastra, 2003; Wieting, 2004; Husnah et al., 2010). Possible reasons may be the effluents of the pulp and paper mill *Indah Kiat* as well as the high levels of polycyclic aromatic hydrocarbons (measured in the Siak River) but also the low oxygen levels (Aglionby, 2001; Rixen et al., 2010; Lukman, 2010). Besides, the effluents of pulp and paper mills show a high biochemical oxygen demand, which leads to even more oxygen consumption (Ali and Sreekrishnan, 2001). Also the accumulation of pesticides, polycyclic aromatic hydrocarbons and heavy metals in fish affect their viability and reproductive performance and may reach humans through the food chain (Oliveira Ribeiro et al., 2005).

The pollution of the river does not seem to be constant but rather recurrent, depending on different conditions, such as heavy rain or insufficient sewage systems in the industrial plants. Although *Okura* is located upstream of the pulp and paper mill “*Indah Kiat*” its effluents still affect the village because of the tides that push the water uphill. Further studies will have to focus on the question to what extent the changes of the fish stock are due to chemical substances or to a low oxygen amount in the river or indeed to fishing pressure.

Water Usage and Behavioural Changes

All informants (the five women) used and still use the river water regularly for bathing, brushing their teeth and washing their clothes. Some of the women used to drink the water 15 to 20 years ago. At present, the women of *Okura* and *Buatan II* drink ground water, mineral water or boiled rainwater because they regard river water as polluted, whereas the women in *Kotagaro* consider the river water as clean, yet drink ground water because of its better quality.

For all interviewed women, the river plays an essential role in their everyday life especially for those people who live close to the riverside and do not have access to ground water. The river is needed for the people’s daily hygiene, as well as for fishing, for their own food and for sale.

The changes of the river are mostly considered natural and caused by the tropical rain (monsoon). Differences in colour between red, brown, black and white are generally accepted as normal changes dependent on the weather, silt or sedimentation. In *Kotagaro*, interviewees recalled only one incident in the past, when the river was polluted and the fish stock decreased.

In Okura and Buatan II, the women talked about changes in the smell, the taste and the fish stock of the river: Due to pollution the river allegedly smelled and tasted muddy and polluted, and fish catch had decreased constantly over the past 20 years. Twenty years ago, it had been easy to catch more than 25 kg of fish daily. About ten years later the daily catch had already decreased to five to ten kg, and today it was difficult even to catch one or two kg. In Buatan II, two women pointed out that not only fish quantity but also the diversity of fish had decreased during recent years and that the smell of the catch today had become rather bad. In Okura one woman mentioned lobsters that, due to pollution, did not look healthy and normal, some of them were even blind. In Buatan II, they stated that nowadays not only the river but also the air smelled bad when the river was heavily polluted.

In Kotagaro, the people of the village use the river to fish and bathe. Once a year, they clean the river and its banks to prepare for a festival before Ramadan. As part of the festival, they sacrifice a buffalo and a goat and give their heads to the river. In Okura, the interviewed women believed that it was impossible to clean the river water. They used to wash their clothes after heavy rain because of the better quality of the river water. In Buatan II, the women went to a small branch of the river to take a bath and to wash their clothes when polluting substances appeared and the river water turned to a very bad quality.

In all three villages, the women advised their children not to swim in the middle of the river because it was too deep. Three women in Kotagaro were not concerned if their children drank or swallowed the river water whereas the women in Okura and Buatan II instructed their children not to drink the water because of pollution and not to go to the river alone. Moreover, the women in Buatan II used to bathe their children in gallon water until they were three years old². But even older children were not permitted to take a bath in the river because of pollution.

Kotagaro is upstream Pekanbaru; there was not much rubbish in the river. But in Okura as in Buatan II, both located downstream, the women deplored their downstream location as disadvantageous because the trash and domestic waste from Pekanbaru, from upstream villages, and industrial waste from riverside plants affected them.

Generally, the river was important for the families in all three villages because they needed the fish to eat

and earn a living. For all 15 women interviewed in the three different regions, the river plays an essential role in their and their families' daily hygiene and their livelihood strategies of catching and selling fish.

In Kotagaro, all women judged the river water to be good and did not mention health problems. The women in Okura, however, mentioned skin irritations, which they traced back to the polluted Siak water. In Buatan II, most of the women and their families had skin and sometimes eye irritations, which they traced back to the poor water quality of the Siak. Furthermore, the women in Okura and Buatan II talked about a significant reduction in fish stock quantity and diversity during the last years. None of the women in Kotagaro saw a connection between the Siak water quality and their health status whereas some of the women in Okura and all in Buatan II felt sure that a casual relation existed.

The deteriorating quality of the river water has modified women's behaviour in Okura and Buatan II. They have turned more and more reluctant to accept and use the river as a source of drinking water. In Buatan II they even turned to washing their clothes in a river side branch when the Siak is heavily polluted.

Welfare and Livelihood Effects: Economic, Social and Cultural Aspects

This section discusses the social and the welfare of residents in the Siak river basin. This includes changes in their income, job mobility and health, associated with decreasing water quality.

As the industries started to develop along the river, the role of fishing changed and fisheries declined. Supporting industries and services were flourishing. However, this economic growth did not significantly affect those who were part of the poorer population strata. Particularly the local people who work in traditional sectors like fisheries, agriculture and forest-dependent activities did not benefit. On the contrary, their income options even eroded as fish catch and river water quality began to decline. For a few years, locals enjoyed the economic fortune from selling the land and illegal logging. They did, however, not have many alternative opportunities as they were not in tune with modern economic activities. Traditional riverside communities still depend heavily on traditional jobs such as working in agriculture, forestry, fishery and other natural resource-based activities. Because of

² Gallon water is sometimes mineral water, sometimes purified ground water filled into containers.

lack of education and short future vision they were increasingly marginalized and impoverished.

The amount of fish caught declined over the last ten years. Consequently the income of fishermen also declined. Ten years ago a fisherman could catch about 15 kg per day or more, but it later declined substantially to around 4 kg per day, while presently it is down to 2 kg per day, according to our informants. The decline of the fish catch is a direct consequence of degraded water quality which makes it difficult for fish to survive. This has forced fishermen to leave their profession with plantation labour as their main alternative.

The average income of fishermen in Tualang village is between Rp 100,000 and Rp 500,000 per month, down from Rp 500,000 to Rp 1,000,000 ten years ago. The figure for Meredan village is between Rp 500,000 to Rp 900,000 per month, down from Rp 1,000,000 to Rp 1,500,000 ten years ago, this means before the water quality degraded. Ever since water quality has been severely deteriorated fisherman can earn no more than Rp 1,000,000 per month from fish catch³. The case is somewhat different for fishermen in the village of Meranti Pandak. They have not been affected as strongly by the reduction of fish catch because they do not depend solely on fishery activities. The occupations of people in Meranti Pandak is predominantly services oriented.

Not only did water contamination reduce the villagers' income, it also led to the reduction of the number of fishermen. Between 2008 and 2010, the number of fishermen declined by about 50%. In 2009, only 105 fishermen remained in the three villages, roughly 1% of the total population. In 2010, based on interviews, it was estimated that the number of fishermen declined by another 40%. We assume that many fishermen moved to other jobs, following another substantial fish catch decline. In the village of Meranti Pandak, near Pekanbaru city, there are no fishermen left. They mainly moved to service sector in the city (Government of Siak Regency, 2009).

It is expected that, in the future, fisheries in the Siak vicinity will disappear within a few years, particularly in the downstream areas of the industries. Upstream fishermen will probably continue as long as the water quality remains as it is now. As the income from selling fish is no longer sufficient to make a living, fishermen have to find alternative income sources. Some become labourers in the services sector, in palm oil and rubber

plantations and as street vendors to establish small trades.

Another impact of downgraded environments on community welfare is on people's health. Survey data indicate that in Tualang village 70% of those who use river water for bathing, have experienced skin diseases or itchy skin. In Meredan village, about 80% of those who use river water for bathing have once experienced or suffered the same skin diseases. The location of these two villages is quite close to the pulp and paper factory in Siak Regency, so it is likely that there is a strong relationship between the disease incidence and water quality. In the village of Meranti Pandak, the incidence of skin diseases is not as high as in the two other villages. Only about 40% of those who take a bath in the river state that they had experienced skin diseases. This is probably due to the location of this village in the upstream part of the river far from pollution sources.

In addition to the reduced income from fish, there is a second economic consequence of water quality deterioration: The "economic value" of the river. The "disappearance" of clean water has put another economic burden on the villagers. Because they can no longer use river water directly, they have to buy water for drinking, laundering clothes, bathing and other cleaning activities. Those who are unable to pay for clean water or to construct a well have to suffer from skin diseases, itchy skin, and diarrhoea. Ten years ago when the river water was still clean they did not experience such misery.

Another loss experienced by the fishermen is the fishery culture which they inherited from their ancestors and which relates to the river. There are routine rituals which they are now missing in their life and daily routine. Every morning or at a certain time of the day (depending on the river tides) they would go down to the river with their canoes and traditional equipment to catch the fish. This activity and the associated cultural heritage is now disappearing.

Health Impacts and Local Perceptions

How do the people involved view and understand the water quality of the river? Do they relate it to health problems? Do they recognize the social-ecological history? How do they feel about it?

Health Studies

The main health problems reported in the interviews with the five women villages were skin irritations and

³The exchange rate was approximately Rp 9,000 for US\$ 1.

eye irritations, which the interviewees traced back to the use of the river water. Possible causes are the effluents of industrial plants like the pulp and paper mill Indah Kiat or the petroleum processing industry Chevron, both located near the city of Perawang. A study carried out in a paper mill found that workers who had been in contact with process water, often showed skin diseases like atopic dermatitis or mycosis (Jungbauer et al., 2005). The amounts of gaseous emissions of paper and pulp mills have not been measured yet (United Nations Environment Programme, 2005). They contain nitrogen monoxide, sulphur dioxide, carbon monoxide, carbon dioxide and volatile organic compounds, among which the sulphur containing compounds can easily be identified by its smell (Latorre et al., 2005). Emitted gases may affect the human body through inhalation and may affect ecosystems and people through acid rain (United Nations Environment Programme, 2005). The atmosphere is the principal recipient and global transporting mechanism of many pollutants, and may thus contribute to the environmental burden in the surface water of streams and lakes (Ritter et al., 2002). Through the acid rain pathway, chemical compounds and pesticides may find their way into water bodies and land. When rain water is drunk these pollutants enter the human body.

A literature review also showed that due to polluted water 89 million cases of diarrhoea were registered, about one million cases of helminthes, about 715,000 cases of hepatitis A and about 23,000 cases of hepatitis B. Also linked to polluted water is malnutrition in children: in Indonesia about three million children under five years suffered from malnutrition in 2006 (Water and Sanitation Program, 2008a).

In Riau the yearly incidence rate for diarrhoea among children aged under five was 12,883 in 2006 (Water and Sanitation Program, 2008a).

Subjective Health Status

In Kotagaro the women interviewed reported no health problems related to the river water in the past or today. They had only once been concerned about pollution, but that was long ago. They were not worried about their future situation and did not see a correlation between the quality of the river water and their own and their families' health.

In Okura, interviewees had had no health problems in the past, which they related to the quality of the river water. As for the present, five of six women reported skin irritations. They were convinced that bathing in the polluted river was the reason for these skin

irritations. One of the women had lived in Java before and was suffering from skin irritations only after she arrived in Okura three years ago. The skin irritations consisted of small red, sometimes black itchy spots, which became worse after scratching. They received powder against these irritations from the local health post, PUSKESMAS.

The women suffered from this kind of skin irritation between twice a month and once in five months. One woman reported eye irritations that sometimes occurred after taking a bath in the river, whereas another woman sometimes suffered from diarrhoea after having eaten fish that was caught after the river had been heavily polluted. The women stated that they would not want to use the river water any more if the pollution gets worse—but some do not have access to other water sources, and ground water has often dried up during the dry season.

Three of five women did not see a connection between the river water and their health status; one woman, however, thought it caused the skin irritations. The fifth woman was convinced that the river water quality affected her health.

In Buatan II, the women felt sure that ten or twenty years ago there were no health problems related to the quality of the river water. One woman, however, remembered that after the industry had been founded a lot of people died reportedly because they had eaten polluted fish. Presently, seven of eight interviewees in Buatan II and their children and families plus some of their neighbours suffered from skin irritations similar to those described in Okura. The skin irritations occurred intermittently between daily and three times a year. The woman who claimed to suffer from skin irritation only three times a year related these symptoms to temporary heavy pollution of the river and dying fish. Furthermore three women complained about eye irritations, i.e. about red eyes and a blurred vision after a bath in the river. Four women and their children sometimes suffered from cough as a result, so they presumed, of swallowing river water while brushing their teeth or because of air pollution. One child was reported to have had diarrhoea, which persisted for three days after swallowing river water.

As in Okura the women in Buatan II received a certain powder against the skin irritations from the local health post PUSKESMAS but they did not get enough of it to treat the whole family as often as necessary. All the women considered the skin irritations as something which belonged to their lives, but they did not want

to use the river water anymore if the pollution gets worse.

During the time of the interviews a new water supply system was being built in Buatan II. This would offer an alternative to river and ground water, yet only to those families able to pay. All interviewed women were quite sure that river water quality affected their health.

Discussion: Increased Poverty and Deteriorating Health

In this final section, we discuss the poverty-health link and summarise future related outcomes and conclusions. It seems obvious that more detailed research is needed to obtain a more comprehensive picture.

Future Prospects

All interviewees in Kotagaro were certain that the state of the river would not change within the next five years: “The river is clean and will be clean.” In contrast, all interviewees in Okura and Buatan II expected that the state of the river will change for the worse with more pollution and higher risks. One woman in Buatan II said that the situation in the village with regard to the river depended on three factors: First, the government should help the people who live there. Second, the residents needed to develop an awareness of and feel concerned about the pollution. And third, the industry should stop draining the effluents into the river.

Since all interviewees in Kotagaro considered the river clean there was only one woman who expressed future wishes and hopes: The river should remain the same in the future, without pollution, so that they would be able to continue using the river water daily. Three of five women in Okura wished the river to turn clean again, and four women wished for ground water.

The wishes of the women on Buatan II were more differentiated: Two women wanted the industries to stop polluting the river and the government to help them clean it up. One woman expected the government to help her repair her house which was being damaged by the waves produced by river ships, specifically speedboats. Two women wanted free access to the new water supply system for all people in the village or at least free access for poor people who could not afford to pay for this supply. The fifth woman had given up hope and therefore did not express any wishes. She pointed out, however, that although the river had already been polluted for a long time, she used the river water every day since she did not have access to other water sources.

Activities for Improvement

The people in Kotagaro clean the river once a year and since the women considered the river to be clean, they did not feel the need for special activities to improve the quality of the river. Once, when their village was confronted with massive pollution, the community organised a demonstration. Two women reported a compensation payment “for discomfort” from the responsible industry to the village after the demonstration; the money, however, was not distributed among the members of the community, the village head withheld it.

The interviewees in Okura believed that cleaning the river is not possible. Some years ago the government helped the community to build a ground water well but since it was not deep enough the ground water was not clean. Besides, in the dry season it is sometimes empty. The women in Okura primarily wanted access to ground water, this is what they save money for. They were convinced that nothing else could be done since they had neither the abilities nor the facilities to do more.

During the past years, the people of Buatan II have often demonstrated against the industry, mostly against the pulp and paper mill Indah Kiat. They received fishery equipment and tanks to collect rainwater but they were not given money to compensate them for damages. One woman believed that the industries did not like these demonstrations. Another one added that the industries had a lot of money, enough to stop villagers’ activities against them as they had done once before. The women had no idea what to do about the fact that everybody throws rubbish into the river.

Responsibility for Water Quality

The women interviewed in Kotagaro did not give any statement about who was responsible for the quality of the river water, supposedly because they considered the river to be clean and did not see the need for action. Also, a lot of people in the village had ground water and did not use the river water regularly. Only those people who lived directly by the river used it every day.

In Okura three of five women considered the government to be responsible for the quality of the river and the ground water. One woman mentioned that a solution could only be achieved if all those concerned worked together: The people in the village should have to keep the river clean, the industry should have to stop draining pollutants into the river, and the government should supply clean water. The fifth woman felt disenchanted: She mentioned that the government

had already made a lot of promises but nothing had happened.

The women demanded clean ground water as the only true alternative to the river water. According to the women's experience the ground water seemed to be better the farther away from the river it was collected. Whereas one woman claimed to drink the ground water, another one pointed out that the ground water was yellow, salty and not potable because of poisonous substances from the river.

In Buatan II, four of the five women believed that the responsibility for the miserable situation partly rested with the industries and partly with the government. Only the industries could stop allowing effluents to float into the river and should thus initiate a programme to clean the river. Yet, in their opinion they should not stop production because this would lead to a large-scale loss of employment. In Buatan II the women used boiled rainwater, mineral water or gallon water for drinking. People who did not have access to ground water walked to a side branch of the Siak River to bathe and wash their clothes when the river was heavily polluted (see Figures 1-3).

Resignation and Social Injustice

Most of the interviewed women held the government responsible for the state of the river water. At the same time, waning confidence in the government as a regulating authority and resignation regarding their living conditions by the riverside was apparent.

The situation downstream of Pekanbaru and of the industrial plants has led to a feeling of being

disadvantaged, of dissatisfaction and resignation among the women in Okura and Buatan II. This became particularly clear in connection with the wish to have access to ground water or to an alternative resource of clean water so as to no longer be forced to use polluted river water.

It is particularly interesting that two women, one in Okura and one in Buatan II, spoke of a joint



Figure 2: Okura. A father and his child are taking a bath in the river.



Figure 1: Kotagaro. Two women are taking a bath in the river; they are washing their hair, brushing their teeth and washing their clothes. Their children are playing and swimming in the water.



Figure 3: Buatan II. A woman is washing her clothes in the river next to a house.

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