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**Land use change and rural water supply in the tropics.
Perceptions and impacts of oil palm expansion in Sumatra,
Indonesia**

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presented by

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ABSTRACT

The increase in the global demand for palm oil has led to rapid large-scale land use changes in Indonesia often at the cost of tropical rainforests. The social and environmental consequences of this development are still far from being fully understood.

Based on the reports of water shortages in the surrounding areas of oil palm plantations, this thesis wishes to investigate the relationship between recent oil palm expansion and villagers accusations that oil palms have led to water scarcity during dry seasons. Studies of hydrological processes on oil palm plantations remain limited and often lack of analyses on watershed scale or the consideration of agricultural practices (cf. COMTE 2012). Some few and very recent reports by non-governmental organizations and scientific institutions denounce oil palm companies and their cultivation practices as the cause for water pollution and the decreases in water flow during dry seasons. The objective of this research was therefore to investigate this proposition, in the form of a case study; questioning whether village residents had observed changes in local water resources during the last twenty to twenty-five years and inquiring how these changes could be explained according to their personal evaluations. Additionally, the impacts to the village water supplies and individual households generated by these hydrological changes were also analyzed.

The concept of *societal relations to nature* (BECKER & JAHN (eds.) 2006) was used as a framework to provide an insight into the dynamical patterns of relations between humans, society and nature. Situated at the interface of social and natural science the thesis tries to provide a link between 1. the existing knowledge of hydrological consequences of oil palm expansion and 2. the environmental perception of local villagers. Additional focus of this research was put on the communication of local land use change among different social groups to give credit to the social embeddedness of the natural processes. Furthermore, the Drivers-Pressures-State-Impacts-Responses framework (DPSIR), as elaborated by the European Environmental Agency, was used as a supporting structure to understand and analyze the interrelations between diverse factors in a coupled social-ecological system.

For the field research a qualitative research design was selected. Focus was put on problem-centered household interviews in Bungku which were triangulated with participatory methods such as group discussions or resource mapping and expert interviews with different stakeholders at regional and national levels. The research is part of the joint Indonesian-German collaborative research center "Ecological and Socioeconomic Functions of Tropical Lowland Rainforest Transformation Systems (Sumatra, Indonesia)", funded by the Deutsche Forschungs-

gemeinschaft (DFG). Due to this context, the case study was conducted in one of the research areas in Jambi, a province in southern Sumatra. The selected village Bungku is situated in the Batanghari district in the southern part of Jambi province. The landscape is mainly characterized by oil palm and rubber land use systems and is highly dynamic as it has been marked by large scale deforestation activities and the development of oil palm plantations during the last twenty-five years.

Empirical field research in Bungku showed that villagers have observed the following changes in local water resources: A higher fluctuation of streamflow with particularly low dry season flows, a faster depletion of groundwater levels and an increasing pollution of surface waters. The explanations given for these changes are manifold but all of them are directly or indirectly related to the ongoing land use change developments. Most importantly deforestation and oil palm establishment are blamed for causing water shortages during dry season. Pollution of surface waters is mainly attributed to erosion and high waste and waste water emissions to the environment. The local water supply in Bungku is affected in the way that water, and particularly potable water becomes extremely scarce during prolonged periods without rainfall. Subsequently, clean water has increasingly turned into a commercial commodity difficult to access. For the individual households this implies that they have to spend significant amounts of money to purchase bottled water, to collect water at distant springs in neighboring villages or to expose themselves to water of dubious quality. Since when clean water started to become a scarce resource has been hard to specify exactly. Most people indicated that developments turned problematic at the beginning of the 21st century which coincides with the major boost in oil palm development in Indonesia (cf. SHEIL et al. 2009) and the decentralization process which has led to uncontrolled deforestation in large areas of Jambi (cf. DJOGO & SYAF 2004). However, the decrease of dry season flow and groundwater replenishment seems to be a gradual and ongoing process. The changes described have further gained strong support from a hydrological study conducted within the collaborative research center EFForTs. Results of streamflow measurements in Bungku showed higher streamflow fluctuation in an oil palm catchment in comparison with a rubber catchment (TARIGAN et al. 2014, in prep.).

Despite of the numerous compelling pieces of evidence for the changes described, the social embeddedness of the processes has to be acknowledged. Through land use conflicts with international oil palm companies and the associated involvement of diverse regional and even international stakeholders, the cultivation of oil palms in Bungku is a highly contested development. The way people communicate changes in local water resources is deeply

influenced by their personal attitude towards oil palm development. Water in this context is being used as an argument to substantiate the personal views in a wider land use change discourse and represents the social construction of the ongoing processes.

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ABBREVIATIONS

amsl	above mean sea level
BDU	Bangun Desa Utama (the former name of PT Asiatic Persada)
cf.	confer (compare)
coll.	colloquial
CRC	Collaborative Research Center
EFForTS	short title of the Collaborative Research Centre 990: "Ecological and Socioeconomic Functions of Tropical Lowland Rainforest Transformation Systems (Sumatra, Indonesia)"
ET	evapotranspiration
HPH	Hak Pengusahaan Hutan (concession to exploit the forest)
HGU	Hak Guna Usaha (land use concession)
HKM	Hutan Kemasyarakatan (community forest)
i.a.	inter alia (among others)
ibid.	ibidem (in the same place)
LCC	leguminous cover crops
LTSER	Long Term Social Ecological Research
n.d.	no date
NGO	non-governmental organization
PDAM	Perusahaan Daerah Air Minum (state-owned water supply company)
PRA	Participatory Rural Appraisal
PT AAS	timber plantation company in Bungku
PT AP	PT Asiatic Persada (large-scale oil palm company in Bungku)
PT REKI	PT Restorasi Ekosistem Indonesia (forest rehabilitation project in the southern part of Bungku)
POME	palm oil mill effluent
qtd. in	quoted in
snR	societal relations to nature
SAD	Suku Anak Dalam ("children of the Interior", postcolonial category for nomadic and semi-nomadic groups in Jambi)
SER	Social Ecological Research
TaHuRa	Taman Hutan Raya (\approx great Forest Park, forest reserve in Bungku)

1. INTRODUCTION

The global production of palm oil has increased significantly during the last twenty years. The market is firmly determined by Indonesia and Malaysia which produce almost 90 % of the global share (cf. SHEIL et al. 2009: 15, Tab. 1). Rapid large-scale land use changes have been the consequence in many parts of Indonesia and environmental and social consequences still need to be fully understood. The development of oil palm is embedded in a number of global discourses about climate change, biofuels, tropical deforestation, biodiversity loss, indigenous rights and the economic development of emerging markets. In turn, these have been contested by a number of diverse stakeholders from politics, economy and society. While impacts on biodiversity, climate or indigenous rights have been discussed in detail in science, popular literature and press (latest: JAUERING, H. 02/26/2014 for Spiegel Online), possible impacts of oil palm expansion on local water balances have been largely ignored. The only concern often raised regarding impacts on water resources, is the pollution of these due to a lack of palm oil waste management (i.a. Friends of the Earth, Sawit Watch & LifeMosaic 2008, SHEIL et al. 2009; BRIGGS et al. 2007).

The catalyst for this research on the impacts of oil palm expansion on rural water supplies was a doctoral candidate who came back from his field research in Indonesia. He reported that people in a village claimed to have problems with water scarcity ever since oil palm plantations began to dominate the local landscape. The occurrence of water scarcity in the humid tropics immediately awakened my interest and I undertook a short literature review to see whether some explanations for this phenomenon might exist. Indeed, I found there might be a link between water scarcity and deforestation. But hydrological processes in oil palm plantations are yet far from being fully understood (cf. COMTE et al. 2012). First evidence on community grievances about water scarcity are only found in very few and recent studies. The objective of this study therefore was to provide further empirical evidence of hydrological impacts of oil palm expansion and to depict the impacts of these on the local communities and their water supply.

Hence, the focus of this research was to conduct a case study on the villagers' perception of land use change and possible changes in local water resources. This was considered especially important as environmental perception strongly determines the way how local people make use of and manage their natural resources. Furthermore, it has the advantage of giving an insight into the real impacts that are experienced by the community. Because:

"Hydrologic complexity, in particular surface water/groundwater interactions and inter-annual variability, often obscures how reallocation takes place and what the associated impacts on the environment and diverse social groups are." (MEHTA et al. 2012: 194).

Environmental perception therefore constitutes a good entry point into understanding the way relations between society and nature are shaped. The interconnection between both provides the conceptual framework for this thesis, based on the concept of societal relations to nature ("gesellschaftliche Naturverhältnisse") by BECKER & JAHN (ed., 2006). Situated at the interface of social and natural science the research tries to provide a link between environmental perception and the current state of knowledge in natural sciences.

The main research questions to this thesis were:

- *Which changes in local water resources have been perceived by the villagers during the last 20-25 years?*
- *Which explanations are given by the villagers for these possible changes?*
- *How do these changes in water resources affect the local water supply?*
- *Which consequences for individual households emerge as a result of these changes?*

These questions were investigated during a three month stay in Indonesia from April to July 2013. The focus of the field research was put on problem-centered interviews on the household level. Data was crosschecked and complemented with participative methods at village level and stakeholder interviews on regional and national level.

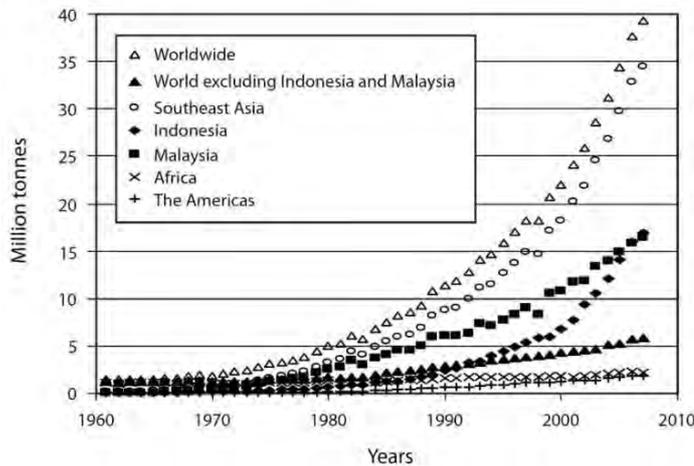
The first chapters of this thesis shall give an overview on current oil palm development in Indonesia as well as the current state of research on hydrological impacts of oil palm expansion. The following parts explain the theoretical concept as well as the methods and procedures used to collect and analyze the data. Chapter 6 provides a detailed analysis of the information gathered during the field research and finally chapter 7 and 8 discuss the collected data with reference to the current state of research and the theoretical concept applied. Chapter nine summarizes the results of the research and gives a brief outlook.

This Master thesis is part of the DFG-funded Collaborative Research Center 990: "Ecological and Socioeconomic Functions of Tropical Lowland Rainforest Transformation Systems (Sumatra, Indonesia)" (EFForTS), a joint research project of the Georg-August University Göttingen and the Indonesian partners: University of Jambi (UNJA), Bogor Agricultural University (IPB), Tadulako University (UNTAD) and the Indonesian Institute of Science (LIPI).

1.1. Global demand developments for palm oil

The international market price for palm oil has risen almost constantly in the last few years. Although prices declined during the financial and economic crisis in 2008, they have since shown a sustained growth (Index Mundi, qtd. in QVM Group LCC 2012). According to SCHOLZ (2004: 13) one reason for the rising demand is the significant price advantage compared to the main competitors: soy, rapeseed and sunflower oil, which is owed to a great extent to low Indonesian labor costs. The multifaceted utilization of palm oil and palm kernel oil as edible oil or for the production of pharmaceuticals, cosmetics, soaps and biodiesel is a further reason for the increasing demand. Currently, food production accounts for the largest share of global palm oil production with 68%, followed by industrial uses (27%) and energy generation (5%) (FNR 2011: 2). Apart from the rising demand of biodiesel (OECD & FAO 2011: 77ff), SCHOLZ (ibid. 2004) names two further developments as major drivers of a prospective continued demand growth: The continued increase in global per capita consumption of vegetable oils (from 5.5 kg in 1960 to 18 kg in 2000) and the ascending importance of the oleochemical industry over the petrochemical industry. Until today demand has been mainly determined by the three actors China, India and the EU (cf. Tab. 2).

Tab. 1: Palm oil production in Indonesia and other countries in comparison (1960-2010)



(SHEIL et al. 2009: 15)

Tab. 2: Main export countries for palm oil and palm kernel oil from Indonesia in 2008 (in tonnes)

	Palm oil	Palm kernel oil
India	4,789,663	128,649
China	1,768,240	230,608
The Netherlands	1,295,881	412,425
Malaysia	745,493	269,593
Singapore	600,875	14,545
Bangladesh	506,809	5,015
Egypt	495,888	12,800
Italy	464,768	25,006
Pakistan	409,752	5,020
Germany	404,772	11,000

(modified after ÜLLENBERG et al. 2011)

In Indonesia oil palm plantations have been expanding rapidly since the middle of the 1990s. In 2010 oil palm plantations covered an area of 7.8 million hectare¹ and Indonesia's palm oil production (SLETTE & WIYONO 2011, qtd. in CAROKO 2011: 2) reached 43% of the global production in 2006 (DANIELSEN 2009: 349, see Tab. 1). Although the recent expansion of oil

¹ This is equivalent to an area as large as the German federal states North Rhine-Westphalia, Rhineland Palatinate, Saarland and Hesse altogether.

palm was mostly determined by a rising international demand especially for edible oils (CAROKO 2011: 2), complex links between political and economic developments have to be considered as major drivers of local oil palm expansion.

1.2. Drivers of oil palm expansion in Indonesia

During the military regime (1967-1998) president Suharto pursued a strongly growth-oriented policy which was mainly achieved by the exploitation of natural resources. Vast deforestation, mining, plantation and timber industry led to massive encroachment on the natural environment. As land use was exclusively determined by the government in Java, sparsely populated islands such as Sumatra and Kalimantan were most affected by these policies (BARKEMEYER 2004: 268ff, MOELIONO & DERMAWAN 2006). The transmigration program (*transmigrasi*), which started in 1969 aimed at the resettlement of mainly Javanese people to sparsely populated areas. People were attracted to participate in the program with the promise of land ownership of two hectare, a house and seeds among other incentives (STRUTYNSKI n.d.). Since the 1980s the focus of the program has shifted from subsistence cultivation towards oil palm cultivation. Thus, every household received a two hectare oil palm plantation which was often managed in close cooperation with private plantation companies (so called “nucleus-estate schemes” (NES)) (SCHOLZ 2004: 11f). According to official information sources 1.7 million households were resettled during the transmigration project (STRUTYNSKI n.d.) and roughly 900,000 ha of land were provided for NES-schemes (ÜLLENBERG et al. 2011: 48).

After the collapse of the centralistic Suharto Regime the newly elected president Habibie initiated a decentralization policy which aimed at empowering regional and district governments. As many competences and responsibilities remained unclear at the beginning of the decentralization process, district governments often determined local resource use without any further consultation with the national institutions. Decentralization for them also implied that they had to use their land efficiently and profitably. Thus, they often revised land use plans, trying to maximize the profits of their natural capital. "*De facto* decentralization" (MOELIONO & DERMAWAN 2006: 109) therefore often occurred much faster than the formal decentralization process (cf. also SIAGIAN & KOMARUDIN 2008: 6). The active shaping of regional economic development by affluent, powerful companies created significant possibilities for corruption (FEINTRENIE, SCHWARZE & LEVANG 2010). Together with a severe lack of law enforcement, corruption led to further deforestation and illegal granting of land

use concessions (BARKEMEYER 2004: 274f). Unclear land ownership provided further opportunities for uncontrolled land use changes (MOELIONO & DERMAWAN 2006: 11ff). Watch Indonesia (2011) assumes that less than 40 % of the Indonesian population possesses official ownership titles.

During the last years the Indonesian government strongly tried to stimulate the use and production of renewable energies to reduce the country's reliance on imported fossil fuels while securing profits from its important oil and gas economy. In this context, a sustained growth of biofuels is currently secured by government investments in large-scale plantations (OBIDZINSKI et al. 2012).

Not only has the political environment fostered the expansion of oil palm plantations, but economic profitability has had its share in this development as well. During the last few years this growth was also strongly forwarded by individual smallholders. In 2010 they had already cultivated about half of the total oil palm plantation area in Indonesia (Indonesian Ministry of Agriculture 2011, qtd. in OBIDZINSKI et al. 2012, cf. Tab. 3). FEINTRENIE, SCHWARZE & LEVANG (2010) argued that farmers prefer growing oil palm due to its high yields, low required labor inputs and a short growth period until the first harvest. According to the

Tab. 3: Oil palm area and palm oil production 1970-2010

Year	Palm oil area (million of hectares)				Palm oil production (million of tons)			
	Small- holders	State owned	Private estates	Total	Small- holders	State owned	Private estates	Total
1970	-	0.09	0.05	0.13	-	0.15	0.07	0.22
1980	0.01	0.20	0.09	0.29	0.00	0.50	0.22	0.72
1990	0.29	0.37	0.46	1.13	0.38	1.25	0.79	2.41
2000	1.17	0.59	2.40	4.16	1.91	1.46	3.63	7.00
2005	2.36	0.53	2.57	5.45	4.50	1.45	5.91	11.86
2010	3.31	0.62	3.89	7.82	7.77	2.09	9.98	19.84

(Indonesian Ministry of Agriculture 2011, qtd. in OBIDZINSKI 2012)

authors, the highest priority is a quick and high return on labor costs. In any event, it remains difficult to evaluate the situation of smallholders as conflicting studies exist claiming both higher or lower incomes for oil palm growers in comparison to other farmers (SHEIL et al. 2009 & WAKKER 2004, qtd. in ÜLLENBERG et al. 2011: 51).

While the Indonesian economy significantly profits from the rapid oil palm expansion - palm oil industry is expected to contribute 8.8 % to the total export revenue and to employ around 15 million Indonesians – the consequences for the environment are severe. Large scale deforestation is attributed to rapid land use change on the islands Sumatra, Kalimantan and West Papua. For Sumatra average annual deforestation rates of 550,000 ha between 1985 and 2007 have been reported. While forest areas still covered 57 % of the island in 1985, this area has since decreased to almost 30 % in 2007 (WWF 2012). Estimates of the direct contribution

of oil palm plantation growth to deforestation vary between 27 to 56 % of the cleared area (CARLSON et al. 2012: 3; KOH & WILCOVE 2008: 62).

Jambi, a Sumatran province, is one of the main areas of oil palm cultivation and significant future growth is expected there (cf. Fig. 1). As of the second half of the 19th century, Sumatra's landscape was mainly characterized by rubber (*Hevea brasiliensis*) land use systems. In the beginning, rubber was mainly cultivated in agroforestry systems. However, since the 1980s monocultural land use systems increased constantly. Oil palm (*Elaeis guineensis*) was introduced in Sumatra in the early 1980s. Today oil palm land use systems determine large areas of Jambi (FEINTRENIE & SCHWARZE & LEVANG 2010; MURDIYARSO et al. 2002). Currently 1.1 million ha land are officially allocated for oil palm cultivation. In 2008, however only 486,001 ha had been developed (SLETTE & WIYONO 2001, qtd. in CAROKO et al. 2011: 3). The average forest loss measured between 2006 and 2009 was 76,522 ha² per year (PERBATAKUSUMA et al. 2012, qtd. in HEIN 2013: 12).

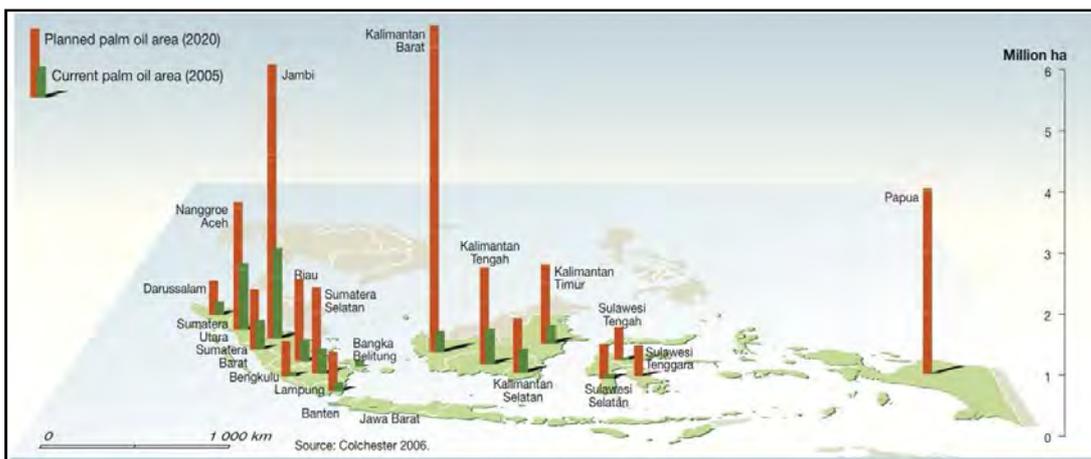


Fig. 1: Current and planned oil palm cultivation areas in Indonesia (REKACEWICZ et al. 2009, modified after COLCHESTER 2006)

² This roughly equivalents the area of the German state Hamburg (75,500 ha)

2. HYDROLOGICAL IMPACTS OF OIL PALM EXPANSION – CURRENT STATE OF RESEARCH

In order to analyze the impacts that current oil palm expansion might cause to the hydrological cycle in Sumatra, two different developments must first be taken into account: 1. the forest clearing operations that may possibly forego the development of oil palm plantations, 2. site preparation and plantation management practices such as harvesting procedures or the use of agricultural inputs. Possible consequences of deforestation and agricultural practices, common in oil palm plantations, will be discussed in this chapter. On any account, one must consider that a diverse range of physiographic factors such as geology, climate or topography may influence or even exceed effects caused by human alteration. Understanding the total complexity of the effect of ecosystems on water flows still remains a challenge for managers and decision makers (LOCATELLI & VIGNOLA 2009: 1864).

2.1. Hydrological impacts of deforestation

Most studies regarding the hydrological impacts of deforestation base their conclusions on the following three effects when dealing with the clearing of vegetation: the effect on regional rainfall, on total and seasonal water yield and on erosion and sediment yields.

Regional rainfall is often estimated to decrease significantly as a result of large scale deforestation due to decreased evapotranspiration. Nevertheless, BRUIJNZEEL (2004: 185) argues that the influence of secondary vegetation regrowth and maritime climate, influenced by sea-surface temperatures, can be expected to be more pronounced than the climatic effects of land-cover change. This, according to him, is particularly true for Southeast Asia.

Caused by a severe decrease of evapotranspiration upon clearfelling, total water yield generally increases during the first years. As long as the intake capacity of the surface soil is not impaired too much the increase in flow is normally observed in the form of baseflow. If the development of regrowth is allowed, a decline of total water yields to pre-clearing levels is expected with time. Otherwise, if forest is being converted to agriculture cropping, permanent changes in water yields may be produced (BRUIJNZEEL 2004: 194ff). Indeed, many authors argue that the effects of forest growth on water flows are discernible only in small watersheds, because separating hydrological effects of forests is more difficult in larger and more heterogeneous catchments (BRUIJNZEEL 2004: 199f; FAO & CIFOR 2005, qtd. in LOCATELLI & VIGNOLA 2009: 1867). In areas of seasonal rainfall, the distribution of

streamflow throughout the year is often more important than total annual water yield. A common notion about the hydrological role of the forest is that the complex of forest soil, roots and litter act as a sponge soaking up water during rainy spells and releasing it evenly during dry periods. Upon deforestation this sponge effect may be lost due to a number of factors: rapid oxidation of soil organic material, the exposure of bare soil to intense rainfall, the compactation of soil by machinery, gradual disappearance of soil faunal activity or the increase of areas occupied by impervious surfaces such as roads and settlements (BRUIJNZEEL 2004: 201f).

“As a result [of gradually reduced rainfall infiltration opportunities], catchment response to rainfall can be more pronounced and the increases in storm runoff may become so large as to seriously impair the recharging of the soil and groundwater reserves feedings springs and maintaining baseflow.” (ibid. 2004: 201).

Rather than an increase of baseflow the decrease of it is the consequence, resulting in diminished dry season flows. Accounts of diminished dry season flow upon tropical forest removal are numerous (i.a. PATTANAYAK 2004; ADOPKO MIGAN 2000; HAMILTON & KING 1983). Although this “infiltration trade-off hypothesis” (BRUIJNZEEL 1989) remains to be proven, support for it comes from a modeling exercise by VAN DER WEERT (1994, qtd. in BRUIJNZEEL 2004: 202). VAN DER WEERT (ibid.) simulated three streamflow components: surface runoff, subsurface stormflow and baseflow for fully forested and fully cleared conditions with gradually increasing surface runoff coefficients. The model (Fig. 2) shows that baseflow remains only slightly affected if surface runoff remains below 15%. But if runoff becomes as high as 40%, the baseflow is roughly halved. VAN DER WEERT (ibid.)

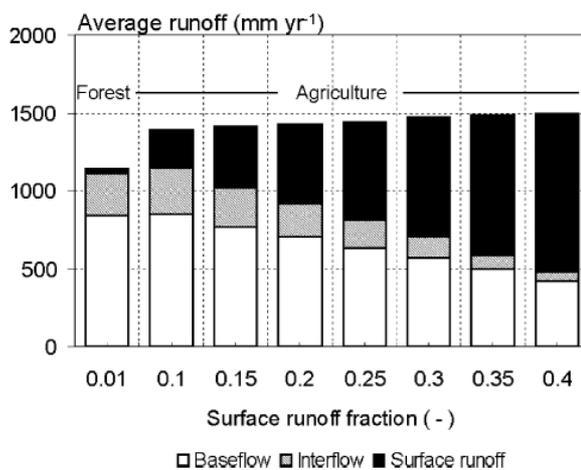


Fig. 2: Simulated changes in streamflow components for forested and agricultural conditions with increasing soil disturbance (WEERT, van der 1994, qtd. in BRUIJNZEEL 2004)

further suggests a more rapid diminishing dry season flow in the case of deep soils with large storage capacity. Additional support comes from a study by KRISHNASWAMY et al. (2013) conducted in India. The authors measured streamflows in eleven catchments with three different ecosystems: tropical evergreen forests (NF), heavily degraded forests which have been converted to tree savannas (DF) and Acacia plantations

(AC). Flow duration curves demonstrated a higher frequency and longer duration of low flows under natural forest conditions when compared to the other more disturbed land types. Groundwater recharge during wet season was estimated under NF, AC and DF to be 50 %, 46 % and 35 % respectively in coastal areas and 61 %, 55 % and 36 % in the Western Ghats mountains region (ibid.) An additional factor that can affect the infiltration capacity are reduced transpiration rates after forest clearing which cause that the field capacity of a soil is reached earlier during rainfall events. (DID 1989, qtd. in COMTE et al. 2012: 96f). However, one must consider that the impact can differ given the enormous differences in groundwater reserves and geological conditions. Further research regarding the separate effects of climate, vegetation, soil and geology is urgently needed (BRUIJNZEEL 2004: 203).

While diminished dry season flow can be one of the effects of forest conversion, an increase in storm flow is often observed during rainy season (ibid.). Although FAO and CIFOR argue that there is no hard evidence that tropical forests reduce floods, this might be explained by

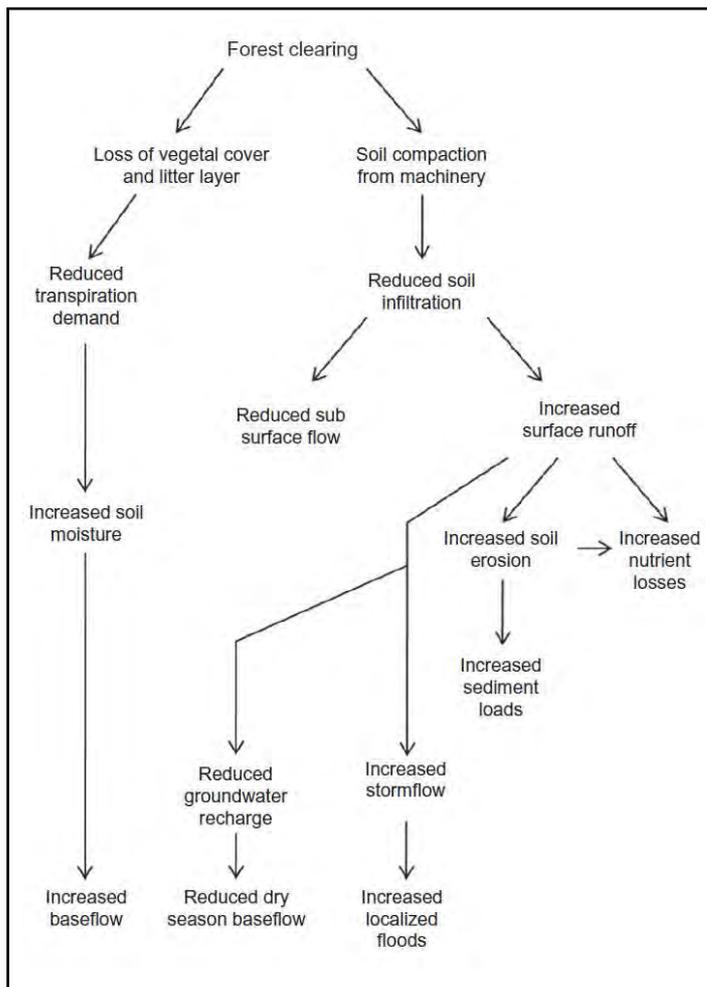


Fig. 3: Hydrological impacts of forest clearing (modified from HENDSON 1999, after COMTE et al. 2012: 112)

the weak effect of forests on large-scale floods or extreme rainfall events, especially if soils are wet (LOCATELLI & VIGNOLA 2009: 1867, cf. also BATHURST et al. 2010: 114). On the contrary, BRADSHAW et al. (2007) showed that flood frequency is negatively correlated with forest cover. They reported an increase of 4 % to 28 % flood frequency based on a modeled natural forest cover loss of 10 % using data from 56 developing countries. Even if soil disturbance is kept to a minimum by careful planning, there will be increases in peak-flows after forest removals associated with reduction of evapotranspiration (BRUIJNZEEL 2004: 203ff). The impact will be

more pronounced if the soil is being degraded and overland flow increases as a result of diminished infiltration opportunities. Burning practices or the use of heavy machinery for logging are important factors contributing to the occurring of storm flows (ibid.). Although agricultural burning has been prohibited by the Indonesian government since 1997 (COMTE et al. 2012: 81), this law appears to be poorly enforced as became evident during the forest fires in June 2013 (cf. i.a. SIZER et al. 2013).

Finally, it seems that the effects of forest cover change on water flows mainly depend on two factors: evapotranspiration (or water use) and the infiltrability of water into the soil. While forests on the one hand contribute to a low base flow by high transpiration rates, the high infiltration capacity under forest generally contributes to soil water recharge and high baseflow on the other hand (LOCATELLI & VIGNOLA 2009: 1867). Fig. 3 provides a good summary of the hydrological consequences that may occur after forest clearing.

2.2. Hydrological processes in oil palm plantations

The most important literature review on hydrological alterations caused by oil palm plantations comes from COMTE et al. (2012). As large-scale oil palm development has only taken place during the last twenty years (cf. Tab. 1, p. 3), they found a substantial lack of research. While most studies investigating agricultural practices are of experimental character, only few studies actually review practices followed by farmers. A further lack of research still exists regarding studies on watershed scale, as most research was only conducted on plot scale (ibid.: 113f).

Almost 25% of all oil palm plantations in Indonesia are located on peat soil, although oil palms cannot survive in waterlogged areas (SHEIL et al. 2009: 5ff; TAN et al. 2009, qtd. in COMTE et al. 2012: 77). Thus, drainage channels are installed between 40 and 80 cm depth. During an extended drought, according to Wetlands International, the water table could even recede below 80 cm (Watch Indonesia 2010, qtd. in COMTE 2012: 77).

Evapotranspiration of mature oil palm plantations is considered to be similar to natural forests ranging from 1000-1300 mm year⁻¹ (COMTE et al. 2012: 96; BABEL, SHRESTHA & PERRET 2011: 8).

Infiltration was found to decrease significantly after deforestation attributed mainly to compaction by heavy machinery. Particularly prone to compaction are soils with a high clay content. After plantation establishment, infiltration rates however returned to pre-

disturbance level, attributed mainly to the planting of legume cover crops (MDID 1989: 59). Further proof for relatively good infiltration rates in oil palm plantations was given by BANABAS (2008: 336) and YUSOP, CHAN & KATIMON (2007: 44). BANABAS (ibid. 2008) on the other hand also emphasized the spatial variability of infiltration rates, which were much lower along roads, harvest paths and weeded circles (cf. Tab. 4). Weeding circles in mature oil palm plantations are normally up to four meter wide and are implemented to prevent weed competition (JANICK & PAULL 2008: 123, cf. Fig. 4).

Tab. 4: Soil infiltrability (mmhr⁻¹) for major soil types and at specific locations in oil palm plantations

Soil	Fron piles	Between zones	Weeded circles	Harvest path	Source
Typic Hapluland, sandy clay to clay loam	1351	997	270	265	Banabas <i>et al.</i> (2008)
Typic Udivitrand, sandy loam to sand	7350	1230	340	60	Banabas <i>et al.</i> (2008)
Typic Hapludult	2050	—	—	175	Maena <i>et al.</i> (1979)

(COMTE *et al.* 2012: 97)

Different results have been found regarding the impact of oil palm plantation development on the water balance. As YUSOP, CHAN & KATIMON (2007: 44) and MDID (1989: 16f) found high infiltration rates in their studies, it is not astonishing that both reported a high proportion in baseflow. YUSOP, CHAN & KATIMON (ibid.) even stated that the baseflow proportion found in the oil palm catchment investigated showed quite similar characteristics with forested catchments. On contrary, BABEL, SHRESTHA & PERRET (2011) reported that the impact of oil palm plantation establishment depended on the different scenarios for oil palm expansion. While a conversion of orchard or rubber plantations to oil palm had no significant effect on surface runoff, the conversion of forest to oil palm plantation resulted in an increased surface

Tab. 5: Surface erosion rates in tropical forest and tree crop systems (t ha⁻¹)

	Minimum	Median	Maximum
Natural forests	0.03	0.3	6.2
Tree gardens	0.01	0.1	0.2
Tree crops with cover crop/mulch	0.1	0.8	5.6
Tree crops, clean- weeded	1.2	48	183

(modified after WIERSUM 1984, qtd. in BRUIJNZEEL 2004: 211)



Fig. 4: Weeded circle under an oil palm (own picture)

runoff of about 13 % and a reduced baseflow by about 7 %. While they agreed with YUSOP, CHAN & KATIMON (2007) and MDID (1989) regarding negligible changes in total annual water yield, they found a significant change in monthly water yield. Further support for marginal changes in water balance comes from NELSON et al. (2010). They reported that: "Mature oil palm has a similar water balance to the original forest, which underpins the sustainability of oil palm systems." (ibid.: 33). This finding once again highlights the importance of the physiographic conditions of the research area, since the study by NELSON et al. was conducted in a mountainous area with large water reservoirs an evenly distributed rainfall over the year. Furthermore, the area of oil palm cultivated was small relative to the size of the catchment.

Surface runoff is likely to occur in oil palm plantations due to a high variability in soil infiltration capacity (BANABAS et al. 2008: 336f). MDID (1989: 59f) reported erosion five to seven times higher in deforested than in forested area. After legume cover crop planting erosion was greatly reduced but not eliminated. This is in line with research done by WIERSUM (1984, qtd. in BRUIJNZEEL 2004: 211) who emphasized the importance of a litter layer maintained by some vegetation or a mulching layer for soil protection. If these layers are kept, erosion rates from tree crop systems are generally reported to be minimal. While the removal of understory vegetation may increase erosion rates somewhat, surface erosion rises dramatically if the litter layer is removed or destroyed as a result of burning, weeding or overgrazing (ibid. 1984, cf. Tab. 5 & Fig. 4). Especially during the first years after plantation establishment this proves to be important, as tree crops may require two to five years to close their canopy (SANCHEZ et al. 1985, qtd. in HARTEMINK 2005: 14).

If legume crops are planted, erosion is supposed to be mainly initiated in the weeded circle where stem flow causes highest local water inflows as well as in the harvest path zone (BANABAS et al. 2008: 337). Yet, HARTEMINK (2005) points out that:

“As the cover crop disappears after the closure of the palm canopy, harvest paths become exposed and compacted, which enhances run-off and soil erosion. Therefore, soil erosion may not necessarily decrease when the palms get older and the canopy is closed.” (ibid. 2005: 14).

Nutrient losses in oil palm plantations depend first of all on the soil type, rainfall intensities and agricultural practices. COMTE et al (2012: 97ff) summarize that nutrient losses via leaching and nutrient concentrations in groundwater quality were generally reported to be low. Higher nutrient losses certainly are reported during the first year after logging and are expected to be higher in immature than in mature oil palm plantations. Nutrient losses

according to their review occurred primarily from leaching rather than from runoff. BABEL, SHRESTHA & PERRET (2011: 21ff) though found that nitrate and phosphorus loss increased significantly for different scenarios of oil palm expansion (e.g. from forest to oil palm or from rubber to oil palm). With the use of the SWAT model they evaluated the impacts of land use change on water balance and quality. In their assessment it would follow, that oil palm expansion would have a significantly adverse impact on the quality of surface waters. But as COMTE et al. (ibid.: 103) point out, further research on the link between nutrient leaching and groundwater quality is strongly required.

An urgent issue regarding stream water quality is the release of POME (palm oil mill effluent) from large oil mills. It is often released directly to streams, sometimes without treatment (COMTE et al. 2012: 109). A study by OLALEYE and ADEDEJI (2005) ascribed the near absence of zooplankton in a large Nigerian river as a result of POME discharge in the stream (qtd. in COMTE et al. 2012: 109). Further evaluation also comes from BRIGGS et al. (2007) who warn of the detrimental ecological effects that POME discharge might have due to its high nutrients and heavy metal levels and an acidic pH. Pesticide application, including herbicides, is further expected to impact water quality. Until today, however, the absence of data on this topic remains a major knowledge gap (COMTE et al. 2012: 109).

As mentioned at the beginning of this chapter, it must once again be emphasized that most existent studies on the hydrological impacts of oil palm plantations lack linkages to agricultural practices and studies at watershed scale are almost nonexistent. Thus, COMTE et al. conclude:

"...hydrological process dynamics and magnitude (e.g., total water yields, dry season baseflow, stormflow dynamics) and nutrient outflows from oil palm plantations are far from being fully assessed and understood." (ibid. 2012: 113).

Most importantly, though most authors emphasize the importance of good agricultural practices. If stringent plantation practices are observed, oil palm catchments may function reasonably well in maintaining their hydrological regime (i.a. YUSOP et al. 2007; COMTE et al. 2012). As current agricultural practices used in oil palm plantations in Southeast Asia, especially among smallholding, are yet poorly described and efficient and long-term monitoring often lacks resources in developing countries, further research is urgently needed (COMTE et al. 2012: 114).

2.3. Community grievances on the degradation of water resources

While plenty of scientific and NGO reports exist on the social consequences of oil palm expansion, particularly such regarding land conflicts, current reports about water grievances remain limited. Most studies focus on the impacts on water quality that may arise due to pesticide application or the discharge of POME into surface waters. NGO complaints about this are numerous (COLCHESTER & CHAO (eds.) 2011; COLCHESTER et al. 2006; Friends of the Earth (FoE), LifeMosaic & Sawit Watch (eds.) 2008; WAKKER 2005).

“There are hardly any fish left...Some days we do not find any fish at all. It is not only the liquid waste of the CPO plant, but the actual oil palm plantation pollutes the water, too. During the dry season the plantation is sprayed with pesticides, herbicides and fertilizers, and as soon as the rainy season comes, the rain washes them into the river. These substances are poisonous for the fish and kill them.” [Interview with a fisherman in Riau Province conducted by NGO staff in 2006 (FoE, LifeMosaic & Sawit Watch (eds.) 2008: 98)].

The report by FoE, LifeMosaic and Sawit Watch is the only NGO report also reporting about reduced water availability caused by oil palm expansion.

"In the past when there was no oil palm plantation here, water in the river was very deep, but now it's very shallow. We run out of water, it is difficult for people to find clean water in the dry season, not every one [sic] has a drilled well. In the past in the forest, after a month and a half of dry season we would still find many small rivers. Nowadays after a month or so of dry season they have all dried up.” [Interview with smallholder in West Kalimantan conducted by NGO staff in 2006 (FoE, LifeMosaic & Sawit Watch (eds.) 2008: 96)].

FoE, LifeMosaic and Sawit Watch argue that the drying of the rivers might be explained by a decreased permeability of the land and as well by drainage channels constructed by the oil palm companies. In addition to the observations of decreased water levels during dry season, an increased incidence of floods was reported (*ibid.*).

The first scientific study mentioning impacts of oil palm expansion on the local water balance was conducted by CIFOR members OBIDZINSKI et al. (2011). Their study was conducted in three sites in the Indonesian provinces West Kalimantan, Papua and West Papua. The main complaints reported by local residents were soil erosion and subsequent sedimentation of rivers, areas becoming waterlogged due to the destruction of natural drainage, the occurrence of flash floods, water pollution and a more frequent occurrence of skin diseases. In all three villages people also complained about a growing scarcity of water quantity during dry season

(cf. Tab. 10, appendix). Only one of the villages was located on peat soils (cf. drainage of peatsoils, p. 139). Unfortunately neither the NGO reports nor the CIFOR report delivers further details on the issue of increasing water shortages.

Indeed, the first and only scientific study *focusing* on water grievances by local communities was conducted by KLØCKER LARSEN et al. (2012) for the Stockholm Environment Institute in cooperation with two Indonesian NGOs. As the research questions and methodology employed were similar to those of this thesis, the results of the former shall be discussed in detail to allow for a detailed comparison afterwards. KLØCKER LARSEN et al. examined the impacts and risks of water resource management associated with oil palm plantations in Central Kalimantan. Using a qualitative research approach they interviewed inhabitants of three villages, government officials, NGO representatives and members of research institutions about their observations and evaluations of hydrological impacts arising from oil palm plantations. The field sites were located mainly around Lake Sembuluh in Central Kalimantan, where oil palm plantations, rubber and mining (coal and gold) are the main land use systems. The province boasts the majority of Indonesia's peat soils. In all three villages large plantation companies had settled down, but also local residents had started to grow oil palm in their gardens in hope of economic benefits. The hydrological impacts reported were related to both water quality and water quantity and included:

- Erosion and run-off from plantations leading to turbid water,
- release of toxins into the water bodies through pesticides application on the plantations,
- decline in fish stocks and aquatic wild plants,
- POME and other palm oil waste dumped or released into waterways,
- reduction in or redirection of water flows by dam or channel construction,
- floods linked to deforestation (increased peak flows and risk of flash floods), and
- the drying of community land adjacent to plantations and a lowering of the water table (including wells), forcing villagers to give up traditional rice farming (cf. Fig. 5) (KLØCKER LARSEN et al. 2013: 6).

A major issue, reported in all three villages and approved by government officials and NGOs was a significant degradation of water quality. In all three villages the water quality of streams and rivers had decreased to such an extent, that people could no longer make use of local water resources (cf. Fig. 6). In two of the villages the oil palm companies were therefore forced to provide a drinking water supply system for the village. In the third village the state-owned water supply company (PDAM) initiated deliveries of drinking water. In the first village, however, the company failed to provide reliable water to the households so that

people had to resume using their wells and distant rivers to secure their water supply. Some villagers even tried to find other nearby water resources which they claimed were of dubious quality. Skin diseases were reported to be frequent health problems related to the poor water quality. While fishing once constituted an important source of income prior to the development of oil palm plantations in the area, today only few fishermen remain due to the rapid decrease in fish stocks (ibid. 2012: 22ff).

“[We] now use wells, but in [the] dry season there is no water. Then [we] search for water elsewhere in the plantation area, for instance in a nearby excavation site, but [we] are not sure the quality is good there.” (KLØCKER LARSEN et al. 2013: 6).

“In the dry season there is almost no water in the river, and in the rainy season people cannot consume the water; it is polluted... and they get skin diseases. It is related to the palm oil mills. The water also changes colour. Now the groundwater is better.” (KLØCKER LARSEN et al. 2012: 23).

While villagers claimed pollution was mainly caused by POME being released into the rivers, government officials considered household waste, mining and fish poison to be further important sources of pollution. A research institution explained that the degradation of drained peat soils which in result turned acidic and toxic might be another source of the pollution experienced by the villagers (ibid. 2012: 28ff).

According to private sector representatives as well as to government officials, law enforcement was the most important obstacle towards a more sustainable oil palm production. A sustainability manager of one of the major palm oil buyers reported that in Indonesia no plantation was unproblematic. Two officers of the Ministry of Environment further admitted:

“Almost nobody complies with regulations to keep the required minimum distance from river and streams...the legislative framework is too complex and law enforcement too weak.” (KLØCKER LARSEN et al. 2013: 7).



Fig. 5: Small river in a research village during dry season (KLØCKER LARSEN et al. 2012: 23)



Fig. 6: Clearly visible water pollution in a river of a research village (ibid. 2012: 27)

3. THEORY, CONCEPTS AND FRAMEWORK

As the preceding chapter shows, a number of references already exist that indicate a possible relevance of the impact of oil palm expansion on the hydrological cycle. The research at hand shall give an insight into local observations and arguments on the topic in a village in Southern Jambi. To provide for a deep understanding of the mutual relations between society and environment, the social ecology as elaborated by the Frankfurt Institute for Social-Ecological Research, shall serve as a theoretical orientation. At the nexus of natural and social sciences this research is therefore situated at what GEBHARDT (ed., 2007) calls the "third pillar" ("dritte Säule") of Geography, the society-nature interactions (ibid.: 70). Geography has a long tradition of focusing on the integration of natural and social sciences and often claimed this to be the particular characteristic of geographical sciences. One famous and very early example of this most certainly is the article "Geography as Human Ecology" by BARROWS in 1923. On the other hand, likewise the criticism of *how* an integration of human and physical geography can actually be forwarded has been debated extensively (cf. i.a. WEICHHART 1993). ZIMMERER (2012) identified six important conceptual connections between "HE-NS geography" (Human-Environment, Nature-Society geography) and Long Term Social Ecological Research (LTSER). These include among others "Coupled Human-Environment Interactions", "Sustainability Science, Social-Ecological Adaptive Capacity, and Vulnerability" and "Environmental Governance and Political Ecology" (ibid.: 8). This thesis can be situated in the research on coupled human-environment interactions. "Couplings", according to BECKER and SCHRAMM (2002: 361) can be understood as the arrangements and constellations between the different entities (objects, systems, structures, processes) and are analyzed at multiple interlinked socialecological scales, both spatially and temporally (ZIMMERER 2012: 167). The Social Ecology by the Frankfurt Institute for Social-Ecology Research approaches these interconnections in human-environment systems with the concept of societal relations to nature which shall be elaborated hereafter.

3.1. Societal relations to nature

Societal relations to nature ("gesellschaftliche Naturverhältnisse") constitute the common reference of research of social ecological sciences as described by the Frankfurt Institute for Social-Ecological Research.

“Social Ecology is the science of the relationships between people and their natural and social environment. SER [social ecological research] investigates the existing forms of these relationships and the possibilities of transforming them, by means of a comprehensive, disciplinary unbound perspective. The research objective is to generate knowledge for societal concepts of action in order to be able to ensure the future reproduction and development potential of society and its natural life stock.” (JAHN & KEIL 2004: 7).

Societal relations to nature “[...] emerge from the culturally specific and historically variable forms and practices in which individuals, groups, and cultures design and regulate their relations to nature.” (BECKER, HUMMEL & JAHN 2011: 2) These dynamic interactions between societal action, natural processes and technical solutions lie at the root of current socio-ecological crisis phenomena. These crises may emerge on different spatial levels, such as local environmental degradation or global climate change (BECKER & JAHN 2006: 97f). A particular light is therefore shed on the examples of unsuccessful regulation causing social-ecological problems (BECKER, HUMMEL & JAHN 2011). Furthermore, a strong focus is put on the so called “basic” societal relations to nature, such as work, production, health or land use among others. As these form the context in which basic needs are satisfied and life-supporting goods and services are regulated, they are indispensable for societal and individual reproduction and development (ibid.).

In the context of social ecological research the relationship between nature and society is investigated by making clear distinctions between the physical-material and the cultural-symbolic aspects of the relations. At the same time the interconnection of both is emphasized. Thus, it can be said, that although the materiality of all natural relations is emphasized, the “embeddedness of these in symbolic orders, interpretive contexts and social constructions is taken into account” (ibid. 2011: 3). Through this approach SER tries to overcome the dualism of social and natural sciences and to integrate natural and socio-scientific knowledge (BECKER & JAHN 2006: 165f). Basic societal relations to nature are also closely related to the concept of transdisciplinarity, in which research on real-world problems is particularly stressed. All kinds of stakeholders, scientists and societal actors, shall work together in a mutual learning process towards a problem driven integration of knowledge and methods. What issues are problematic shall not be defined by scientific criteria alone but rather by interests, needs and values of a society (JAHN et al. 2009). Thereby social ecological research aims to reveal practical applications that strengthen the capacity of societies to cope with challenges. Furthermore, SER follows a normative orientation closely linked to the ideas of sustainable development as SER investigates how the regulation of nature can guarantee the satisfaction of basic needs by

all human beings (BECKER, HUMMEL & JAHN 2011). The regulation of nature itself is formed within the encounters and interactions of numerous actors and institutions, at various levels and in different functional areas. Patterns of regulation might thus range from the individual satisfaction of needs, societal organizations and institutions to society-wide structures and processes. Changes in these patterns, according to BECKER, JAHN AND HUMMEL (2011) constitute social-ecological transformations.

Using the societal relations to nature as a frame of reference, this research shall focus on the question how possible crisis phenomena of local water balance arise and how and by which processes the patterns of societal relations to nature are formed. The research is conducted in an inductive manner trying to capture the real world problems that villagers perceive concerning their water supply. Different explanations by involved stakeholders shall be analyzed to understand why regulation of water resources fails and how the provision of clean water can be guaranteed for all villagers.

3.1.1. Current perspectives on water-society research

Throughout history, Water and society have been deeply interconnected. As a life-sustaining good, a life threatening natural force, a transportation medium or a disease-transmitting fluid, it has shaped societies in manifold ways. Water resources have been a trigger for the determination of settlement areas, its management has enabled the development of intensive agriculture, even in arid areas, and on the other side water has threatened local population through tsunamis (e.g. 2004 in Indonesia and Thailand or 2011 in Japan) or through the spreading of diseases like cholera (e.g. in Haiti 2010). The control of scarce water resources has led to numerous violent and even military conflicts (e.g. Israel and Palestine, conflicts over water privatization in Bolivia in 2000). Although a seemingly commonplace resource the study of water has thus given rise to innumerable research projects that have discussed the role of water in the past, current and future societies. In an attempt to categorize the different perspectives on water-society relations, five major groups were identified:

1. *Water & poverty*: The focus of this research is put on the different aspects of water-related poverty such as household specific barriers to access, low productivity, chronic or acute vulnerability, costs and reliability of water access or sanitation and health. As a particular emphasis is put on the poor, this research is often situated within the Sustainable Livelihood Approach (CHAMBERS & CONWAY 1991) (see e.g. TSEGAI, MCBAIN & FISCHBEIN 2013, KEMP-BENEDICT et al. 2011, NICOL 2000 or BILTONEN & DALTON 2003).

2. Water & global change: This topic comprises research related to global change in general. It focuses for example, on the global water crisis (JURY & VAUX 2007), impacts of climate change on water resources (PARISH et al. 2012; GREEN et al. 2011) or the unequal global distribution of water access and the export of virtual water to highly developed countries (ERCIN & HOEKSTRA 2014; CHEN & CHEN 2013; VANHAM, MEKONNEN, & HOEKSTRA 2013).
3. Water & sustainability: The focus within this group lies on the sustainable management of local and international water crisis phenomena. Examples of research topics are integrated water management (BUTTERWORTH et al. 2012), the adaptive capacity of societies (BOHENSKY & LYNAM 2005; TURTON 1999) and determinants of resilience or sustainable management in general (OSTROM 2009; FOLKE et al. 2007).
4. Water & governance: The fourth group is situated around the Political Ecology of water. This kind of research focuses on the analysis of how power relations and water governance determine water crisis phenomena and how access to water among specific social groups is negotiated (i.a. MOLLINGA 2008; BUDDS & HINOJOSA 2012; MEHTA, VELDWISCH & FRANCO 2012; CRIFASI 2009 or LOFTUS 2009).

All these different lines of research depict the multiple interconnectedness of water and society and the importance of understanding these relations to achieve sustainable development. The fifth group focuses on these dialectical relations of water and society and constitutes the social ecological research on water. An important concept within this topic is the "hydrosocial cycle", which shall be explained in more detail.

The "hydrosocial cycle", as elaborated by LINTON & BUDDS (2013) is an analytical tool to investigate hydrosocial relations. The main idea behind the concept is that water cannot be regarded as an object of social process but rather one that is both shaped by and in itself shapes social relations, structures and subjectivities in a cyclical process. The authors criticize concepts like the integrated water resource management (IWRM) for supposing that the hydrological and the social are priori separate and unconnected. Instead, they argue that water and society are related internally and should thus be considered as hybrids. Hybridity means that all things are simultaneously social and natural, engaged dialectically as product and agent of socio-natural change. The hydrosocial cycle according to LINTON and BUDDS can be defined as "a socio-natural process by which water and society make and remake each other over space and time." (ibid. 2013: 6).

Similar to the understanding of the interconnection of nature and society by BECKER & JAHN (eds., 2006), the term hydrosocial cycle regards water "simultaneously as a physical flow (the

circulation of H₂O) and a socially and discursively mediated thing implicated in that flow..." (BAKKER 2002: 774, qtd. in LINTON & BUDDS 2013: 6).

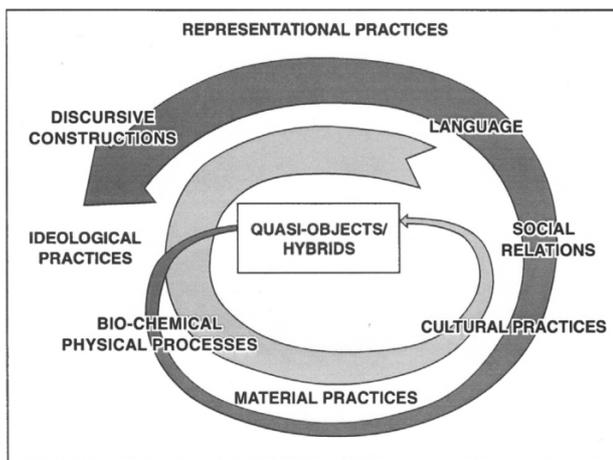


Fig. 7: The production of socio-nature (SWINGEDOUW 2004, reproduced by LINTON & BUDDS 2013: 5)

Water is embedded in social relations in different ways. On one hand the way water is understood depends on the viewpoint of different stakeholders, but also on alternative knowledge, such as local or indigenous concepts. In this sense for example, water can be considered as a resource that has to be allocated to the people, an agricultural input, or a spiritually loaded fluid.

Water can further be considered as

something inherently political as the control of water produces certain types of social power relations and structures. On the other hand, water itself also plays a positive role in social formations. Through its fluidity it changes landscapes, threatens established orders or provides basis for individual or societal claims (cf. Fig. 7). Thus, it takes over the role of an active and dynamic agent. Applied as an analytical framework the hydrosocial cycle shall direct attention to three principal areas of insight:

- What is water? (What cultural, economic and political processes constitute the particular character of different types of water, e.g. holy water or treated drinking water?)
- How is water "made known" and represented? (How is water constructed through discursive practices, how is it represented and what are its effects?)
- In which way does water internalize social relations, social power and technology? (LINTON & BUDDS 2013: 10).

3.2. Conceptual framework

3.2.1. Environmental perception and communication

In order to achieve a local understanding of the development of oil palm plantations and their impacts and services, the focus of the qualitative research was put on the perception of changes in land use by the local people. They were asked to report on their personal observations of environmental and possibly hydrological changes and to explain them using their own knowledge.

The core of the environmental perception thinking is that researchers no longer act on the assumption of "objective reality" but rather focus on the subjective perception of individuals (WERLEN 2000: 266). The basic premise is that the environment only becomes relevant for individual behavior as it is being perceived by the individuals (ibid.). Aiming at a sustainable regulation of social ecological systems, it becomes indispensable to understand how local perception of environmental change influences peoples' behavior and adaptation and thus creates feedbacks between the environment and society. Thus, local environmental perception builds a basis for interpreting local societal relations to nature, reflecting on motives and catalysts of changing patterns in a socio-ecological system. According to ALESSA et al. (2008 154f), the differences between perception and actual change in the environment influence the community's ability to respond and adapt to change. Thus, it may be an important determinant of resilience or vulnerability. Furthermore, perception of environmental change can be important from a policy point of view as such perception reflects local concerns and actual impacts on people's lives (HALDER et al. 2012: 666). Hence, in trying to achieve a profound understanding of the hydrological processes in oil palm plantations, this thesis focuses first of all on the analysis of local problem perception by rural villagers, depicting their subjective points of view, observations and argumentations.

Environmental perception of individuals is influenced by a number of factors, including, among others, type and depth of environmental knowledge, environmental values, norms, individual place attachment, interests and motivations and personal experience (cf. i.a. CHOKOR 2004; KYLE et al. 2004; GUSKI & BLÖBAUM O.J.; FERRARA 2000, qtd. in SAMPAIO SIEBER, MEDEIROS & ALBUQUERQUE 2011). As for societal relations to nature, individual perception of the environment is not only influenced by internal factors but also deeply embedded in the socio-economic, political and cultural context of a person (i.a. WERLEN

2000: 282; GUSKI & BLÖBAUM O.J.). This point of view is especially advanced by the concept of political ecology:

"The environment and how we acquire, disseminate, and legitimate knowledge about it are highly politicized, reflective of relations of power, and contested."
(NEUMANN 2005: 1, qtd. in BOAMAH 2013: 1).

The development of biofuels is a topic debated on a global level with innumerable actors involved. While the initial global discourse on biofuel development focused on economic and technological opportunities for Europe, by now a serious shift in discourse has taken place. Today this discourse is mainly dominated by a discussion of negative side effects for the environment and local communities (cf. SENGERS, RAVEN & VENROOIJ 2010). Oil palm, as an important crop for biofuel production has gained great attention in the European Media. Negative local side effects of oil palm development in Southeast Asia have been reported in most German newspapers (i.a. MIERSCH (Die Welt, 13/10/2009); GERMUND (Berliner Zeitung, 03/16/2007); HENNEMANN (Sueddeutsche.de, 09/06/2012) & ZIEGLER (Sueddeutsche.de, 12/03/2013); REIMER (taz.de, 02/24/2008)).

The actors involved in land use change in Indonesia are no longer national and regional governments alone but rather a mix of international and transnational actors. On the one side international investors continue to expand their oil palm plantations in Indonesia and the World Bank continues supporting them by investments in the oil palm sector (International Finance Organisation n.d.). On the other side, national and international NGOs raise international attention towards local environmental degradation and land conflicts (i.a. Robin Wood, Friends of the Earth, Worldwatch Institute; Life Mosaic; Down to Earth) or work at promoting sustainable oil palm cultivation (WWF). Thus local land use development in Jambi has to be understood in a contested globalized context, often at the encounter of opposing interests.

How these processes and discourses shape local perception of land use change manifests itself in the way how people communicate about their environment and the land use changes taking place. Hence, local communication and discourse about the current developments shall constitute another important part of this thesis. Due to the inductive character of the research at hand, the importance of the local communication concerning the water supply problems was added after the empirical research. Thus no in-depth discourse analysis can be provided. Rather different arguments from villagers shall be explained in detail and a typification and interpretation of the different standpoints shall be given.

In order to conceptualize and visualize the main research of this work, the constitution of possible impacts of oil palm development on the local hydrological cycle, the DPSIR framework shall be used as an analytical tool to depict the possible ecological crisis dilemma.

3.2.2. The DPSIR framework

The DPSIR framework was primarily developed as the PSR framework (Pressure-State-Responses) by Anthony Friend in the 1970s and subsequently adopted by the OECD (UNEP n.d.). Later the framework was further developed into the DPSIR framework (Drivers-Pressures-State-Impacts-Responses) which in its present form was elaborated on by the European Environmental Agency (EEA) (SVARSTAD et al. 2008: 117).

"According to the DPSIR framework there is a chain of causal links starting with 'driving forces' (economic sectors, human activities) through 'pressures' (emissions, waste) to 'states' (physical, chemical and biological) and 'impacts' on ecosystems, human health and functions, eventually leading to political 'responses' (prioritisation, target setting, indicators)." (KRISTENSEN 2004: 1) (cf. Fig. 8).

Thus, the DPSIR is a systems-based approach which captures key relationships between socio-economic factors (ATKINS 2011: 215). The DPSIR can be argued to be a problem structuring method (BELL 2012) that can provide and communicate knowledge on the causes, consequences and responses to change in a holistic and interdisciplinary way (SVARSTAD et al. 2008: 116; ATKINS 2011: 217). Tab. 6 shall give a more detailed overview of the definition and function of the individual elements of the framework. While in some applications of DPSIR, *Drivers* or *Pressures* include natural drivers such as climate change, this application shall regard *Drivers* and *Pressures* as specifically human-derived as in line with EPA (2012). Natural processes are included separately within the *State*.

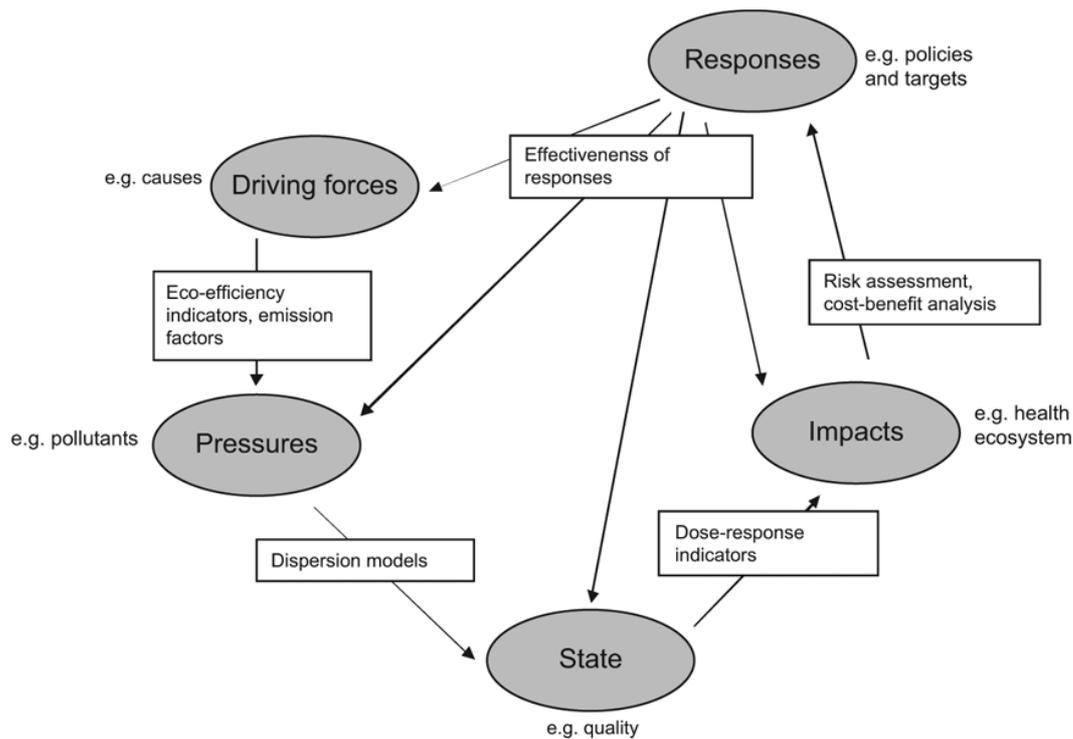


Fig. 8: The DPSIR framework (elaboration from EEA 2003, qtd. in BOTTERO & FERRETTI 2010: 621).

Tab. 6: Description of the DPSIR elements

Element	Functions
Driving Forces	<ul style="list-style-type: none"> - <i>Driving Forces</i> are social, demographic and economic developments in order to fulfill human "needs". - Primary needs are e.g. shelter, food and water. Secondary needs can be mobility entertainment or culture. - Needs can originate on different scales (e.g. by individuals, economic actors, governments or international institutions) and act globally, regionally or locally.
Pressures	<ul style="list-style-type: none"> - <i>Driving Forces</i> lead to human activities that result in meeting a need. - <i>Underlying Pressures</i> (e.g. population, poverty) may intentionally or unintentionally lead to <i>Actual Pressures</i>. - <i>Actual Pressures</i> are divided into three categories: <ul style="list-style-type: none"> (i) excessive use of environmental resources, (ii) changes in land use, and (iii) emissions (of chemicals, waste, radiation or noise) to air, water and soil. - Pressures depend on the level of these activities and the kind and level of technology involved in these activities. - <i>Pressures</i> can vary across geographic regions and spatial scales.
State	<ul style="list-style-type: none"> - <i>Pressures</i> affect the 'state' of the environment. That is "the quality of the various environmental compartments (air, water, soil, etc.) in relation to the functions that these compartments fulfill" (KRISTENSEN 2003: 2). - These may be direct or indirect changes in the environment that are caused through a variety of natural processes. - The <i>State</i> of the environment is thus the combination of the physical, chemical and biological conditions which result from: <ul style="list-style-type: none"> o <i>Pressures</i>, but also from o changes in the natural environment (such as climate change, droughts or floods).

Impacts	<ul style="list-style-type: none"> - Changes in the <i>State</i> of the environment determine the quality of the ecosystem and, through the provision of ecosystem services, may impact the welfare or well-being of human beings. - Ecosystem processes benefit humans through: <ul style="list-style-type: none"> o Provisioning services (e.g. food, timber, water) o Regulating services (e.g. air quality, water quality, or diseases) o Cultural services (e.g. aesthetic or recreational value) o Habitat or supporting services (e.g. maintenance of genetic diversity).
Responses	<ul style="list-style-type: none"> - <i>Responses</i> by groups or individuals in society and governments are the result of undesired impacts and can affect any part of the chain between driving forces and impacts. - <i>Responses</i> depend on how the impacts are perceived and evaluated. - They are actions taken to prevent, compensate, ameliorate or adapt to changes in the state of the environment by seeking to : <ul style="list-style-type: none"> o Control <i>Drivers</i> or <i>Pressures</i> (e.g. through regulation, prevention or mitigation), o maintain or restore the state of the environment, o "do nothing".

(own representation after KRISTENSEN 2003; EPA 2012; UNEP n.d.; TEEB n.d.)

Benefits of the DPSIR framework are that it can be an effective tool to communicate complex interrelations occurring in a system. This communication can take place between researchers and policy makers as well as between researchers from different disciplines (PINTO et al. 2013; SVARSTAD et al. 2008; EPA 2012). It can further be used to identify policy options or to assess, manage and communicate the impact of environmental policy changes (GREGORY et al. 2013; EEA Report, 1999 cited after NESS 2010). Therefore, today DPSIR is often applied as a key decision support tool for policy makers and has been used extensively in the development of state-of-the-environment reports (GREGORY et al. 2013; WALMSLEY 2002).

Yet, owed to this simplicity of the framework a lot of critics of DPSIR have arisen. GREGORY et al. (2013) summarize the criticism of other authors as follows:

"In summary, DPSIR:

- o cannot take into account the dynamics of the system it models;
- o cannot handle cause-consequence relationships;
- o suggests linear unidirectional causal chains; and
- o ignores key non-human drivers of environment change." (ibid. 2013: 563).

Thus, the DPSIR can lead to "a narrow and discourse-selective understanding of controversial issues" (MAXIM et al. 2009: 117, qtd. in GREGORY et al. 2013: 564), that represents only a "snap-shot" taken at a particular moment (GREGORY et al. 2013: 563). From a systems perspective, the research determines, where the boundary is placed and which stakeholders are included how much (ibid.: 564). Thus,

"[t]he drawing of these boundaries depends on the particular issue of interest and its conceptualization, which are strongly influenced by the perspective of those using the framework." (SVARSTAD et al. 2008: 117f).

In Order to take into account dynamics of the systems and not to reach at linear unidirectional causal chains, SVARSTAD et al. (2008: 123) argue that the understanding of socio-economic and cultural drivers has to be broadened by properly analyzing social, economic and cultural conflicts that surround the issue in focus. Therefore, they suggest explicitly combining applications of the DPSIR framework with discourse analysis to avoid producing a "single narrative" (ibid.: 123). NIEMEIJER and DE GROOT (2008) further suggest applying DPSIR as a causal network rather than a causal chain to increase insight into the interrelation between system elements.

For this thesis the combination of both, DPSIR and an analysis of local communication patterns, was chosen, to cope with the complexity of social-ecological systems. While DPSIR represents a good tool to visualize the interrelations between society and nature in general, the analysis of environmental perception and communication sheds lights onto relations to environment by individuals.

4. METHODS

In order to explore possible impacts of oil palm expansion on the local hydrological cycle and the local water supply, the objective of this study was to conduct a case study in a village where rapid land use change towards oil palm plantations has taken place. This case study aimed to explore the local perception on possible changes in local water resources and the impacts for the individual and village-wide water supply. The central questions guiding the research were:

- *Which changes in local water resources have been perceived by the villagers during the last 20-25 years?*
- *Which explanations are given by the villagers for these possible changes?*
- *How do these changes in water resources affect the local water supply?*
- *Which consequences for individual households emerge as a result of these changes?*

These questions were explored using a variety of qualitative empirical research methods.

4.1. Data generation

After an intensive literature review from February to April 2013 the empirical research was conducted in Jambi Province in Sumatra. The field research was part of a three month stay in Indonesia from April to July 2013. Language skills of Bahasa Indonesia were obtained during private study in Germany as well as during an intensive two-week one-to-one language course in Yogyakarta (Java). The course was especially designed for field research demands by stressing speaking skills and vocabulary related to the research topic. Although field work was conducted with the help of an Indonesian field assistant, basic language skills proved to be fundamental for earning trust with the villagers and to avoid misunderstandings during interview situations. The time spent in Yogyakarta further helped to acclimatize to Indonesian climate and culture.

The field research was conducted during an eight week stay in Jambi Province. A combination of different methods was chosen to crosscheck interview results and to challenge the obtained data from different viewpoints. The range of qualitative methods applied included semi-structured, problem-centered household interviews (after MAYRING 2002: 67ff), different methods of Participatory Rural Appraisal (PRA) (after KUMAR 2002), participative observation and expert interviews on regional and national levels. All interview

activities were conducted in Bahasa Indonesia. An Indonesian research assistant helped in translating questions and answers. Information obtained during the interview was mutually discussed and interpreted afterwards.

The village Bungku was chosen as a research site for this thesis based on existing knowledge of the dynamic land use history and on villagers' complaints about water shortages reportedly related to oil palm cultivation. Bungku represents a rather exceptional village, by occupying an area of 60,000 ha (600 km²)³ (Desa Bungku 2010) with a distance of roughly 30km from North to South. Consequently, two different village sub-districts (*dusuns*) were chosen for the field research.

During the field research in Bungku the researcher and her assistant were accommodated at local guest families to facilitate acclimatization with the village environment and to build up closeness and trust with the villagers. During the week the research team stayed in the village to be able to observe and participate in the daily activities of local residents (Fig. 9 & 10). The weekends were spent in Jambi city to reflect and interpret first data and to adjust interview guidelines or interview procedures if necessary. As organizational issues and expert interviews demanded extra time spent in Jambi, the field research phase in Bungku comprised five weeks in total.



Fig. 9 & 10: Participating in daily activities (fishing, and watching TV with the guest families (own pict.))

Household interviews

At the beginning of the field research in Bungku, informal interviews were conducted with village representatives. These were used to identify those households which were particularly important for interviews, for example due to their long stay in the village or their belonging to an ethnic group. Subsequent interview partners were selected by the snowball sampling

³ This roughly equivalents the area of the German cities Köln and Düsseldorf together.

method. After choosing possible families to be interviewed, the research team tried to meet them at their house. There they were asked about their willingness to participate in an interview as well as for a good place and time for the interview, so as not to further interrupt the normal course of their daily life. Often interview partners welcomed the research team warmly and spontaneous interviews were frequently possible. Whereas during the day women who stayed at home were mainly interviewed, the evening hours, after *Maghrib* (last prayer of the day for Muslims), were used to interview mostly men or entire families. Thus, a balanced gender-representation in the interview partners could be achieved. This was regarded to be important as it was assumed that men might be able to report more on oil palm development or management, while women might have a more detailed perspective on the impacts of changed water supplies to their family's daily activities and livelihoods.

The main foci of the field research were the household interviews that followed the problem-centered, semi-structured interview approach by MAYRING (2002: 67ff). The interviews were structured by guideline questions which were mainly concentrated around the core research questions: the perception of land use and environmental/hydrological changes, the water supply on household and village levels, problems related to water supply and personal perspectives on future development. Household characteristics were further collected for an in depth analysis of the interviews. Farmers (rubber and oil palm) were additionally asked about specific management practices on their plantations in order to provide some insights into local environmental management. The established guideline was used as a flexible guideline, allowing for spontaneous comments, explanations or additional in-depth questions specifically adjusted to the interview partners. Although the guideline was used as a reference for the structure of the interview, questions were often asked randomly according to the progression of the interview. Not all questions were asked during every interview, trying to create a comfortable interview situation for the interview partner and adapting and focusing on to key information the interview-partners could give. In order to nevertheless allow for some comparison, we tried to ask a certain set of questions in every interview. The complete guideline used for the interviews can be found in the appendix of this thesis (p. 139). Data gained through these interviews was completed by additional spontaneous informal individual and group interviews or field trips during the stay in the village. Five short quantitative interviews were further conducted with water vendors in Bungku to obtain information about the management of and the demand for bottled drinking water. In total a number of 30 formal and informal household have been conducted.



Fig. 11, 12 & 13: The different environments of household interviews (rich migrant family from Java, poor woman and daughter from Lampung (Sumatra), SAD man at his cassava plantation, f.l.t.r.) (own pictures)

In order to augment the data obtained from the interviews and to gain an insight into local discourse about the research topic in the village, two **group discussions** were conducted in the two village districts. As LAMNEK (1995) pointed out, it is hardly possible to capture collective communication patterns in single interviews. Instead, these will rather be expressed in social group situations (qtd. in BINTERNAGEL 2011: 46). The discussions should be conducted according to the documentary method (after PRZYBORSKI & RIEGER 2010: 438ff), with the subject of discussion being the collective knowledge and structures that participants had acquired during daily practice (ibid.). The composition of the groups was chosen based on purposive sampling and by residents who were close to the research team in order to create an open and comfortable situation. The groups should be homogeneous, consisting of five to six independent oil palm farmers. As LOOS and SCHÄFFER (2001: 44, qtd. in PRZYBORSKI & RIEGER 2010: 440) argue, it is easier to start into a vivid discussion in homogeneous groups, rather than in heterogeneous groups, as common topics and connecting links already exist. While a mix of local and migrant farmers was intended at the beginning, the participants were exclusively migrants, representing their dominance in the oil palm cultivation in Bungku. The objective of the group discussions was to provide an insight into the specific view of independent oil palm farmers on the research topic. Focus was therefore put on general advantages and disadvantages of oil palm cultivation, environmental impacts of oil palm plantations and environmental management practices.

Participatory Rural Appraisal

Crosschecking of the obtained data was further conducted by applying some participative methods. Owing to the short time of field research the use of participative could not follow all principals that characterize the Participatory Rural Appraisal (PRA) approach as explained by KUMAR (2002: 23ff). Participation during the field research was therefore conducted in the sense of "participation as means" (KUMAR 2002: 26) rather than emphasizing participation in the sense of empowering people and actively engaging them in the research process.

Nonetheless, important characteristics of PRA were used as a guideline for research. According to KUMAR (2002) the use of PRA methods shall "enable local people to share, enhance, and analyze their knowledge of life" (ibid.: 33). Hence, this should initiate a mutual learning process between researchers and participants and encourage people to discuss and reflect critically on the research topic. The open research process should enable the researcher to capture the realities of people, to get internal perspective of the research topic and to emphasize the rapport with the local people. Furthermore, the group interaction is supposed to provide greater and more in-depth information and analysis in shorter time. The drawing or visualizing of the topic should further foster that participants, especially illiterate or timid persons, lose inhibitions and express themselves more openly. PRA methods do not try to arrive at averages but focus on variability, complexity and diversity of local conditions (ibid.: 41ff).

During the first few days in the village a **timeline interview** provided the research team with essential background knowledge regarding the village development and important events in its history. A timeline interview is considered to be a good, enjoyable starting point to develop a rapport with the villagers and engage elderly persons and their knowledge (KUMAR 2002: 118ff). After capturing important past events in the village development, as perceived and recalled by the people, a discussion of changes was initiated. Changes in the quality and quantity of water resources were of special interest. Though normally it is expected to be difficult for elderly persons to recall the exact years of events (ibid.), this did not constitute a problem as people apparently had previously recalled these events when participating in earlier research activities.



Fig. 14 & 15: Timeline exercise (left) and group discussion with oil palm farmers (right) (own pictures)

Resource mapping was also tested in both village sub-districts to visualize and then compare the land use patterns and the presence of water bodies in 1990 and today. Resource maps are considered to be especially useful because they provide a focused spatial structure for discussion and analysis and help to create a common understanding amongst participant as a baseline for discussion (KUMAR 2002: 71ff). While the older people were asked to paint a map of the village as they remembered it in 1990, the younger ones were asked to paint a map of the village as it is today. Afterwards both groups were involved in a discussion concerning major changes during that time. Land use changes as well as changes in water bodies were the focus of discussion. While it was easy to find participants for the group discussion in Bungku Indah, in Johor Baru this proved to be extremely difficult. In the end only one farmer agreed to paint resource maps of both 1990 and today.

Expert interviews

In order to provide for the necessary scientific and political background of the obtained data, a number of expert interviews were conducted at regional and national levels. Experts were selected to represent different, possibly opposing viewpoints and to comprise the variety of stakeholders engaged in the broader context of the research topic. The interview partners therefore included:

- Three civil society organizations (the NGOs WARSI Jambi, Setara Jambi, Sawit Watch (in Bogor)),
- two government officials in Jambi (from the plantation ministry, DINAS Perkebunan, and the Batanghari watershed management agency, BPDAS Batanghari),
- one research institution (Forestry Faculty, Bogor Agricultural University (IPB)),
- one representative of an oil palm company located in Bungku, and
- two staff members of the community health center in Bungku.



Fig. 16, 17 & 18: Expert interviews with a nurse in Bungku, an oil palm company representative (left man) and two members of the NGO WARSI (f.l.t.r.) (own pictures)

4.2. Data processing and analysis

All household interviews and participative activities were audio-recorded. Based on these records a detailed protocol was prepared by the assistant. Afterwards, the researcher listened to the audio-file and completed the protocol if necessary. Meaning, logical coherence and interpretation of the statements made during the interviews were crosschecked by the researcher and the assistant in a mutual collaboration. The first interviews were written down in protocol form, putting down important information in categories. However, after some interviews it became clear, that for an in-depth interpretation of the interviews a more detailed protocol form was needed. Thus, the course of the interview was then recorded in a chronological order, and whenever it seemed expedient, questions and answers given during the interview were typed down as literally as possible.

As the protocols were directly written in English, a loss of information and details to some extent had to be taken into account. To avert any further loss of data, the English protocol provided by the assistant was corrected in regard to English grammar only if fundamentally relevant to the understanding of the text. Additionally, for sentences or specific formulations of extraordinary importance, the exact phrasing in Bahasa Indonesia was written down by the researcher, as far as the knowledge of language allowed for this. Thus, the protocols became more and more detailed towards the end of the field research reflecting the development of the researcher's skills. Nonetheless, if quotations of the interviews are provided in chapter six on data analysis, it has to be kept in mind, that these translations reflect the statements made during the interviews as detailed as possible, but are not to be viewed literally as a transcription.

In addition to the chronological protocols a reminder revealing information about the reason for choosing the specific interview partner or about the interview atmosphere were supplemented in the protocol file. Afterwards, a second version of the protocol was elaborated. This version served to categorize the data obtained during the interviews to prepare for an analysis following the principles of a qualitative analysis of content (after MAYRING 2002: 114ff). Categories were mainly defined along the interview guideline questions (cf. appendix, p. 139). Furthermore, a personal profile of the interview partner was added at the top of each protocol (cf. Fig. 19). If several interviews or field activities were conducted with the same person, information obtained was summarized in a single protocol file.

Protocol no. 4/5/11, household + informal interviews, Bungku Indah, 28., 29. & 31.05.2013

Reminder: Pak [redacted] as one of the first migrants from Java settling down in Bungku. During field research in Bungku Indah we stayed at his house.

Place & time: Bungku Indah, Pak [redacted] house, ~19-21h, 28.05.2013
 Bungku Indah, Pak [redacted] oil palm plantation, ~10h, 29.05.2013
 Bungku Indah, Pak [redacted] house, talking to Pak [redacted] wife in front of the TV, 31.05.2013 (informal)

People present: Pak [redacted]

Name:	Pak [redacted]
In Bungku since:	1974
Moved to Bungku because:	-
Born in:	West Java
Before lived in...because...:	-
Born in.../age:	~1952 (60y.)
Religion:	Muslim
Ethnicity:	Javanese
Profession:	farmer
Former professions:	He worked in a wood company 1974-1978 (Sumber Bulian), he made <i>balok</i> and cut the wood; Kepala dusun (2000 to 2005), opened 3haj. rubber in 1978
Education:	-
Children (age):	2 (~16y, 25y)
Marital status (name, age)	married
Wife's/husband's profession:	owns a kiosk (since 2 years), administers road tax for trucks
Household income:	2ha j. rubber, 1ha very little oil palm + kiosk
Owens car/motorbike:	motorbike
Land ownership:	3ha

Fig. 19: Excerpt of a categorized protocol including a personal profile of the interview partner (own data)

The analysis of the interviews was undertaken according to the principles of a qualitative analysis of content (MAYRING 2002: 114ff). Since the number of interviews was manageable, Microsoft Office Excel was used for the analysis. Interview parts were thematically coded according to general categories like "land use change" or "water supply" and then further sub-coded into categories like "land use before 1986" or "water availability" (cf. Fig. 20). These categories were developed led by the research questions of this thesis as well as by an inductive analysis of the interview protocols. To avoid that statements were taken out of the interview context, additional information was added whenever this proved necessary. These for example could include the question asked by the research team or comments like "no question asked" or "very direct question". To provide for a fast overview on the household's characteristics every interview partner got an individual code. These codes revealed information about their village district, origin, date of migration, job and sex. The Code "BI-mJ-1974-op-r-m" thus stands for: "Bungku Indah – migrant from Java – moved to

Bungku in 1974 – works as oil palm and rubber farmer (op-r) – male". Afterwards the information given by all interview partners regarding one single category was gathered, summarized and finally coded according to diverse characteristics of the answers given.

household - water supply						
ID	ID-Code	Name	Water supply (+changes)	water supply dry season	waste (water) management	water availability
1	Bl-mS-2011-op-m	Pak P.	He has one well for everything (drinking, cooking, washing etc.)	If his well runs dry in the dry season, he has to buy drinking water (isi ulang). Furthermore, he only stays one or two days in Bungku and takes a shower and washes clothes only if he is back in Jambi city (normally he stays two weeks in his plantation).	He doesn't treat waste water. Garbage is burned.	In the dry season it's difficult/ kering semua. The wells run dry in dry season. In Bungku, even if you dig a drilled well 100m deep there is no water, tidak ada mata air disini, it's too high here, the meaning of Bungku is bukit-bukit (in Bahasa Jambi)
2	Bl-mS-2011-pw-f	Ibu S.M.	She has one well for drinkin water(=3,5m deep) and one well for other purposes (=3m deep). (the water is much clearer in the drinking well). Both wells are only secured with soil.	The family gets the water from a neighbor's well (for shower etc.), which is about 5m deep. Ibu S.M. has to walk about 50m to collect the water. They don't have to pay anything for the water, but the water quality is not good anymore (keruh), she cannot drink it. During dry season she has to buy drinking water (20l = 6000/7000Rp) She tries to use less water in everything. E.g. she only washes clothes once a week (normally twice)	Waste water is collected in a pond next to one of the wells (it just flow into the soil). The toilet is somewhere else. Garbage is burned in front of the house.	In the dry season the well runs dry. The well also ran dry 4 months ago. (mandi susah, untuk minum dibeli)
3	Bl-mJ-1997-o-m	Pak A.				Some people apparently have a well with a pump which is up to 100m deep, but in the dry season, they also don't get water.

Fig. 20: Data processing and coding with the help of Microsoft Office Excel (own data)

As during the field research, the communication of water related problems and land use change appeared to be of interest for the thesis, it was also aimed to analyze which respondents made what kind of observations and who supported which line of argument to explain these changes. Therefore, an empirical typification of the respondents was carried out according to the guidelines of KLUGE (2000). First of all, all respondents were analyzed according to 1. their observation of hydrological changes and 2. their explanatory statements for these changes. Afterwards respondents were grouped and empirical regularities regarding answers in both categories as well as regarding personal characteristics, such as profession or ethnicity were analyzed to identify homogenous groups. Thereafter, the groups were reviewed to check if the identified types were appropriate for generalization and if they could be explained within the research context. Finally, the groups were described in detail and ideal types (cf. MAYRING 2002: 130) were selected to represent the group type in an easily comprehensible manner.

In order to provide for an easily comprehensible representation of the data, direct and indirect quotations of interviews in this thesis are always supplemented with the number of the interview (I) and the number the respondent (R) of the same interview activity (e.g. I2R1). As it was not always easy to identify individual voices during group interviews, sometimes only

the number of the interview is given. "I38.1" refers to the same activity as "I38", but a different interview situation (e.g. interviews with different kiosk owners within the activity "kiosk inventory").

4.3. Limits of methods applied

As already stated above, several limitations were encountered in the methods applied during field research. One obvious limit is the scope of this work. The study only represents a case study of one single village and can therefore not provide any details on the impacts of oil palm expansion in other villages with different physiographic conditions, distinct water supply systems or different land use mosaics.

The work with an Indonesian assistant on the one hand facilitated acclimatization and integration with the local people. On the other hand the need for translation during the interviews as well as during protocol preparation always meant a loss of information. Furthermore, due to the limited fluency of the researcher in Bahasa Indonesia, misunderstandings between researcher and assistant sometimes revealed in the too direct or suggestive formulation of questions. As the knowledge of language and interview techniques of the researcher improved during the field research, unfortunate formulations during interviews could often be detected and marked as such in later crosschecking of interview protocols and audio files. The work with an assistant nevertheless proved to bear several advantages as well. The assistant supporting this thesis had a lot of former research experience within the EFForTS-CRC 990 project as well as within former research projects. This helped to facilitate comfortable interview situations while at the same time obtaining the needed information. On the other side, the gap of experience between the young researcher and the experienced assistant also revealed some challenges. While possibly fewer misunderstandings would have arisen regarding the research approach in working with a new assistant, the fluency in English of the assistant involved was a major advantage. Thus, research assistants should be chosen carefully considering the specific purposes of their employment and research objectives.

PRAs and group discussions proved to be interesting, diversified methods to crosscheck data obtained during interviews. Whether these methods could be applied successfully however depended on a number of factors, such as group composition, place, time or mood of the participants. The first group discussion for example was conducted in the dining room of the guest house. Unfortunately a TV located in the same room and switched on to a soccer match

between Indonesia and the Netherlands, provided a significant source of distraction for some participants. While such circumstances can also occur during any form of interview, it is much more unfortunate during group interview situations as they have to be prepared with more effort and participants were much harder to find. Furthermore, the analysis of group interviews provided much more work and if protocols were not prepared immediately after the interview, it was hard to distinguish the voices of the individual participants. In general, participative methods should be prepared in detail and explained carefully to the respondents as well as to the assistant. Furthermore, the time needed should be taken into account, to avoid interruptions of ongoing discussions by people that have to leave early. Thus, while if organized properly such methods can provide detailed and illustrative additional information, if time for the empirical survey is short it has to be weighed if further household or semi-structured group interviews can possibly also reveal the same information.

Bungku, as a core plot village of the research project EFForTS-CRC 990 had been frequented by various researchers in former phases of the research project. This had positive as well as negative effects for the research atmosphere. While some villagers were rather skeptical towards new researchers, others who had made positive experience with interview situations were more confident with the interview situation and also the audio-recording. Furthermore, it has to be mentioned that Bungku, due to an ongoing land conflict had attracted several NGOs whose work sometimes clearly reflected in the interviewees' statements, especially in those of local indigenous people.

To sum it up, several difficulties were experienced when applying the chosen methods in the field. The days spent in Jambi city therefore proved to be very suitable to provide a neutral atmosphere and helped to reflect on former interview experiences and outcomes and to discuss further ways of proceeding in the village.

5. CASE STUDY - A GEOGRAPHY OF THE VILLAGE BUNGKU

The village Bungku is situated in the provincial sub-district (*kecamatan*) Bejubang in the district (*kabupaten*) Batanghari. The capital city of the sub-district is Muara Bulian (55,000 inhabitants) which lies at a distance of 60 km to Jambi. The village Bungku itself starts another 20 to 30 km from Muara Bulian and can be reached via a road that is mainly asphalted but often very poorly maintained. Sometimes the asphalt cover is missing completely. The most notable characteristic of Bungku is its extent. The distance from the northern to the southern part of the village is about 30 km. Field research was therefore limited to the village districts (*dusuns*) Johor Baru 1⁴ and Bungku Indah (cf. Fig. 28, p. 43).

Physiography of Bungku

Despite of the large extension and the occurring local differences a rough general overview of the local physiography shall be given to allow for some interpretations regarding possible hydrological changes afterwards.

Bungku lies in the well drained eastern lowlands (Peneplains) of Sumatra (after VERSTAPPEN 1973, qtd. in LAUMONIER 1997: 23), with altitudes between 50 m to 70 m amsl (GOOGLE EARTH 2007). The most common soil group according to COLEMAN et al. (1989, qtd. in SCHEU



Fig. 21: Soil profile in Johor Baru (own picture)

2011) in the pediment peneplains are Acrisols (WRB classification; USDA soil taxonomy = Ultisols (TRIPATHI, B. R. & PSYCHAS, P. J. 1992)). The occurrence of these soils in the region around Bungku was also confirmed by EFForTS-CRC 990 researchers (HENDRAYANTO, personal communication 05/01/2013 and GUILLAUME, TH., personal communication 02/11/2014). Further, a government representative in Jambi stated that soils in Bungku are Red Yellow Podisols (EI7), which according to FAO (2006) also correlate with Acrisols. As no official soil classification for Bungku has been conducted yet, this can only serve as a rough orientation. Acrisols are very deep soils and have a subsurface horizon in which clays have accumulated as a result of pedogenetic processes, especially clay migration (FAO 2006: 67f). This is in line with observations of high clay contents in the field (cf. Fig.

⁴ Although Bungku actually comprises the village districts Johor Baru 1 and Johor Baru 2, for the sake of simplicity, Johor Baru 1 is only referred to as "Johor Baru" in the following.

21), as well as with statements by villagers that soil in Bungku "contains no sand". Acrisols are strongly leached, acid forest soils with relatively low native fertility. With the use of fertilizer, however they can be very productive. They are red or distinctively yellow in color and have diffuse horizons: typically A, E, Bt, BC, C (FIEDLER 2001: 301; MCDANIEL n.d.). Acrisols are susceptible to erosion and compaction (TRIPATHI, B. R. & PSYCHAS, P. J. 1992). Thus, the preservation of the surface soil with its organic matter and the prevention of erosion are important conditions for farming. Especially mechanical forest clearing with the extraction of root balls can cause toxic levels of aluminum (FAO 2006: 67f).

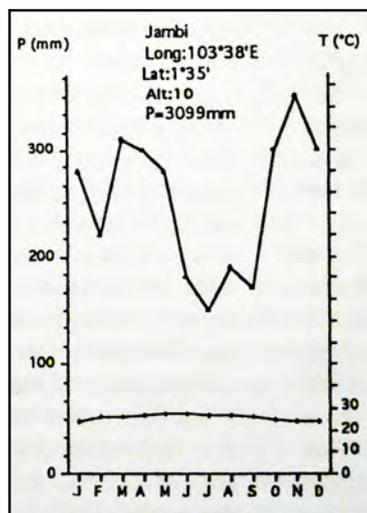


Fig. 22: Climate diagram of Jambi province (LAUMONIER 1997: 36)

The mean daily temperature in Jambi is 25.2 °C with an average daily temperature amplitude of 9 °C and an average annual temperature amplitude of 1.6 °C (Statistik Indonesia 1981, qtd. in SCHOLZ 1988: 36). Annual precipitation in the research region ranges from 2000 mm to 3000 mm (SUNARTI et al. 2008, qtd. in TARIGAN et al. 2014, in prep.). According to OLDEMAN et al. (1979, qtd. in WHITTEN et al. 2000: 14f) the climate in the region surrounding Bungku is characterized by seven to nine wet months and three or less consecutive dry months. A biological dry season is defined by precipitation being lower than potential evapotranspiration and is reached in

the tropics in months with less than 100 mm precipitation (OLDEMAN et al. 1979, qtd. in SCHOLZ 1988: 39). Although the intensity of the dry season according to LAUMONIER (1997: 37) seems insignificant at first glance (cf. Fig. 22), she argues that there is a biological dry season in the south of Sumatra. SUNARTI et al. (2008, qtd. in TARIGAN et al. 2014, in prep.) support this view by arguing that the average monthly rainfall ranges from 179 mm to 279 mm during wet months and from 68 mm to 106 mm in dry months. The main dry season occurs in July and August and the main rainy season is from October to December. A secondary minimum exists in February and a secondary maximum in March/April. In particularly dry years, forest fires can even occur in swamp areas (SCHOLZ 1988: 37ff). During the last years exceptionally dry as well as exceptionally wet years have been recorded. While the climate diagrams of the years 2009 to 2012 show clear dry seasons with precipitations less than 100 mm during dry months, the year 2010 represented an exceptionally wet year with an annual precipitation of 3207 mm (BPS Jambi 2009, 2010, 2011, 2012) (cf. Appendix: Fig. 72-75).

Bungku lies in two different watersheds, with the largest area belonging to the Musi River flowing through South Sumatra. Only the very northern part of Bungku belongs to the Batanghari watershed, the most important watershed in Jambi. As Bungku Indah is situated right at the edge of both watersheds, only very small rivers and some forest ponds/swamp areas can be found there. The only bigger river in the northern part of Bungku is Sungai Bahar, crossing Johor Baru. In Bungku Indah only very small rivers and some forest ponds/swamp areas can be found. Johor Baru further also seems to have much more swamp area than Bungku Indah (cf. Fig. 76: Watershed of Bungku (base map: Google Earth 2013; data: Zuhdi (based on Landsat 2000), GADM, Peta Rupa Bumi Indonesia (Bakosurtanal); Cartography: Jennifer Merten).

The natural vegetation in Bungku is lowland evergreen forest with the presence of the very valuable Borneo ironwood (*kayu bulian*). These forests are characterized by an extremely high diversity in flora and fauna (WHITTEN et al. 2000: 189ff). Big mammals that naturally appear in these forest areas are, among others the Asian Elephant, the Sumatran tiger and the Tapir (ibid.).

Today's land use

Today natural vegetation can only be found in patches in the Harapan forest, a forest rehabilitation project at the southern end of Bungku. This forest is the last regional refugee for elephants, tigers and innumerable bird species. It is administered by the company PT REKI (Restorasi Ekosistem Indonesia) which is a joint initiative of a consortium of national and international NGOs (NABU 2010). PT REKI is one of five companies operating in Bungku. The others are three oil palm plantation companies: PT Asiatic Persada (PT AP), PT Sungai Bahar Pasifik and PT Humusindo and an industrial timber plantation company PT AAS Wanakasita Nusantara. As a consequence of overlapping land claims important land conflicts exist with PT AP, PT AAS and PT REKI. All of them have led to violent clashes in the past. The latest escalation of the land conflict with PT AP occurred just recently in December 2013. According to the online magazine Mongabay and NGO reports more than one thousand company members and security forces have destroyed about 150 to 300 houses of local indigenous people who had occupied company land (cf. Fig. 23) (PARKER 2013; CONANT 2013; Setara Jambi 2013; Robin Wood e.V. 2013). The history of the conflict is a long one. PT AP was granted a land use permit (HGU – Hak Guna Usaha) of altogether more than 27,000 ha in the mid-1980s during the Suharto military regime. This occurred although a forest inventory by the Forestry Department suggested that there were about 2000 families

living in the concession area. As it was extremely dangerous to oppose the government during



Fig. 23: SAD woman in front of her demolished house (IRAWAN, FERI 2013)

the military regime, local opposition to the takeover of lands by PT AP first became overt around the year 2000 (COLCHESTER et al. 2011: 11ff). Since then the clash over land ownership has led to demonstrations, occupation of ancestral land and violent clashes with a number of diverse local, national and even international stakeholders involved. For more information on the conflict see COLCHESTER et al. (2011).

Local indigenous people in Bungku are normally referred to as "SAD". SAD actually stands for "Suku Anak Dalam" which means "Children of the Interior" and is a postcolonial category for nomadic and semi-nomadic groups in Jambi (STEINBACH 2013, qtd. in HEIN 2013: 15). The term is negatively connoted, as SAD people were assumed to be backward people in need of modernization (COLCHESTER et al. 2011). Yet, although indigenous people in Bungku actually belong to the group *Batin Sembilan*, today they proudly refer to themselves as Suku Anak Dalam. Until the 1980s they lived from shifting cultivation, hunting, fishing and gathering forest products both for their own use and for trade.

Today the landscape outside of the big industrial plantations is dominated by oil palm as well as rubber plantations. According to the village head, about 40% of the land in Bungku Indah is planted with oil palm, another 40% with rubber plantations and 20% with jungle rubber (agroforestry system) (I8R1) (cf. Fig. 24 & Fig. 25). Johor Baru 1 instead is mainly dominated by oil palm. This is due to the direct vicinity to PT AP oil palm plantation (cf. Fig. 26) as well as to extensive oil palm plantations by smallholder farmers (cf. Fig. 27). In the northern part of Bungku, the protection forest "TaHuRa" (Taman Hutan Raya \approx Great Forest Park) directly borders on the village center of Bungku Indah (cf. Fig. 28). Today, however, most of the area has been taken over by local and migrant people and has been converted into agricultural plantations. For detailed information on land access in Bungku see HEIN (2013).



Fig. 24: Rubber plantation inside HKM area



Fig. 25: Jungle rubber inside HKM area



Fig. 26: Oil palm plantation of PT AP



Fig. 27: Newly planted oil palm plantation next to small cassava field (bottom left corner)

(own pictures)

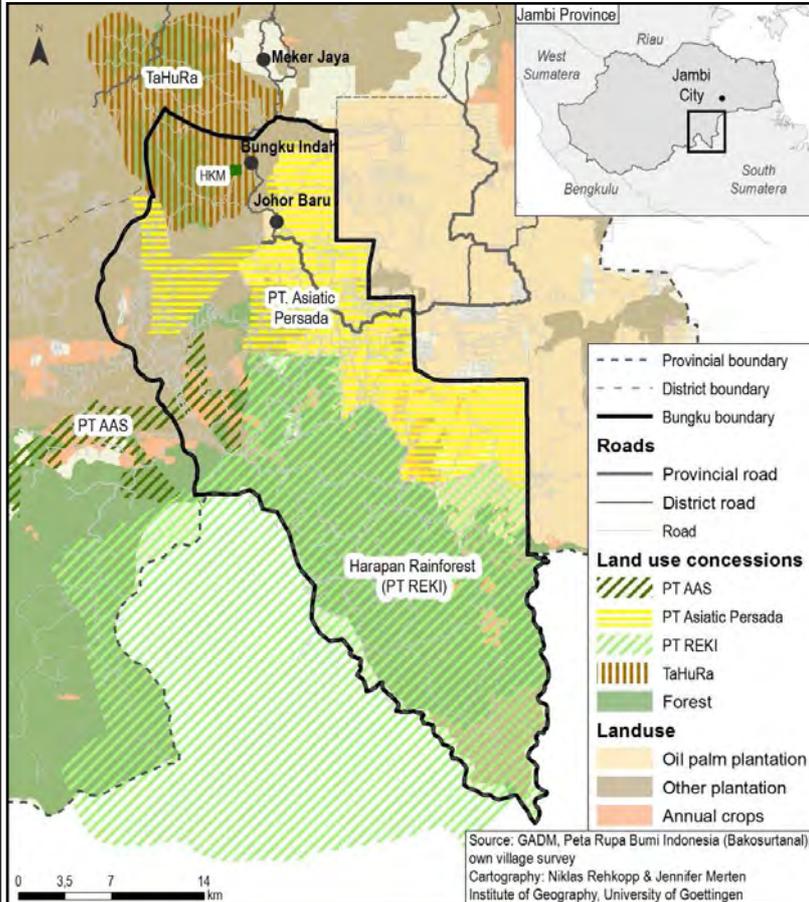


Fig. 28: Land use concessions in Bungku

Demography and Infrastructure

Bungku Indah is the historical center of the village and also today's administrative center. Bungku Indah was founded in 1974 as part of a settlement project for SAD people by the government department of social services. Johor Baru became a village district only much later, around the year 2000. It was formed after former workers PT Asiatic Persada began to settle along the main village road and established their own plantations in the surroundings. Other *dusuns* are even younger. Today Bungku has a total of almost 10,000 inhabitants distributed in five different *dusuns*: Bungku Indah, Johor Baru 1, Johor Baru 2, Kunangan Jaya 1, Kunangan Jaya 2 (Desa Bungku 2010). Village development has been largely determined by the ongoing migration processes to the area.

The ethnic composition in Bungku Indah was described by the village head as: 20 % local (SAD), 20 % from villages around Bungku, 40 % Javanese (incl. Sundanese), 10 % Palembang (Melayu tinggi), 10 % from Medan (Batak), 5 % other (some from Kerinci) (ISR1). About 90 % of the population are Muslims, and around 10 % are Protestants (mainly from North Sumatra). The economic standing of the people is quite high. In a village document 30 % are categorized as rich, 40 % as medium and 30 % as "less rich" (Desa Bungku 2010). Indeed, many people have newly built stone houses (cf. Fig. 32) and most households have their own motorbikes, many even own a car. While SAD people are more likely to still live in wooden houses (cf. Fig. 31) and are less wealthy in general, they often still own a motorbike and several have accrued considerable wealth as well.

By contrast, the educational level is low. 20% of the population have not even completed primary school, 40% have graduated from primary school, 20% completed junior high school (SMP) and 15% graduated from senior high school (SMA). Only 5% of the population holds a university degree (Desa Bungku 2010). While there are several primary schools in Bungku, there is only one junior high school in Johor Baru. The next senior high school is in the district capital Muara Bulian. The only community health center of Bungku is located in Johor Baru as well and has hardly any equipment at all. There are three midwives and two nurses working there but no doctor is present. There is still no electricity in Bungku, but cables were being installed during the time of research.

Johor Baru and Bungku Indah differ a lot in their character. Bungku Indah is still dominated by small-scale agriculture and most inhabitants plant oil palm as well as rubber. Local SAD people are often married with migrants and the atmosphere between both groups seems to be one of trust and friendship. On the other side Johor Baru directly borders with PT Asiatic

Persada's oil palm plantation. Apparently about 90% of the inhabitants have worked for the company at some point in their life and many still do so today (I23R1). Others have bought land and established their own oil palm plantations. Daily life appears to be very much influenced by the neighboring plantation and PT AP trucks are loaded with oil palm fruits during the whole day and evening (Fig. 34). As local SAD people still fight for their rights over ancestral land with PT AP, the atmosphere between migrants and SAD people is much more reserved. Migrants often only spoke about SAD people in hushed tones as "those stealing oil palm fruits" or "those staying inside the plantation". In general Johor Baru seems even richer than Bungku Indah and there are many more specialized shops as well as quite a number of small street restaurants (*warung*) along the main street (Fig. 35). It also has a market and an official bus stop. While the asphalt road next to the company is well maintained, large parts of the asphalt cover in Bungku Indah are almost completely destroyed or nonexistent (Fig. 29).



Fig. 29: Destroyed asphalt road and mosque in Bungku Indah



Fig. 30: Houses along the main road in Bungku Indah



Fig. 31: Wooden SAD houses in Bungku Indah



Fig. 32: Newly constructed house in Bungku Indah



Fig. 33: Modern and luxurious house in Johor Baru



Fig. 34: Oil palm trucks are dominating the appearance of Johor Baru 1



Fig. 35: One of the many small shops in Johor Baru



Fig. 36: Small hut of an SAD family occupying land of PT Asiatic Persada

(own pictures)

6. DATA ANALYSIS

This chapter is structured according to the research questions. Thus, the first part of the chapter is concerned about *environmental perception*. In this part the land use change, as perceived by the villagers, as well as hydrological changes reported are explained. The second part focuses on the *communication patterns* observed during the field research. It mainly focuses on the different lines of arguments for hydrological changes as presented by villagers and stakeholders as well as on general communication about the current land use change. The third section concentrates on the *impacts* that arise from alterations in the local water resources. A fourth section depicts *possible solutions* to the water supply problems encountered in Bungku as discussed by villagers as well as by different stakeholders. As the results of the field research will be displayed with the help of the DPSIR framework in chapter seven, the following diagram serves as an orientation how this chapter's sub-sections are later on integrated into the DPSIR framework.

Drivers	6.1. Environmental perceptions (land use change)	6.2. Local communication (attitudes towards oil palm cultivation)	6.4. Review and outlook (responsibilities)
Pressures	6.2. Local communication (reasons for hydrological changes by villagers and stakeholders)		
State	6.1. Environmental perceptions (hydrological changes + further env. changes)		
Impact	6.3. Livelihood impacts		
Response	6.3. Livelihood impacts (water supply during dry season)	6.4. Review and outlook (possible solutions)	

6.1. Environmental perceptions

This section describes the local land use change and associated environmental changes as perceived by the villagers and explained during the interviews. As the issue of land use history of Bungku and the actors, projects and institutions involved is extremely complex, the first part concerning land use change is elaborated to my best knowledge. Therefore, it shall

serve as rough orientation of land use history but is not suitable as a basis for in-depth analysis where full accuracy in every detail is needed.

6.1.1. Land use change in Bungku

Village establishment and the beginning of the logging era (1971-1982)

The village Bungku was officially founded in 1971 as part of a settlement program by the social department. The project PMST (pemukiman anak suku terasing) was a settlement project for local SAD people who until then had practiced shifting cultivation. As part of the project about fifty family houses and three houses for teachers were built in the village district that today is called Bungku Indah, the "beautiful Bungku". At that time, SAD people earned their living mainly by trading products from the forest, such as different types of rattan or resins. These products were bartered with outsiders. SAD people also practiced shifting cultivation of rainfed rice fields and cultivated small areas with different vegetables and fruits such as chili, cassava, maize or bananas. The collection of fruits from the forest constituted another important addition to their diet. The only commercial activity in Bungku area at that time was a mineral oil field near today's Bungku Indah. According to the village head, oil is already being exploited since colonial times.

In the seventies, the landscape around Bungku was mainly dominated by forests with rich faunal diversity. Tigers, elephants, deer and bears could be seen frequently. After the social department built some houses, the first individual migrants (mainly from Java) came to Bungku. The first rubber plantations were probably established around the mid-1970s. But as seeds were difficult to get, only few trees were planted per hectare (30-50 trees/ha). Another development that started shaping the environment at that time was the increasing logging activity. In 1969 the first HPH (Hak Pengusahaan Hutan = Concession to exploit the forest) was issued by the government to a Malaysian investor. Logging, especially of the valuable Borneo ironwood (*kayu bulian*) became an important economic activity during the next decades, roads were built and many villagers found work with the logging companies for the next decades.

Settlement of first oil palm companies and rubber boom (1982-1995)

More migrants started to move to Bungku at the end of the 1970s and especially at the beginning of the 1980s, when further companies settled down in Bungku. Tanjung Johor started its activities in Bungku in 1982 and BDU (Bangun Desa Utama) in 1985/86. While in some area (probably Tanjung Johor) cocoa plantations were developed, in other areas

(probably BDU) oil palms were planted from the very beginning. As cocoa cultivation didn't succeed the plantation was also changed to oil palm, reportedly in the early/mid- 1990s. The most important concession was the one given to BDU, which covered an area of 20,000 ha. BDU was later renamed PT Asiatic Persada and belonged to regularly changing owners such as Cargill Inc. and Wilmar International Limited (until 2012). Plantation development started about 1987. But not all of the land was developed at the same time and large scale plantation development probably started in the mid 1990s. The land acquisition of BDU gave rise to violent land conflicts with the local SAD population that have lasted until today (cf. chapter 5). According to reports of the people their land was taken away violently by the military and many had to migrate to other areas. A compensation for the loss of land and plantations was never paid. Unfortunately, it is not possible to enter into more detail involving this land conflict, as it is so complex that it would be easy to elaborate an entire Master thesis based entirely on land conflicts in Bungku (cf. also COLCHESTER et al. 2011).

Many migrants kept coming to Bungku during the 1980s. They migrated from Medan (North Sumatra), Palembang (South Sumatra) and also from Java. Sometimes they even came in groups of 20-30 persons. A mixture of migrant families with SAD families became common. Yet, there were only few houses in Bungku, and the distance between houses was often considerable. Many SAD people were still living somewhere in the forest. Today's district of Johor Baru didn't exist as yet, as company workers lived in special settlements build by the companies. Along the main road, today's center of Johor Baru, only some few houses existed. Although village growth due to migration continued, its development was slow. In 1993, according to one woman, there were only about 10 houses in Bungku Indah and most of the people opening the land were still SAD people. Another interviewee stated that when he moved to Bungku in 1997, only about 20% of today's houses in Bungku already existed. While during the 1980s the main income still came from selling different types of rattan and their resins and the landscape was characterized by rice fields, by the 1990s rubber had become the main source of income for local people in Bungku Indah. By that time the forest had already been degraded severely although it still extended over large areas. The perception of what can still be claimed as "forest" differs a lot among the people questioned. While many interviewees stated that until the mid or end of the 1990s there was still a lot of forest around Bungku, others emphasized that already during the 1980s only small trees remained after intensive logging activities had taken place (i.a. I24R1, I36R). For them the forest in the area around Bungku had already been gone by the mid-1980s. The oldest person in the village

(SAD) even claimed that the forest had disappeared when he stopped being head of the village, which would mean around 1974 (I12R).

Village growth and oil palm expansion after the collapse of Suharto's regime

Around 1996, still during the Suharto Era, TaHuRa was founded. The forest reserve area should embrace an area of 15,000 ha (cf. Fig. 28) and should serve as recreational park. The important turning point in the village history according to almost all interview partners seems to be around the year 2000. Although by referring to the year 2000, probably a much broader time span (\approx 1998 to 2003) has to be considered. People emphasized that during that time many migrants moved to Bungku, the main village road was asphalted and TaHuRa was gradually illegally deforested to establish plantations or to exploit valuable woods. Apparently it was mostly local people who sold the land to outsiders or who were paid by them for opening the land. Two interviewees asserted that the selling of the land actually began with the changing of the village head of Bungku in 1997. The government, often accused by villagers for not protecting TaHuRa, was apparently too weak to interfere. At the beginning, plantations established inside TaHuRa were mainly rubber cultivations. First independent smallholder farmers only started to plant oil palm since around the very late 1990s. But at that time it was still very difficult for them to get the seeds.⁵ Thus, the wider development of oil palm in that area only started a few years later (roughly around 2006).

Another important project that started in the year 2000 was the "HKM" (Hutan Kemasyarakatan). HKM, literally meaning "forest for the people" comprised an area of 300 ha and was said to be initiated to stop people from clearing land inside TaHuRa. As the forest in HKM area had already been severely degraded, jungle rubber should be developed. Each of the 150 households in Bungku therefore received 2 ha land inside the project area. The households were provided with rubbers seeds, seeds for fruit trees, fertilizer, herbicides and money for the site preparation as well as agricultural training for rubber cultivation.

As explained before, the people had quite different perceptions on when the forest cover in Bungku had disappeared. Many interviewees continued to argue that the forest was gone by the year 2000. As some people also stated that TaHuRa was being cut since 2000, it seems obvious that again this year can only be taken as a rough landmark. However, the development of deforestation in TaHuRa seemed to proceed extremely rapidly. The latest date

⁵ According to a representative of the plantation department (DINAS Perkebunan) the government has only worked together with smallholders since the year 2000. Before that they didn't recommend growing oil palm to smallholders due to their dependence on the fast processing of fruits in oil palm mills.

I got when asking, "When was the forest gone completely?" was "2007/8" (I27R). Although today a very small band of forest still exists at the very western edge of TaHuRa, for most people, this cannot be called *forest* anymore: "Now TaHuRa doesn't exist anymore, the only thing left is oil palm." (I18R1). (cf. also Fig. 67: Deforestation in northern Bungku between 1990 and 2000 Fig. 68: Deforestation in northern Bungku between 2000 and 2012).

Today oil palm is the dominant element in the landscape of Bungku. Especially during the last five to ten years any existing land seems to have been converted into oil palm plantation. Especially the land of TaHuRa is now mainly dominated by oil palm plantations. According to the interviewees land now belongs almost exclusively to people from outside. Apparently, these people are often from Medan (North Sumatra) or Kerinci (East Jambi), who sometimes own up to 25ha land but don't live there.⁶

"The government cannot control it [TaHuRa] because local people maybe only open one or two hectare land. But the people from outside buy the land from the local people after these have already moved on. And they buy up to 25 ha because they have the money." (I4R1).

The area for TaHuRa and the huge concessions of oil palm plantations in the area make people lament a lot that there is no land left in Bungku. While in Bungku Indah the oil palm concession of PT Asiatic Persada starts after some 300-500 m to one side of the road, TaHuRa directly reaches the village road on the other side.

"As SAD, we have to open land every year to plant rice, trees and other crops. But now where shall we make our cultivations? There is no forest left anymore and the remaining forest is protection forest [...]." (I30R1).

"The forestry department says they cannot control people who illegally log the forest because the road access is very bad. But if so, how can people who cut the trees transport the wood out of the forest and the village?" (I35.1R2).

Despite these complaints, it has to be considered that also local people were involved in selling land in TaHuRa. Thus, it is hard to comprehend who in the end profited from land selling and which people were negatively affected the most. As HEIN (2013: 16f) argues, most local land conversion or land use permits in Bungku are issued by village and customary authorities. They are not backed by national legislation and often overlap with forest land or with land use concessions of companies.

While in Johor Baru the landscape is almost completely characterized by oil palm plantations, in Bungku Indah many rubber plantations or jungle rubber cultivations can still be found,

⁶ This information was only given by local residents. None of these landowners in TaHuRa have been interviewed.

especially inside HKM area. How long these will last remains unsure as land around HKM is being encroached on continually by oil palm plantations. Many local people have also already sold their two hectare land to people from outside. Thus, one of the interview partners, a newly migrated Javanese rubber farmer, stated to own six hectare land inside HKM area. The initial idea of developing jungle rubber on that land also did not survive as many cultivations today are much more managed like rubber plantations (cf. Fig. 24, p. 43). Migration and population growth in Bungku still continues to be high and it will be interesting to see how access to land will be contested during the next few years.

"Now the population is getting more and more but the area for the people to live stays the same. Most of the land belongs to the company while there is no land for the people anymore. If the government had also given some land to the people maybe they wouldn't have cut TaHuRa." (I39R1).

6.1.2. Village perceptions of hydrological changes

A number of alterations in local water resources have been observed by Bungku's residents. In order to understand the importance of these changes, a general description of existing water bodies precedes the specification of the changes reported.

6.1.2.1 General description of water resources in Bungku

The area around Bungku is characterized by only small surface waters. There is only one bigger river near Bungku Indah and Johor Baru, named "Sungai Bahar" (cf. Fig. 76, appendix p. 135). It flows directly through the centre of Johor Baru, which is located at about 6 km distance from Bungku Indah. At the beginning of the dry season the river was about three to four meters wide. The river flows in large parts through industrial oil palm plantations and buffer zones are mostly missing. Although there is a big sign installed by PT Asiatic Persada



Fig. 37: The river Sungai Bahar (own picture)



Fig. 38: River in the southern part of PT AP concession (own picture)

claiming protection of the riverbed, only few bushes grow along the riverside and oil palm is planted directly next to it (Fig. 38, Fig. 40). The color of the water is brown due to high sediment contents (cf. Fig. 37). There are also many small rivers around Bungku, but most were only about 30-50 cm wide at the time of research. Many of these run dry during dry season.

Other water resources are mainly described as "rawa-rawa", which literally means "swamp". Yet many of these swamps constitute real water bodies, more like small forest ponds (Fig. 39). But as people always referred to them as "swamps", I will continue using this term, too. In Bungku Indah there is one important, bigger swamp where people go for washing and fishing. It is situated approximately one kilometer from the centre of Bungku Indah and is accessible by a small path. The biggest swamp in Johor Baru is located directly next to the street. In the past it was said to have been about four meters deep. In general, there are many more swamp areas in Johor Baru.



Fig. 40: River course of Sungai Bahar through oil palm plantations of PT AP (Google Earth 2007)



Fig. 39: Swamp area in Johor Baru (own picture)

There are no springs in Bungku Indah and Johor Baru. The only spring I heard of was at a plantation in Rantau Rasau a subdistrict of Johor Baru, which lies several kilometres from the main road. The closest publicly accessible springs are located in Meker Jaya which is located about 10 km from the centre of Bungku Indah (about thirty minutes by car) (cf. Fig. 28). There are several abundant springs there. Six years ago a public bathing place was built there.

6.1.2.1 Perceived changes in the water quality

The quality of the water in the rivers and swamps has changed considerably according to all interview partners. The water quality "dulu" (= "in the past")⁷ was described as very clean. Words like "bening", "jernih", "bersih" (= clear, pristine, clean/fresh) were often used to describe the state of the water quality. Many people went to take a shower there and some people recounted, that people could drink the water from the river, even of the bigger river Sungai Bahar. Today the water quality is described as "totally different" (I4R1). Words often used are "keruh" or "coklat", meaning "turbid" and "brown". Especially during rainy season people complain that the water turns brown because of sediments:

- I: Did the quality of the water also change?
- R2: Yes, it changed. A lot! Before the water was not that dark, but now it looks like it contains mud. Before there was not that much mud in the water.
- R1: Now there is no clean water anymore. But for washing it's still clean enough.

(I24; "I" stands for "interviewer").

Some people also remarked that the water smells bad (I18R2). Water quality decreases further if many people go to the river for washing and showering, then the water "turns black and white things flow on the water surface" (I24R1). Yet, water quality doesn't seem to be the same everywhere in Bungku. A rubber farmer, living inside the jungle rubber area HKM said that during rainy season the water is still clear. But after one month without rain the water becomes yellow (I35R1). Other people also bore witness that the water turns yellow during dry season, apparently occurring when the water level becomes too low or the river stops flowing (i.a. I26R1). Another depiction of the decreased water quality was made by a local SAD man. He compared water in oil palm plantations to the forests and noted that in the forest the water is "still cold": "[...] because in the forests there are still many trees but in the oil palm plantations the water is hot" (I30R1).

⁷ The term "dulu" is used by people to refer to anything in the past, but is not further defined. Thus, it was difficult to understand which time span people were actually referring to.

While the people generally agree that water quality in surface waters decreased a lot, the quality of the groundwater from the wells is evaluated variably. In general, there are several people who say that they are content with the state of the water and that the quality of the well water is good. However, others remark that the water quality was much better in the past and that the quality has degraded a lot. While the second group is almost exclusively comprised of local people or people that have lived in Bungku for several decades, the first group is represented by many migrants that moved to Bungku after the year 2000, but not only so. One of the oldest local people even described the worsening water quality as following:

I: Why did people start to buy water?

R2: Because the water is not clean anymore. When we are cooking rice the rice is getting red because of the water. The smell is also not very good.

(I10).

On the other hand, there are still quite a lot of people in Bungku that drink their well water instead of buying bottled water. Many of them even stated that they prefer to drink the water from their well, because it tastes better (i.a. I13.6R1, I22R2). One of them even argued that it's better for one's own health to drink well water as people never know whether bottled water is hygienic or not. Because, although being purified the water is only refilled into old bottles that are washed manually. Thus, the perception of what represents clean water is quite different. In any case, it must also be admitted that due to differences in construction or location of the wells, the water quality differs significantly. Most people in the village affirmed, that there are some wells that still provide "good" water.

Erosion appears to be a severe problem for the water quality for most of the people. If soil is being washed into the wells the water becomes brown and turbid (cf. Fig. 41, Fig. 42). That is why many people, that have enough money built their well with cement. Many other wells are only secured with wood or even bare soil. And even wells secured with cement it seems, cannot completely prevent the water from becoming a bit turbid after a rainfall. Even some people with good wells stated that their water quality is best after some days without rain. This, in general, seems to represent the consensus among the people. In consequence, even in the dry season, according to some interviewees, the water is of no good quality as it turns yellow (i.a. I2R1, I16R1). Due to the fact that other people claim that water quality is good during dry season, the water possibly only turns yellow if its quantity decreases a lot. This is in line with the following statement:

"Normally in drought, if wells are good the water is mainly good.... But in wells that are not good, the water changes, sometimes it becomes yellow." (I35R1).



Fig. 41: Turbid water of a non-secured well (own picture)



Fig. 42: Sediments in a water tank in the bathroom of our guest house (own picture)

6.1.2.2 Perceived changes in water quantity

Surface waters

Today, during dry season, many of the small rivers stop flowing and smaller swamps run dry. Especially during a pronounced drought in 2012 it was hard to find water. After how many weeks of drought they actually start running dry depends on the river. When we visited Johor Baru for the first time, it hadn't rained for almost a month and we observed that some rivers had already stopped flowing (Fig. 43). Another one had only a very little flow and we were



Fig. 43: Small river that for the last couple of years has stopped flowing during dry season (own picture)

told it would stop flowing after about another week without rain. According to the people this had not always been the case. Although some interviewees reported that rivers had also stopped flowing in the past, they argued it hadn't occurred that often. In the past ("dulu") they said, the river ran dry after a drought of eight or nine months, but today the water in the rivers decreases after only a week without rain (I32R2).

During the resource mapping in Bungku Indah we even learned that several swamps we saw had formerly actually been rivers. While near Sungai Bahar, in Johor Baru there have always been a lot of swamps, in Bungku Indah this wasn't the case. Swamps only appeared after

rivers stopped flowing. Even the big swamp inside HKM area apparently had been a river before. On the other side in Johor Baru there had even been many more swamps in the past than there are today. While some have run dry, others apparently have been covered or drained by the company PT AP (I24, I30R1). Water drained from swamps into the rivers thus contributed to an even higher sedimentation rate of the river (I28). Because of this condition, missing buffer zones and erosion, rivers have become shallower (I31, I24). Furthermore, people in Johor Baru claimed that also some smaller rivers have been covered or diverted by the company (I30, I24). Two examples shall be given to depict the changes in detail.

R1: Dulu there was a big river here, many people went swimming there. It was near Pak Y. house. Now it doesn't flow anymore and there is a lot of grass around it.

[...]

I: When did the river stop flowing?

R1: Maybe....in the year 2000 it still flowed...maybe around 2005. [...] In 1999, when I graduated from elementary school there were many students that came to swim in the river and after that there were also many people who went swimming there. [...] In 2012 during the drought, I went to the river to get water. But then I was surprised as I saw all the grass. I couldn't believe we could swim there in the past.

(I40. This was an informal interview and we didn't ask her anything about changing of rivers. We had just asked her where she got water in 1997 during the drought and then she started telling this story.)

I: At that time [1997] where did you get the water?

R: In strong drought we took the water from a well which was made by the local people and BDU. Behind Pak M.'s house.

I: It didn't run dry?

R: No, it was next to the swamp.

R2: The swamp behind Ibu S.'s house. That swamp was big dulu.

R5: It was really big! About four meters deep!

I: The one behind Pak M.'s house?

R2: Yes. It didn't run dry, it was clean. Maybe it got less because there was oil palm planted there.

R5: Yes, because of oil palm!

[...]

R2: All the water gets less. In the past the river was big and wide, but after some time it became small. The swamps were large in the past as well, but now they start to become smaller, too.

(I31, group discussion Johor Baru)

Floods do not constitute a real problem in Bungku. Even bigger floods occurring in Sungai Bahar do not reach the houses and thus produce no damage. An important observation made by several different interviewees in Bungku Indah and Johor Baru is that, if these days it's raining hard, flooding happens much faster than in the past. And after the rain stops the water is gone very fast again. While in the past, a flooding lasted for days or even a week, nowadays, it is said to last only a couple of hours or one night (i.a. I18R1, I4R1, I31).

Groundwater availability

When streamflows decrease during dry season, the quantity of groundwater becomes less, too. Most people stated that their wells run dry during dry season. While some wells run dry completely, most people mean by "running dry" that they only get about two buckets full of water from their wells. After that they have to wait half a day until they can get water again. To describe the situation in Bungku, several people narrated stories about people or projects that dug drilled wells. Even if they dug 25 m or even 100 m deep, they couldn't find any water during dry season.

On the other side in Bungku Indah there are also several "good" wells that don't run dry. Although these also provide less water during dry season, the water amount is still sufficient for a family. While some people reported this about their own well, all others at least knew somebody with a good well that doesn't run dry. Sometimes this well could be located just across the street. Thus, there seem to be minimal difference in topography, geology or well construction that determine whether a well is good or not. However, from the data obtained during the interviews there is no common pattern discernible. While in Bungku Indah there are a couple of "good" wells, by contrast in Johor Baru nobody reported about a well that "never runs dry". Furthermore, most people in Bungku Indah stated that wells run dry after approximately two, three or even more dry months. In Johor Baru, on the other hand, many interviewees claimed that their wells already started to run dry after less than one month without rain.

This water shortage during dry season seems to have exacerbated as well. Though some people claim that in the past, the wells already ran dry during dry season others emphasize the shorter time span today. Only few interviewees negate any change at all. Most people complain that today there is much less water in the wells during dry season and that it runs dry much faster.

"When there was still a lot of forest around Bungku even during a drought of two months we still had water in the wells, but now there is no forest anymore, there is oil palm." (I13.7R1).

"Before even if there was no rain during three months, there was still water. But now if there is only one month drought then the well runs dry." (I22R1).

The following diagram (Fig. 44) shall give an overview on the changes observed.

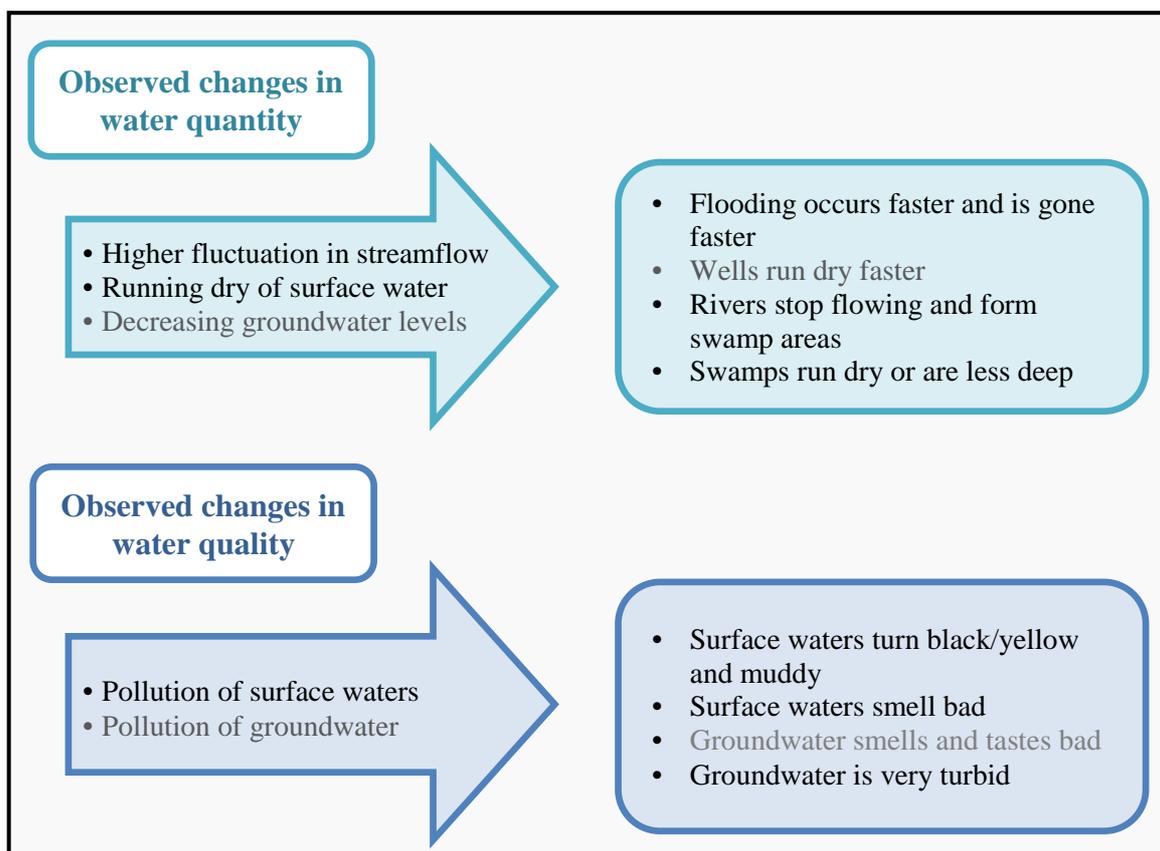


Fig. 44: Observed changes in water quantity and quality (own diagram)
 (text written in grey = not confirmed by all interview partners)

6.1.3. Further observations of environmental changes

In addition to changes in local water resources, many villagers commented on further environmental changes they have observed during the last decades. These mainly included a decrease of biodiversity, soil degradation and changing climate patterns.

6.1.3.1. Biodiversity

When the landscape around Bungku was still mainly dominated by forests, a variety of animals, including tigers, elephants, deer and bears could be seen frequently. According to one interviewee the rivers were so full of fish, that if he started to cook rice and then went fishing, he managed to catch fish and come back to his house before the rice was even cooked

(I18R1). According to some people elephants had already started to disappear during the 1980s. Tigers were still frequently heard at night but seen only on fewer occasions. In another parts of Bungku though, probably where forest cover was still more intact, tigers could still be frequently seen in 1992.

Today elephants and tigers have disappeared completely in the northern part of Bungku. Nowadays, tigers are said to remain only in the forest rehabilitation area of PT REKI. Deer (probably *muntjacs*) are still seen in Bungku but populations are decreasing, too. Furthermore, the fish and shrimp populations in the river have decreased a lot. While, according to the interview partners many birds can be found on rubber plantations, there are only few birds on oil palm plantations.

"Now it's difficult, there are no animals anymore, the forest became an oil palm plantation." (I24R1).

Instead, the populations of monkeys, snakes and pigs have increased considerably and all of them raise different problems for the villagers. Injuries by snakes' bites have been reported frequently (i.a. I1R2, I20, I28). Monkeys and pigs turned into a problem for other cultivation forms. While oil palms are generally not impacted by the population increase, rubber plantations or the remaining small vegetable cultivations have to be protected intensively.

R4: Pigs, find a lot of food on oil palm plantations. Now there are many pigs as well, the population grows fast because they can always find food.

[...]

R5: But the pig and monkey don't really impact their harvest [oil palm]. Pigs only eat fruits that have already fallen down and monkeys are no problem.

(I20).

Two especially striking stories about pests shall be depicted. The first was an interview with rubber farmers in the HKM area. The married couple complained a lot during the interview about the monkeys. While they are working in their plantation, one of them always has to stay close to their house to watch the monkeys. If the monkeys see that there is nobody at home they enter and steal the food. One time, the couple narrated, they had left Bungku for two weeks, because a relative was sick. But when they came back the monkeys had taken everything, they had even broken the plates inside the house. That is why the woman almost never goes to the center of Bungku Indah. The day before the interview there was a celebration at the mosque, but she couldn't participate as one of them had to stay at home. When I asked them why they didn't move to the village center, they said they have no other

choice than living inside HKM area. Otherwise, the monkeys would eat the leaves of the rubber and the pigs would damage the stems (I21).

The second story is that of the eldest person in the village. He is one of the few persons that still have a cassava plantation in Bungku. In order to protect the cultivation from monkeys he has to stay there during the whole day. From five o'clock in the early morning until six o'clock in the evening he stays in a small bamboo shelter and watches the monkeys (Fig. 45 & Fig. 46). According to him the monkeys became a problem ever since there was no longer any forest and since they could no longer find any fruits. If he wouldn't watch the plantation, within minutes they would destroy the whole field (I12). Indeed, both times when we came to see the man on his plantation we could see groups of fifteen to twenty monkeys playing around his fields.



Fig. 45: The village elder on his cassava plantation (own picture)



Fig. 46: Group of monkeys playing in the bamboo next to the cassava plantation (own picture)

6.1.3.2. Perception of climatic changes

General climate memory

The general memory of the climatic history of Bungku differs a lot among the residents. Certainly the most important event remembered by all was the strong drought in 1997.⁸ Most people said it lasted for six to seven months. Another important drought remembered by all interviewees happened in 2012. During that year it almost didn't rain for about three months. In fact, some people even reckon it didn't rain for five to seven months (cf. climate diagram of the year 2012, Fig. 74, appendix). In between those two droughts few interviewees could specify any further drought. Specifically, one person argued there was a drought of three months in 2001 (I4) and two further interviewees, independently of each other, reported of a

⁸ In 1997/1998 an extreme El Niño resulted in strong droughts all over Indonesia. For more information see BELL & HALPERT (1998).

drought of six months in 2007 (I13.5, I23). Prior to 1997 the situation remains even more unclear. Only about four interviewees mentioned droughts before 1997. The local village elder even remembered a drought much harsher than the one in 1997 of nine or even twelve months. But unfortunately he didn't remember in which year that happened (I12). As most interview partners moved to Bungku in the 1990s it makes sense that most of them remember the very strong El Niño year of 1997 as the most important drought. The fact that few people named droughts after that event shows that 1997 has been a very striking year. A drought like that has never happened again and the other "periods without rain" were considered to be much less important by most interviewees (cf. also I20).

Observed changes in climate

When asking interview partners if they have observed any changes in the climate during the last few years, two important changes were often stated: It's not possible to predict the seasons anymore and the weather in general has become much hotter.

While formerly there were clear and regular periods of dry and rainy season, today the course of the seasons can no longer be predicted. Sometimes it rains a lot during dry season whereas it remains dry during rainy seasons. The changing of the seasons is mainly commented by local people or people that lived in Bungku before 1990.

"The first time I came here [1974] the dry season was from May until July. It started to rain in August and rained until January. But now we cannot predict when the rainy season will come and when the dry season will start. Like this year there is still rain until May. Now it's not clear what to name dry season, because we don't know when it will rain and when not." (I4R1).

Yet, for the majority of the people the most important change in climate is that the weather has become incredibly hot during the last few years. Almost all people interviewed complained about that.

R1: When I came to Bungku in 1991 the temperature was different. There was still a lot of forest and the temperature was not so hot like today.

I: Why do you think it got hotter?

R1: Maybe because the forest is gone and there is a lot of oil palm so the temperature is getting hot.

(I16).

The reason for this change in temperature was directly related to land use change by most people. Though not all seemed to understand why the weather has changed, many argued that since the forest had disappeared the weather has become hotter. Or they reasoned the other way round: Since there has been a lot of oil palm the weather has become hotter.

6.1.3.3. Observations of soil degradation

The most important characteristic of the soil in Bungku that was pointed out by interviewees was that, if they dug a well they found a layer of black, hard rock. This layer appears in some areas to be around two to three meters deep, in others up to about seven meters deep. Therefore, it was often said, that it was not possible to dig wells any deeper than seven meters. Furthermore, many people claimed that the soil structure in Bungku was somehow different. Compared to other regions the soil was described to be very dry, especially during dry season. A few interviewees also mentioned that there was no sand in the soil which was perceived as a negative characteristic according to them. Apart from the general description of a "problematic" soil structure very few people also admitted that the soil became more compacted and drier in areas of oil palm plantations.

"The soil structure here is compacted. [...] The compacted soil is only in the area about three meters from the trees of oil palm." (I20R1).

"There is also fertilizer that absorbs water. The soil becomes like cement." (I31R2).

"[...] the soil also changed because of oil palm it looks yellow. Before the soil, where we live was good but now the soil seems like sand. Like the soil has died." (I28R1).

Yet, one man owning a large oil palm plantation of eight hectare argued that he hadn't noticed any changes in the soil. After cutting down some oil palm trees and letting some grass grow, according to him, it was possible to plant vegetables again (I29R1).

6.2. Local communication of oil palm expansion

Aiming to gain insight into local problem perception, this chapter focuses on the different reasons that villagers as well as stakeholders at regional and national level have presented for changes in the local water balance. In order to understand how people communicate these changes and why they argue the way they do, it is essential to get an overview of the people's attitude towards oil palm plantations and the ongoing land use change. Thus, the following section shall give a detailed view on functions and services of oil palm plantations for local people as well as on management issues and environmental impacts as perceived by the residents. A distinction is being made taking into consideration the local attitude towards smallholder oil palm plantations and their attitude towards large-scale plantations by private companies, as views often differ significantly.

6.2.1. Local attitudes towards oil palm cultivation

In general, it can be summed up that the attitude towards oil palm cultivation in Bungku is extremely positive and that most people would like to cultivate oil palm in case they have no plantation yet. The most inhibiting factor why people don't turn to oil palm, although they would like to, is the lack of financial capital. Especially fertilizer application is considered to be extremely expensive and absolutely necessary for the profitable management of a plantation. While companies and large scale plantation owners apply fertilizer up to four times a year, most smallholders⁹ only apply fertilizer when they have liquid funds, normally not exceeding two applications per year. Another important factor impeding oil palm cultivation is the access to land. Some interviewees argued that oil palm cultivation is only profitable if people possess land or enough money: Because if a person has no land, he doesn't earn enough income from the plantation to buy the fertilizer, which in return will lead to a much lower harvest. Furthermore, some people argued that actually the income per hectare for rubber is better than for oil palm. Nevertheless, as one farmer can manage many more hectares oil palm than rubber on his own, oil palm farmers are generally richer than rubber farmers. Because the management of oil palm plantations is extremely easy. A harvest needs only be collected every two weeks, while rubber should be harvested every day. This constitutes one of the most striking factors why people prefer oil palm cultivation to rubber. Furthermore, there is almost no need for pest management on oil palm plantations as they are also more resistant to extreme weather or fire, and trees fructify faster than rubber. As management requires few working hours, people can find other jobs to supplement their incomes or they have several hectares of oil palm plantations and thus don't need an additional job. However, especially local people often do not know how to manage an oil palm plantation properly and therefore prefer to continue their rubber plantations. In other cases oil palm cultivation is started despite a lack of knowledge which often leads to much lower harvest results. Some interviewees observed that many people literally just started to plant oil palm because they see other people doing so:

I: But are there also SAD people who plant oil palm?

R1: SAD plant oil palm because they see the other farmers doing it and they just follow them.

(I28).

⁹ By "smallholders" I refer to farmers with a maximum of about eight hectare land ownership. Most of them own two to four hectare land.

Only a few people in the village are completely content with their rubber cultivations and do not wish to convert these to oil palm. Nevertheless, some of the SAD people that were occupying land of PT Asiatic Persada at the time of research stated that they would prefer to change their land from oil palm to rubber as they knew more about rubber cultivation. But that would mean investing "time and money" which they claimed they didn't have.

On the other hand, several aspects of oil palm cultivation gave rise to concerns for the people. The most important concern seems to be regarding the water use of oil palms. Many people have heard "from research", that oil palms need a lot of water. Their specification however ranges from five to twenty-five liters water per day. Although this data does not seem verifiable and is of doubtful origin, many people argue that swamps and other water resources ran dry after oil palm was planted next to them.

"As I heard from research one oil palm tree needs five litres water a day, that's why the water resources run dry now." (I18R1).

Furthermore, a few people argued that the soil in oil palm plantations became drier (cf. Chapter 6.1.3.3). In addition, the hot temperatures were related to oil palm plantations by several interviewees. Although these aspects of oil palm cultivation make some people assume that rubber cultivations are more environmental friendly than oil palm (e.g. because the soil is moist or there are more animals), few of them would change their oil palm plantations to rubber. During the second group discussion participants argued that rubber was much better for the water and the environment in general. Therefore, I asked them if, theoretically, they would change their oil palm plantations to rubber, if there was a fund from the government to cover conversion costs. But even with a fund they said they wouldn't really want to change. Or they would only start to plant rubber if they had additional land for this plantation. Only one farmer would change immediately as he showed to have a strong aversion against oil palm in general (I31).

A more detailed view on the positive and negative aspects of oil palm cultivation can be derived from Tab. 7 & 8: Positive and negative aspects of oil palm cultivation (p. 67). The statements were gathered from interviews when people themselves started to talk about oil palms as well as from the group discussion with oil palm farmers. At the beginning of each discussion farmers were asked to write down the most negative and the most positive fact related to oil palm cultivation that came to their mind.

While many people want to grow oil palms themselves and regard this as mainly positive, their attitude towards the oil palm plantations of PT Asiatic Persada appears to be quite

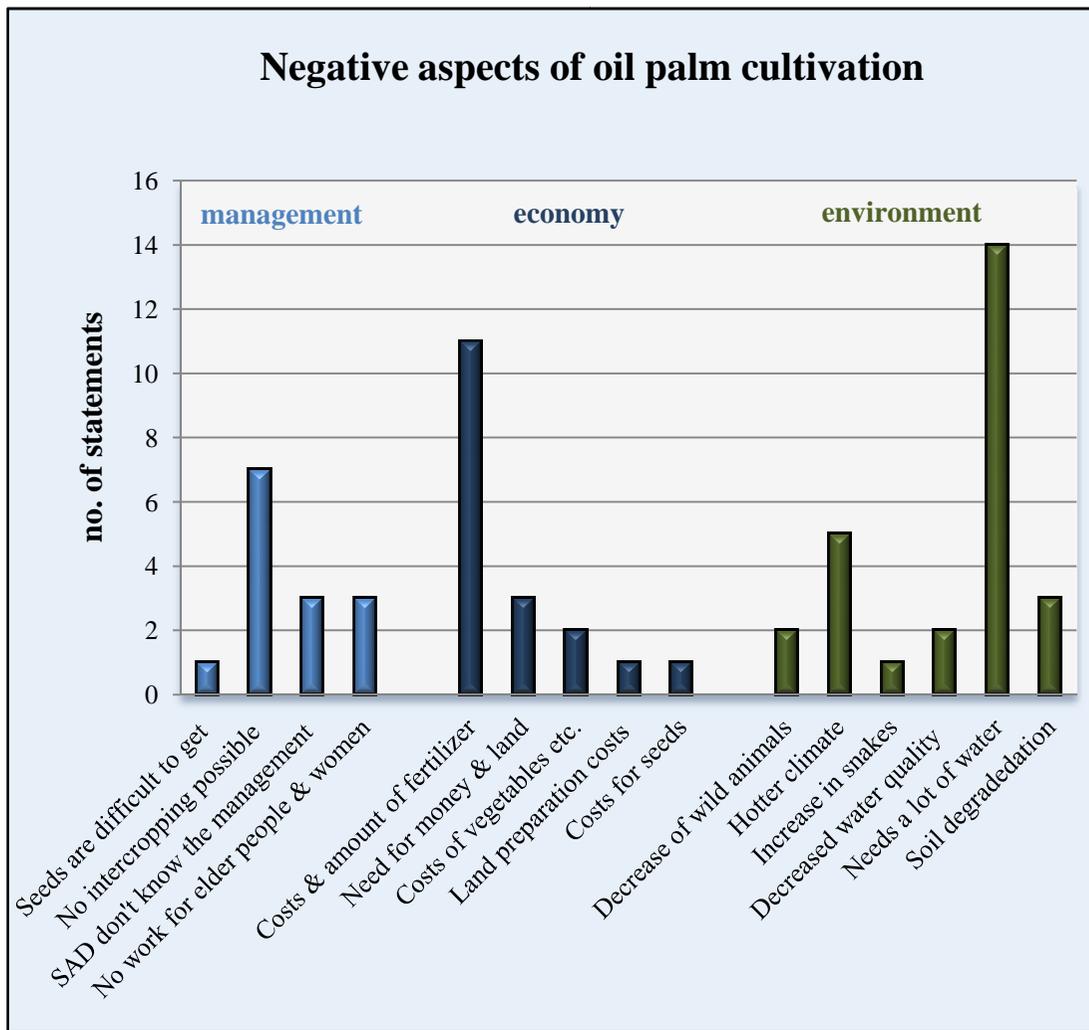
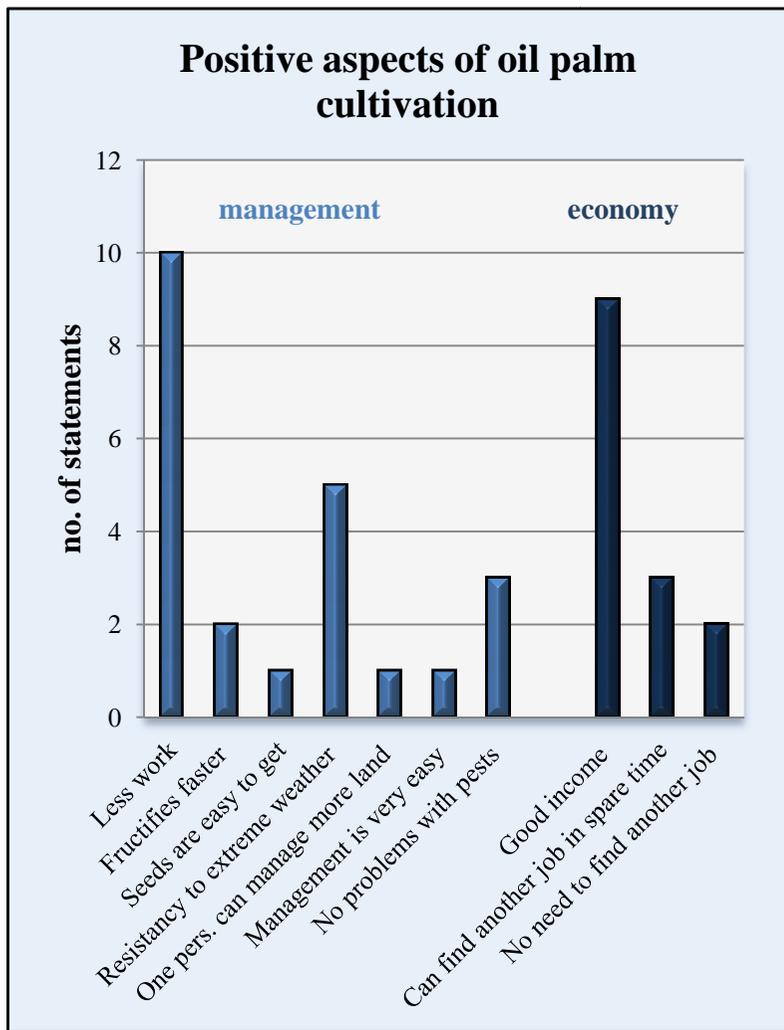
different. Especially in Bungku Indah, where hardly anybody works for the company, resentments against the company are deeply rooted. This is especially owed to the fact that there is almost no land left for the local people to develop (cf. Fig. 28, p. 43). Furthermore, the company's noncompliance with several environmental laws and standards, such as the maintenance of a buffer zone along the river, was believed to have caused environmental degradation. In Johor Baru the atmosphere among SAD people has become even tenser, as they are still fighting for their land rights.

"BDU [the former name of PT AP] took all the land, starting from the land that we already planted with fruits until the area for the graves. Even during colonialism they wouldn't have taken the land for the graves but the company took it all." (I28R1).

During the time of field research about 150 families were occupying land belonging to PT Asiatic (Fig. 36, p. 46) trying to claim back their ancestral land rights. As they were supported by several local NGOs and also by some left-wing politicians, the debate about the company was highly politicized. On the other hand, most migrants living in Johor Baru had worked on the company plantation prior to starting their own plantations. Thus, among these people the attitude towards PT Asiatic Persada was much more relaxed. Yet, they too complained about the lack of environmental management. While management apparently had been much better during the ownership of the company Cargill Inc., nowadays, people reported, it seems the company does take not care at all about the environment:

"When Asiatic was managed by Cargill (England) they didn't allow to plant oil palm 30 meter from the river and if there were some trees there they didn't allow the people to cut them. But since management changed, it's already different rule. [...] They cut everything." (I31).

Tab. 7 & 8: Positive and negative aspects of oil palm cultivation based on interview results



(Representation of own data)

6.2.2. "Since people have opened the forest and have planted oil palm the water in the river doesn't flow anymore" - assumptions for hydrological changes in Bungku

The explanatory statements made by villagers to argue the observed changes of local water resources are manifold and viewpoints sometimes differed significantly. For the sake of clarity, explanations given for changes in water quality and those given for water quantity are presented separately.

6.2.2.1. Reasons for changes in the water quality

As described earlier, most people in Bungku complained that the water quality of surface waters has degraded a lot and that they turned dark or yellow in color. The causes for these changes are mainly attributed to the behavior of the people themselves. The most frequent causes stated by the interviewees that allegedly contribute to the decreased quality were: the use of fish poison, the showering and washing in rivers and swamps, the dumping of waste in the environment and the lack of waste water management and sanitation facilities.

"If a lot of people shower at the swamp the quality decreases and the water becomes black and white things flow on top of it." (I24R1).

"If there is little water in the river we can see the rest of the soap, but if there is a lot of water we do not really see the changing quality." (I26R1).

Apart from these human causes natural processes are also blamed for a worsening water quality. For example, the change in the color of the water is often related to the fact that the rivers don't flow anymore. But additional factors, like resins, roots or leaves in the water are believed to change the color of the water.

"The water is getting red. Maybe because the water doesn't flow anymore or because of the resins of wood or roots." (I26R1).

In effect, only very few people blamed the development of oil palm plantations for influencing the water quality. While two interviewees just argued, that "all the dirty things from the plantation flow into the river" (I10), two others reasoned that the company is responsible for the high sediment contents in the river. These are caused by the company because they built channels to drain the swamps into the rivers and because they don't protect the riverbed with a buffer zone (I24R2, I28).

Direct reasons for a degradation of the groundwater were given by nobody. Only one person argued that in HKM area, the water was much cleaner than in the village itself because jungle

rubber is mostly grown there. While we never tried the well water in Bungku Indah, the water in HKM area, indeed looked very clean and tasted good. Both households interviewed in HKM said, that they never bought bottled water, but this might also just be due to the complicated transport from the village. De facto, while some people claimed they preferred to drink bottled water because of the taste, many people admitted that they bought bottled water only out of idleness. Well water has to be cooked before it can be drunk and the gas to cook it is expensive and sometimes difficult to get. One married couple even told us that they only bought bottled water because many people in Bungku do so and they just followed them (I18).

6.2.2.2. Reasons for changes in the water quantity

The water use of oil palms

With respect to the water quantity itself, the line of argument was a very different one. By far the foremost answers given to explain the decreased water quantity in surface waters and wells were that the forest is gone and that it was replaced by oil palm plantations. As explained before, many people in the village believe that oil palm needs a lot of water and that this causes water resources to run dry. While some people clearly admitted, that they had just heard other people arguing that oil palms need for example twenty-five liters water per day, others strongly supported this view. Some even explained it more precisely, by reporting that rubber needs less water or that it is better able to store water. The owner of our guest house in Johor Baru provides a good example for this group. He had built his well on the other side of the road which meant that the family had to pump the water to the house with long pipes. But on his side of the road, he argued, there was no water, because oil palms grew there. On the other side of the road, instead of oil palm, there were some wood and rubber trees. In Bungku Indah, by contrast, two interview partners argued that oil palm plantations are actually too far to impact the water there. Yet, both didn't have other explanations for a decreased water quantity (I35, I37).

That the debate about the impact of oil palms on water resources is not easy to understand became very apparent during the group discussions. With the first group "the management of oil palm plantations" should be discussed. After letting them write down the most positive and the most negative aspects of oil palm cultivations, it was further aimed to discuss "what is important for a good management of oil palm plantations?", "what are environmental impacts of oil palm plantations?" and lastly, "what can be done to decrease these impacts?". At the beginning, many of the oil palm farmers listed some environmental impacts on their

positive/negative-cards. These included, "oil palm needs a lot of water," or even, "oil palm is not environmental friendly". But later in the discussion when they were asked directly about environmental impacts, the group denied any negative impacts of oil palm plantations. Especially one farmer was very dominant during the discussion and influenced the others to argue similarly to him, claiming that there were no negative impacts. Rather, according to him, all negative changes observed in the environment were caused by other factors. The following statements present some excerpts of the discussion (Text box 1).

Text box 1

Group discussion with oil palm farmers in Bungku Indah (I20)

- I: What are the most important impacts of oil palms to the environment?
- R1: There are no impacts of oil palm. For me, of course it's hot in drought and in rainy season it will be cold, that's normal...Maybe there is an impact from to the air because the company uses fertilizer, pesticides and so on, but we don't feel the impact directly.
- I: But we already got some impacts on the cards here: "oil palm needs a lot of water" "swamps run dry", "less fish", "the weather got hot"...?
- R: And concerning the water: Until now there is still water here.
- R4: In Sungai Bahar [near town] where there is almost 100 % oil palm, there is still a lot of water.
- R2: While in Bungku, we have oil palm and rubber, but less water during drought.
- R1: Even when there was no oil palm in Bungku yet it was still difficult to find water in drought. And now if go to take water from the river, the water is already contaminated by toxins.
- In drought the streamflow of Sungai Bahar is getting less but it doesn't dry completely...
- I: But here it is written, that there are less fish in the river.
- R1: The fish are getting less, because many people use fish toxins. So even the small fish died because of the toxins.
- R4: The level of water infiltration is less in Bungku, if we dig a well only two or three meters deep then there is already batu cadas [black hard stone].
- Experience proves it, in 1997 there was a drought and people didn't plant oil palm yet.
- I: All agree that the water in Bungku is only little because of the black stone?
- All agree.*
- R2: In Johor they drill 40 to 50 meter but there is no water, even if they dig near the river.

R: If we have a well, after raining there is directly flooding but after three days the water is gone. So the soil structure is different in Bungku.

[...]

I: But two of you wrote: Negative impact of oil palm: oil palm needs a lot of water.

R5: The oil palm needs a lot of water but especially in Bungku the problem is not because of oil palm but because of the soil structure.

I: So what about the weather? You wrote: "It's getting hot"?

R5: Yes.

R2: In dry season of course it's hot but if we are sitting under the oil palm trees it's not hot. (*joking*)

R2: If we stand under oil palm and compare it to rubber, then the temperature is very hot under the oil palm trees.

[...]

I: Pak I., you also wrote down, that oil palm "is not environmental friendly". Can you explain what you mean by that?

R5: Maybe oil palm is not environmental friendly because in the forest there are many birds and other animals, but in oil palm plantations not. But in rubber plantations there are still many animals.

R1: Oil palm plantations are environmental friendly because there are many snakes. (*joking*)

R4: But there are still many animals in oil palm plantations, like snakes and ants etc...

R5: But only small animals, not like tigers.

R1: But the people also shoot the birds that's why the population of birds is getting less and less. Although the birds sure bring advantages for the ecosystem.

R5: *Agrees that bird trade is the reason why there are less birds*

R4: In oil palm plantations there is even a new kind of bird, the name is "perkutut".¹⁰

Since there are a lot of oil palms the population of monkey grows fast.

I: Is that positive or negative?

R4: For the environment that's positive.

In the second group discussion the line of arguments was completely reverse. This time the participants were told from the beginning, that we were interested in changes of the water cycle and directly started into this discussion. This time, all participants argued that oil palm had led to a decrease in water resources and that this was a very urgent problem in the village.

¹⁰ Perkutut = possibly zebra dove (*Geopelia striata*) (www.id.wikipedia.org, last access 24.02.2014)

They also noted that water only became a problem since "oil palms grew higher", which was also claimed during another interview with two SAD men. The assertion that water quantity decreased because oil palm needs a lot of water was supported by them by arguing that in rubber plantations they could find much more water than in oil palm plantations (Text box 2).

Text box 2

Group discussion with oil palm farmers in Johor Baru (I31)

R2: The negative thing about oil palm is that it's a plant that needs a lot of water. That's why if we plant oil palm near swamps after some time the swamp runs dry. Before there were many swamps here, but since there is oil palm they are dry, right?

R: Completely dry.

R: The water is gone.

[...]

I: You already mentioned that oil palm needs a lot of water, and the water is getting less. So how is the condition in the village right now?

R: Now in Johor Baru we can't find any swamps that are two to four meters deep. In the past that swamp [behind Pak M.'s house] was at least two meters deep.

I: When was that?

R: In the year 2000 and before that. Since the oil palm is there and especially after it grew higher and higher the water got less and less.

[...]

I: Are there many wells that are dry now?¹¹

R: Yes, dry. It depends on the soil.

R2: There is a well behind my house around 12 m to 14 m deep and it is already completely dry now.

[...]

R3: My well is also running dry now. It's near a swamp.

R2: He has two wells one is lying high and the other low. Which one is dry?

R3: The high one.

I: How deep is it?

R3: About 8 m deep. Now there is only little water left.

R2: But your well Pak A. and mine are not dry yet, right? And they are in rubber cultivations!

R4: It's good to plant trees near the well.

R5: But if we cut rubber, then the water is gone!

R4: My well, which is only 4 m deep is not dry because there are some trees around the well, and rubber also. If there are trees, there is still water. It's good to plant coconut palms, banana, bamboo or rubber. But if there is only oil palm, then there is no water.

¹¹ At that time it hadn't rained for three to four weeks.

Perhaps the farmers spoke more openly with each other during the second group discussion, as they seemed to know each other better, but that's not certain. Another explanation, for the different ways of reasoning is that oil palm is often blamed for being, "not environmental friendly". As oil palm farmers probably have been engaged in this discourse frequently, they tried to defend oil palms – their main source of income – against all accusations.

Other lines of arguments

Some greater congruence could be observed among the interview partners in relation to the "water-forest nexus". When there was still more forest, there was also more water, is the impression that most people reported on confidently.

"Before when people didn't open the forest yet it was better. The water starting getting less when people opened the forest" (I21R1) (*he moved to Bungku in 1999*).

While this is an observation narrated in at least ten interviews, most people could not explain this process further. Only a few added further information, for example, that the forest can keep the water (I21, I18) or that the soil is moister in areas with many trees (I40).

Another important line of argument was that water quantity decreased due to the physical intervention by companies. Apparently the company PT AP has covered big swamps while they drained others. Further, road construction is argued to be responsible for a decreasing number of rivers. According to two interviewees and to the group participating in the resource mapping activity, rivers stopped flowing because none or only inadequate channels were built when roads were constructed. An argument raised by fewer, nevertheless still mentioned by some people is, that there is a lack of water because of the soil structure in Bungku (cf. Text box 1). One man argued further that today, there are possibly just too many people taking water from the rivers. And the former village head claimed that people reported problems because they expected funds from the government. Although most certainly a lot of NGO work has been done in Bungku, this argument can be disproved at least partly. Often respondents started complaining about water shortage when we were just talking about environmental changes and the research topic "water supply" hadn't been mentioned yet.

The point in time when water shortage became a problem is argued similarly by most interviewees. This is due to the broad consensus regarding its relation to land use change. Most people again, name years between 1997 and 2005 (cf. Text box 2 or the quote at the beginning of this sub-section). While some argue that water had already become scarce around 1998-2000 (I4), others still remember swimming in the river in Bungku Indah around

1999 (I40). Only individual persons spoke of completely different time slots. For one interviewee in particular, everything bad started when PT Asiatic Persada started in 1986. Thus, he also argued that water resources had already changed a lot at that time (I4). Furthermore, during the resource mapping a number of individuals stated that the road construction for the logging industry had already caused small rivers to stop flowing. In accordance to this line of argument, the process must have already started in the 1970s. The fact that some people argue, that in 2003 there was still more water in Bungku (I24R1) or that some small rivers had only stopped flowing since the dry seasons of 2003-2005, might indicate that the decreasing water quantity is a very recent problem which still appears to intensify.

To sum it up, most of these arguments for degraded water resources are directly or indirectly related to the land use change. The following diagram (Fig. 47) shall depict the various causes named. The bolder the frame of a factor, the more often it was named. Impacts with white background were not confirmed by all interview partners.

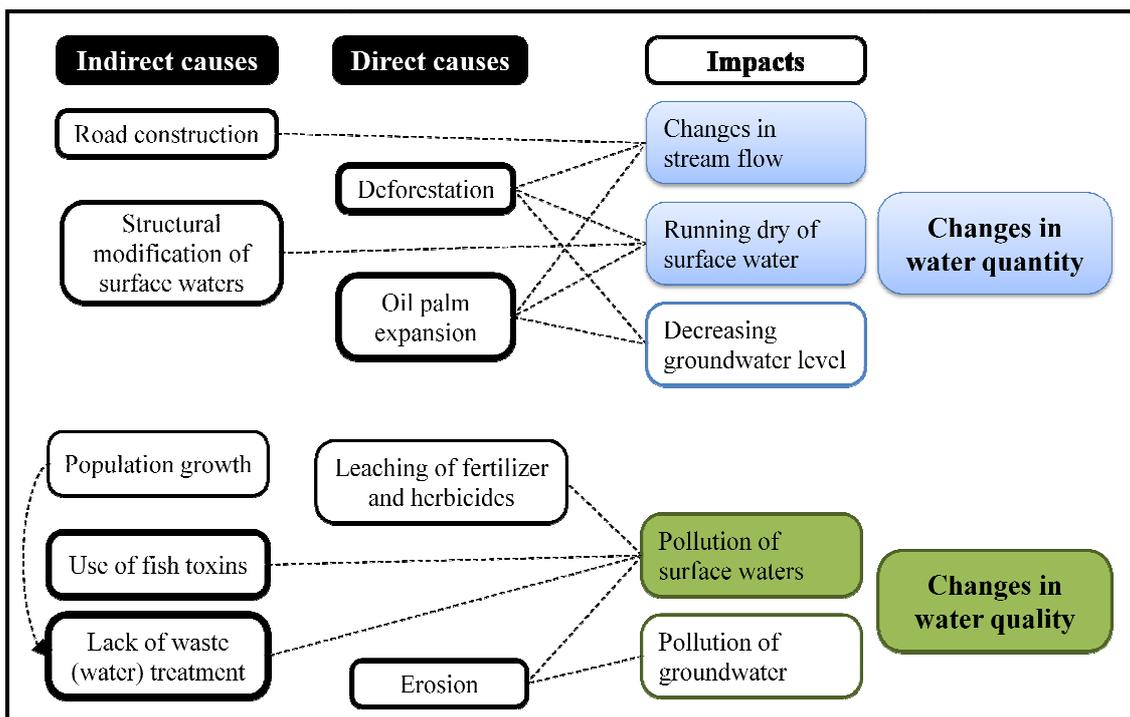


Fig. 47: Direct and indirect consequences of land use change and their impacts on local water resources (own representation)

6.2.3. "Everything depends on agricultural practices" - evaluations of hydrological changes by different stakeholders

The reasons for hydrological changes given by the different stakeholders interviewed correspond with village perspectives regarding the role of deforestation. Although argued distinctively, hydrological impacts of oil palm cultivation have further been confirmed. While villagers mainly blame high water use rates to have contributed to decreasing streamflows and groundwater levels, regional and national stakeholders rather consider agricultural management practices to be key determinants of hydrological impacts. Yet, evaluations and lines of arguments by single institutions showed significant discrepancies which are pointed out in the following.

In total, four representatives of three **NGOs** were interviewed: Sawit Watch in Bogor and Setara Jambi both aim at supporting local communities that have lost forest or livelihoods due to oil palm expansion. WARSI Jambi is an organizational network and serves as a clearing house of conservation related information (WARSI n.d.).



Fig. 48: Roots of the oil palm tree
(own picture)

The representative of **Sawit Watch** reported that oil palm plantations caused several hydrological problems. Pesticides, herbicides and fertilizer from the plantations flow into the rivers and pollute the water. Inappropriate waste management of the companies, such as overflowing sewage ponds, further contributes to a degradation of water quality. Impacts of oil palm plantations the local water quantity, according to our interview partner, can be observed all over Sumatra. Especially if peat soils are drained, the water table lowers significantly. Sometimes people may therefore even have to dig wells as deep as 50 m, he argued. Apart from the construction of drainage systems, deforestation activities near natural springs lead to decreased infiltration capacities and thus contribute to increasing water shortages. Furthermore, he blamed the oil palm roots for causing water scarcity. These roots, "akar serabut" (\approx fibrous roots) (Fig. 48), according to him, take up all the water from the soil during dry season. On the contrary, during rainy season they cannot absorb the water and thus impede water from infiltrating into the soil. Another consequence caused by these processes is an increase in flooding which occurs much faster and more often in areas of oil palm

cultivation. Although all these problems appear much faster on peatlands, the representative of Sawit Watch is convinced that they will be the same for lowland forests in the long run.

The arguments presented by the director of **Setara Jambi**, who has formerly worked for Sawit Watch, are quite similar. Water, according to her has become a severe problem in Jambi: "In the dry season the small rivers will dry and in the raining season the rivers will flood. This is the problem." As the forest has been cleared and rubber plantations have been converted into oil palm cultivations a lack of water has arisen. This, according to her, especially affects paddy farmers who cannot continue their cultivations under these conditions. Pests, like pigs and monkeys, have further become a problem for farmers not growing oil palms. As a result, many of them take the "worst choice" and start to plant oil palm, too. The reason given for the decreased availability of water was almost the same: The roots cannot save the water.

"If in the rainy season the water never goes inside the topsoil, the water will be gone. Because the oil palm never wants to save, but the trees [forest], they will save it. And then, why even the dry season, if we enter to the forest the topsoil is always wet? Because the trees will save water for themselves, but the oil palm will never do that." (EI4).

As the water just runs off on the soil surface this in effect causes soil erosion. In her reasoning, the roots of the oil palm therefore literally destroy the topsoil. Another problem adding to this condition is the application of chemical fertilizers. As the use of organic fertilizer helps to turn the soil color darker again and to increase faunal activity, Setara Jambi tries to promote the use of it among farmers. A severe challenge, she mentioned is, that smallholders do not know much about good agricultural practices. This is among others caused by the fact that graduate students always prefer to work for companies rather than to return to their home villages. Furthermore, smallholders don't have the capital to restore degraded soils. On the other side, local smallholders have traditional knowledge to manage the land, as they depend on the long term productivity of this important resource.

According to the representatives of **WARSI**, the rapid deforestation trends of the last decades have had severe impacts on the water resources in Jambi. On one side, flooding has increased a great deal as the water flows directly into the river. Erosion has further caused high sedimentation loads in the most important river in Jambi, the Batanghari. Plans to develop an international port in Jambi apparently could not be realized because of the high amounts of sediments in the river. On the other side, deforestation has led to less water during dry season:

"The problems of deforestation are two: If it rains, it directly causes flooding and during dry season it becomes dry. This is why the provision of water to the households in Jambi already decreased a lot. Because the PDAM Jambi [regional drinking water provider] also already lack of water. Because they get their water from Batanghari River." (EI3R2).

The most important problem for the water supply in Jambi, according to them, is the access to clean water. The woman described the situation as follows: If a person digs a well in Jambi city and it's only three to five meters deep then he will lack water during dry season. But if he digs deeper, then there is mineral oil in the water. In rural areas there are a number of other problems threatening the water supply. They are caused by people using the river for every purpose from showering, washing and drinking to defecating. As in most villages people don't have wells, they also drink the water from the rivers which is very dirty in consequence. Especially after strong rainfalls, the water gets extremely muddy. Another problem, they added, is the pollution of rivers with mercury by the gold mining industry.

Another expert interview was conducted with a governmental representative of "**BPDAS Batanghari**" (Balai Pengelolaaan Daerah Aliran Sungai ≈ Center for watershed management). He acknowledged the existence of many problems in the Batanghari watershed. The forest conversion to plantations and the resulting erosion and sedimentation of the rivers constituted for him, the most urgent problem. While in the past the Batanghari River was used by big cargo ships, today it has become too shallow because of the high sediment loads. This has led to great economic as well as ecological impacts, such as a decrease in fish and shrimp populations. While in the past big floods only occurred every five or ten years, today, according to him, the intervals have become shorter, now reoccurring every three to five years. Yet, he admitted, he didn't know of any other conditions because, ever since he moved to Jambi ten years ago, it has always been like that. He was also told by natives of Jambi that about twenty years ago, people could still drink the water from Batanghari River. But today, he said, he cannot even eat the fish from the river any longer, because, "the ones living deep in the water are poisoned by mercury and the ones in the upper part by garbage and waste water." (EI5). The causes for these problems lie in the wrong policy and the lack of law enforcement. According to him, all kinds of institutions are responsible for this:

"After the reformation era the people thought that they had the freedom to take any land, even in the conservation areas like in the Merangin district. Today there are 20,000 households that stay inside the state forest there." (EI5).

The oil palm per se is in his opinion, is not responsible for the lack of water. Rather, the large-scale monocultures of oil palms represent the problem. According to him, all monocultures need a lot of water and "if there is a large uncontrolled plantation then people will have the problem that the water is getting less." (EI5). In addition, he stressed that soil degradation constitutes a problem in many oil palm plantations. The use of inorganic fertilizer, for example, changes the soil structure and leads to a decrease in soil nutrition over time.

The second government official that was interviewed worked in the conservation section of the **DINAS Perkebunan** (the plantation department). When the interview partner was asked about the impact of oil palm plantations on the water resources, he admitted that people argued that oil palm needed a lot of water. That's why, according to his information, at the time of research, DINAS Perkebunan was conducting an experiment on an oil palm plantation that had to be replanted. On this plantation oil palm were tried to intercrop with peanuts and vegetables. And providing that the crops were growing well, after twenty-five years of oil palm plantation, he concluded that there was no water problem caused by oil palm cultivation. As a student at the agricultural faculty, he added, he was also taught that there was no water problem because of oil palm. When we asked him about water scarcity in Bungku, he just argued that he had been to Bungku in 1986, and that already then it had been difficult to get water there. Therefore, he recommended we should rather go to other villages, where there was still a lot of water. When we added that people in Bungku recounted that water amounts had been reduced since there was oil palm, he only answered,

"People complain about water while they got a lot of money from oil palm and when the price of palm oil falls they also complain." (EI7).

Later he stated that in his opinion, water access was becoming difficult not because of oil palm but rather because of deforestation. While people should have kept the forest in the upstream area intact, they had cut it all. And as the forest is gone, he continued, the water absorption of the soil has decreased. After we asked him if there was any manner in which the roots of the oil palm could contribute to a lower absorption of the water, he argued:

"I would say, don't always blame the oil palm. From what I have seen the social benefits are much bigger than what these people say. Now the people are much better off. Now they have like 10 ha oil palm. [...] They can already take care of their families." (EI7).

In any event, at the end of the interview he confessed that PT Asiatic Persada is a "crazy company". The management of the plantation hadn't been good from the beginning.

The only representative of an **oil palm company** around Bungku that agreed to be interviewed had a similar view on the issue. When introducing the research topic to him, he immediately started to talk about the drought in 1997.

"[...] I moved here in 1997 and there was a really strong drought here. Even before oil palm, there were already droughts in Bungku. If I noticed an impact of oil palm to the water then it's not really strong. And so far we are still able to get water if we dig a well. And the rivers here also didn't run dry, only the stream flow is low but they still flow." (EI6).

And when he was asked about the environmental impacts of oil palms he just argued that for him the positive impact of the oil palm development was bigger than the negative impact.

"Of course every company has positive and negative impacts but as far as I observed, especially the economic situation of the people here has improved a lot since they plant oil palms five years ago. [...] And later the better economic situation of the people will impact the level of education of their children." (EI6).

Regarding the alleged high water use rates of oil palms he brought forward the argument that as far as he knows, something should only be declared as a fact, if there has been research for about 30 years. But in Indonesia oil palm cultivation is still very young. Thus, there is no proof yet of how much water an oil palm actually needs. Further he added:

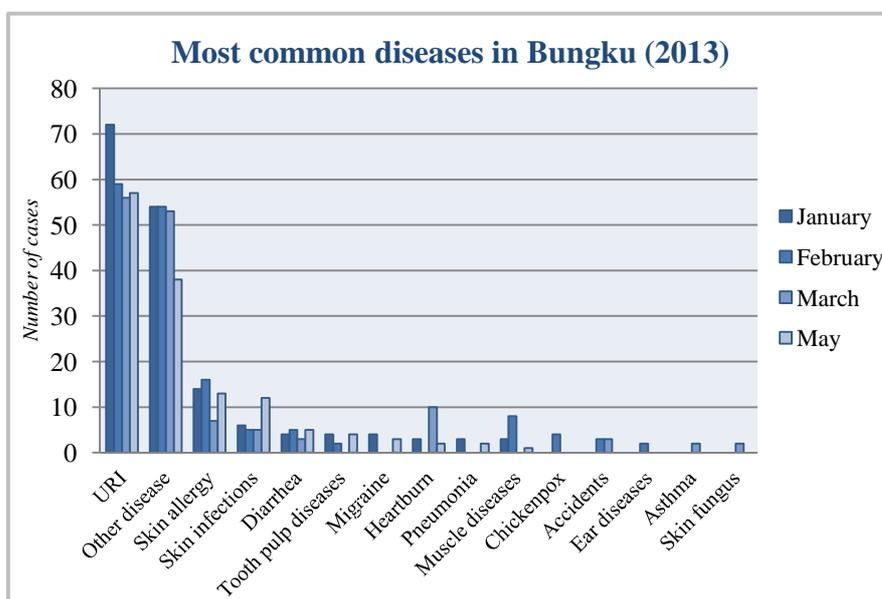
"There is the issue that it's hot and there is flooding because of oil palm, but in Jakarta there is no oil palm but it's also hot and there is flooding." (EI6).

Later in the interview he claimed that if there was a water problem at all then it is caused by the roots of oil palms. "[...] it seems like they cannot keep the water. So when the rain comes the water just runs off and doesn't infiltrate the soil." Therefore according to him, it is better to let some grass grow between the oil palms. If people use herbicides then this will expose the bare ground and the water availability might be impacted.

Both workers from the **community health center** that were interviewed independently of each other were more concerned about water quality in Bungku than the water quantity. The runoff of waste water, the use of fish toxins and the dumping of waste in the environment or around the house contributed in their eyes significantly to water pollution. Especially during dry season, when many people took a shower in rivers and swamps, the water quality worsened considerably. By contrast, the quality of the groundwater was evaluated to be rather good by both of them. Only during a strong drought did the water no longer seem clean. But as people were now able to buy bottled water in Bungku, it was theoretically no longer a problem for them to access clean water. The most common disease in Bungku is URI (upper

respiratory tract infection), followed by diarrhea and skin diseases. According to the nurse working in the health center the diseases occur in accordance with the seasons. Diarrhea for example, occurs mostly from August onwards, the time when the rainy season begins. Especially after longer periods without rain diarrhea occurs frequently because contagious bacteria have spread. On the other hand, skin diseases occur mainly during dry season. The nurse argued that skin allergies could be caused by a lack of hygiene, but also because people go to the river to take a shower there. The midwife working at the center put even more emphasis on the role of dirty swamps and rivers in regard to the occurrence of skin diseases. Therefore, she recommended that people who go there use antiseptic soap. Most people that came to the health center because of skin allergy were apparently from Johor Baru. Among them were also many people working for PT Asiatic Persada or people living inside the oil palm plantation. However, when both women were asked if these conditions were due to the application of pesticides, they clearly stated that they were not able to confirm this. In Bungku Indah there are also cases of skin allergy, but apparently much less than in Johor Baru. Unfortunately the community health center had very few statistics about cases of diseases. The few statistics found are represented in Tab. 9.

Tab. 9: Most common diseases in Bungku in certain months of 2013



(Own representation based on data of the local community health center)

Another interview partner at the national level was a **professor for forest hydrology** at the Agricultural University in Bogor (IPB). He and his research associates had also found several problems concerning the water supply in Bungku while conducting research in the area. A PhD student had also been to Bungku and reported that people had complained about

increasing difficulties to find water during dry season and about a decreasing water quality due to high sediment loads. According to the student this was caused by surface runoff that fills up the wells during dry season. The professor explained that hydrological impacts of oil palm plantations were mainly caused by the missing consideration for water and soil conservation. Although he had no research results as of yet, he thought that the strongest impact to the hydrological cycle was caused during the preparation of oil palm plantations in the first five to six years. After the canopy has closed, he expected hydrology to be similar to that of other forests. However, the missing groundcover constitutes a large problem. The water use by oil palm does not represent a problem according to him, as he expected it to be similar to other tree crops like coconut or rubber. The real problem instead, seemed to be the runoff. For this reason he argued, that if a farmer or a company complied with certain environmental management criteria, as for example, they are defined by the Roundtable on Sustainable Palm Oil (RSPO), these oil palm plantations are free of environmental problems. While in his view, big companies generally complied with certain environmental standards, like protecting riparian areas or planting leguminous cover crops, in smallholder plantations these conservation measures were rarely taken.

6.3. Livelihood impacts of the degradation of water resources

This chapter analyses the livelihood impacts resulting from drying surface waters and increasing water pollution. Therefore, it is first of all necessary to give a detailed insight into the local water supply system in Bungku. As wells often run dry during dry season, the water supply during these months is represented separately. Thereafter, the consequences of altered water balance components for the village water supply are discussed and important determinants of livelihood impacts at household level are identified.

6.3.1. Water supply and sanitation in Bungku

There was no public water provision in Bungku. Most households had their own wells, which were on average three to eight meters deep. As pedological conditions vary within small distances it is not possible to dig as deep as eight meters everywhere. Some households even could not dig any well at all in the near surrounding of their houses. Depending on the wealth of the household, wells are secured with cement, wood (mostly Borneo Ironwood) or only bare soil (cf. Fig. 49-52). A couple of households also had an electric pump to pump the water directly into the house. Some people claimed that about three households in Bungku even had a drilled well which was up to 40 m deep. But we couldn't confirm this claim. While most

households used their wellwater for showering and washing, some people nevertheless still used water from rivers or swamps for personal hygiene. Those people who didn't have an own well used those of neighbors or also used water from swamps and rivers. Rainwater collection was practiced by most households in Bungku.



Fig. 49, 50, 51, 52: Different households and their wells (own pictures)

Bottled water was introduced in Bungku in 2009. Most people started to buy this immediately (in 2009/2010) and today the vast majority of the residents prefer to drink bottled water rather than water from their wells. Although the quality of water is apparently still potable, many people seemed to prefer not having to cook the water before drinking it or they simply preferred the taste of bottled water (cf. also chapter 6.1.2.1). There were only very few people that actually

could not afford to buy drinking water. Bottled water was used mostly for drinking as well as for cooking. One 5-gallon bottle was being sold at a price of 6000 IDR ($\approx 0.46 \text{ €}$)¹² at numerous kiosks along the main road. The water sold in Bungku was refilled into manually cleaned bottles at the water depot (Fig. 53-55). Therefore, some people considered it to be unhygienic to some degree. Yet, almost no one made the effort to cook the water at home any longer. Sealed 5-gallon bottles (coll. "air arthess") could only be bought in Muara Bulian at a price of 14000 IDR. During the time of our field research we only interviewed three households which bought sealed bottles for drinking. The amount of bottled water being consumed by the families per week depended on various factors and even varied a great deal among the families with the same household sizes using bottled water for the same purposes. Thus, the weekly consumption per household can only be estimated very roughly at two to seven gallons (= 12,000 to 42,000 IDR/week or 48,000 to 168,000 IDR/month¹³).

¹² <http://www.finanzen.net/waehrungsrechner/>; at the time of research the currency rate was about 13,000 IDR/€ (June 10th, 2013). At the time of writing (February 15th, 2014) the rate had risen to about 16,000 IDR/€).

¹³ This equaled monthly costs of 3.70 € to 12.90€ at the time of research.



Fig. 53, 54 & 55: Refilling and cleaning of 5-gallon water bottles at the water depot in Meker Jaya (own pictures)

Waste water management also depended on the wealth of the households or the importance they attached to it. Several richer households had a septic tank for their toilet waste water which was secured with wood or cement. Others didn't have any septic tank at all and just let the waste water flow into the environment. While most people with permanent houses did have a toilet, those who didn't only made a hole in their garden or went to the river. The village secretary estimated that 25 % the population of Bungku didn't have a toilet at the time of research (I19).

Garbage was generally burned next to the houses. However, many households often just throw their garbage into the environment around them and burn it every once in a while when they sweep the surroundings around their house. Thus, plastic waste could be found anywhere (Fig. 56, Fig. 57).



Fig. 56: Garbage accumulation behind the house (own picture)



Fig. 57: Goats searching for food in dumped garbage (own picture)

6.3.1.1. Water supply during dry season¹⁴

Water scarcity is a severe problem in Bungku during dry season. As already described in chapter 6.1.2, depending on the length and severity of the dry season some wells run dry or provide only very little water. When wells ran dry, people had to search for other water resources, such as surface water bodies or other wells. In Bungku Indah most people tended to go to the river Sungai Bahar, which is located about six kilometers from the sub-district's center. Nowadays, most people go there by motorbike and bring canisters with them to be



Fig. 58: Public bathing place in Meker Jaya (own picture)

able to transport the water back to their houses, repeating this task sometimes twice a day. If people wanted to wash their clothes they also brought them to the river. In the past, when people didn't yet own motorbikes, the villagers had to walk all the way or take a bicycle. One elderly local woman recounted that sometimes they had to stay at Sungai Bahar for the entire day or even stayed there overnight.

For a couple of years now, many people have preferred to go to Meker Jaya (cf. Fig. 28, p. 43) instead of Sungai Bahar as in Meker Jaya there are several very productive springs next to the water depot. In addition, a public bathing place was constructed next to the springs six years ago. This bath is accessible from the main village road by foot or motorbike. The walk along the cemented path takes only about five minutes. A woman living next to the bathing place claimed that more and more people from Bungku have come in the last two years. Maybe, she reasoned, this was due to the fact that the path had been paved two years ago or because more people owned a motorbike now. Normally, according to her, people started to come after about a month without rain.

Another group of people from Bungku just took their water from nearby swamps as they didn't have to drive so far to obtain any. Others tried to find water in their neighbors' wells in the village. While one could argue, that these families are probably poorer or do not own a motorbike this was not always the case. Even a man possessing a car claimed that he preferred to search for water in the village instead of driving far to Sungai Bahar. The contrary was stated by a man living in Jambi city. He owned an oil palm plantation in Bungku and

¹⁴ With the term "dry season" I refer to a prolonged period without rain that causes many wells to run dry (minimum about four weeks without rain).

normally stayed there for about two weeks in a row. But if his well ran dry he only stayed there for one or two days before returning to Jambi to take a shower and wash his clothes. A small number of families in Bungku Indah actually had a well that provided them with enough water even during longer dry seasons. As their wells were so abundant other households often used them as well. Nevertheless, during dry season, even good wells often didn't provide enough water for several households, thus forcing the neighbors to search for water somewhere else. Despite this hardship, according to the interviewees, this didn't constitute a problem as it was understood by the neighbors that there was only enough water for one family (i.a. I23, I37). Water from the wells was still used by about half of the interviewees for cooking or drinking. However, if wells ran dry or water became scarce and dirty during dry season, almost all households resorted to buying bottled drinking water. According to the kiosk owners, they sold about the double amount of water during dry season as in the rest of the year.

Thus, the search for potable water strongly governed the daily lives of villagers during longer dry seasons. While many families claimed that they still had enough water for their daily uses, others admitted that they tried to save water during these times. For instance, they only showered once a day instead of twice or used less water for washing. As even one of the richest families in Bungku Indah admitted having to save water during prolonged dry seasons, many more families might face the same situation than have actually admitted this. Households which didn't own a motorbike were clearly at a disadvantage due to the considerable distance to Sungai Bahar and Meker Jaya. On the other hand, families who owned a car often reported taking neighbors or older relatives with them when they went to collect water or bringing water to their houses.

In Johor Baru the situation was different. As the river Sungai Bahar flows through the village center, most people just went there for showering and washing and bought bottled water only for drinking and cooking. As there are also some further smaller rivers, many people simply took water from these instead of from Sungai Bahar.

An official village document (Desa Bungku 2010), also recognized several problems regarding the water supply. The "difficult access to clean water" was reported in a list of "challenges and potentials", for all village sub-districts. In Bungku Indah this problem was given the highest priority in the list of challenges. In Johor Baru it was ranked as the third most important challenge. The "difficulty to access bottled water" ranked sixth in Bungku Indah and seventh in Johor Baru as there was no water depot (refilling station) in both sub-

districts. Further problems related to the water supply and sanitation were named as follows: "garbage is scattered everywhere", "the people urinate and defecate anywhere" and "many mosquitoes during dry season because of the lack of health facilities". The causes for scattered garbage and open defecation are attributed to the lack of environmental consciousness as well as the lack of sanitary facilities in the village. However, the problem of access to clean water is explained by the topographic location of Bungku "lokasi tanah berbukit" (hilly landscape). In the next few years (2013 to 2017) the establishment of 45 drilled wells and three water depots is planned in the area of Bungku (Desa Bungku 2010).

6.3.2. Restrictions of water supply by increasing water pollution and water shortages

As described in chapter 6.1.2 on the perceptions of hydrological changes in Bungku, several important developments can be recorded. A decreasing quantity of streams flowing during the dry season as well as the drying of swamp areas and an increasing degradation in the water quality of surface waters have all been observed by the great majority of the villagers. A decreasing quantity of groundwater during the dry season has also been observed by many people. Yet, as several people reported that some wells ran dry in the past, too, it remains questionable how severe these changes have been. The same applies to the observation concerning degrading groundwater quality. There seems to be a consensus that sediment loads in the wells clearly represents a problem and that the water quality decreased in correlation to decreasing water quantity in the dry season. A general trend to decreasing groundwater quality remains debatable. In any event, some important facts on how recent land use change and village development have impacted the local water supply can be summarized.

For whatever reason that wells are running dry or well water has become too dirty to use, people have had to access other resources for their daily water consumption. As most of them go to Sungai Bahar or other nearby swamps and rivers, the quality of these waters can be expected to decrease further. Especially if streamflow has decreased significantly or the extent of the swamps decreases, the quality may then reach alarming levels. This was also affirmed by an interview partner:

"If there is little water in the river it seems there is a change in water quality. We can even see the rest of soap in the river. But if there is much water we do not really see a change of the water quality." (I26R1).



Fig. 59: Small river that stopped flowing during dry season (own picture)



Fig. 60: Small river that is being used for washing, showering and toilet by a poor household in Bungku Indah (own picture)

As discussed in chapter 6.2.2.1, the pollution of surface waters is further increased by a lack of waste and waste water treatment, a lack of sanitary facilities and the use of agricultural inputs (Fig. 60). Due to several cases of skin allergy and general concerns about water quality some households nowadays prefer to use bottled drinking water for nearly their entire daily uses during dry season.

"But sometimes I bought bottled. To shower my child. Because if the water is very turbid, I am afraid that her skin is very sensitive." (I37R1).

The nurse from the community health center also told us that if her well in Johor Baru ran dry they sometimes had to use ten 5-gallon bottles per day, as she used the water to shower her four children as well. But sometimes she also collected water with a big barrel from a river inside PT AP plantation whose quality apparently is still good.

Further options to obtain clean water are: buying a water tank that is brought by a truck (\approx 500,000 IDR for 3000 liters) or buying 1000-liter-barrels of water near the water depot in Meker Jaya at the price of 50,000 IDR. However, only very few families can actually afford to spend that much money on water or have the storing and transportation facilities for such amounts of water. Therefore, these possibilities only seem to be used in cases of bigger social events or by the very rich families of the village. One interviewee recounted that when there was a wedding several years ago, the whole village had tried to store the water together (I4). On an everyday basis, most people just use any water they can find in the village for their daily uses.

R1: [...] and then [in drought] people from over there come to the swamp behind Ibu S.'s house. That swamp never runs dry.

I: But the water is dirty?

R1: Right. The water is dirty but we don't have any choice, we have to go somewhere. So about three to five meters from the swamp we make a well.

(I26).

Thus, the key changes in the water supply in Bungku are the permanent degradation of surface waters and the increasing pressure on the people to access safer water resources such as far springs or bottled drinking water. While in the past wells might have run dry as well, there were plenty of other water bodies that people could access. But today, if wells run dry, an increasing number of people try to search for other, in effect diminishing water resources (Fig. 59, p. 87).

- I: Where did you get water during dry seasons before 2012?
 R1: Before 2012, during drought we tried to dig a new well near the swamps and it was easy to find water. In the past it was easy to find water in drought.
 [...]
 I: Do you remember when your wells ran dry the first time? Were they already dry in 1999?
 R1: Since 2012. In 1997 even if the well ran dry, we could still make a well near the small river.

(I40).

The following diagram (Fig. 61) summarizes the main outcomes of alterations in local water resources. The running dry of wells forces people to opt for different ways to access water. Yet, most of these options lead to a further pollution of surface waters which in turn reduces the suitability of these water bodies for hygienic purposes.

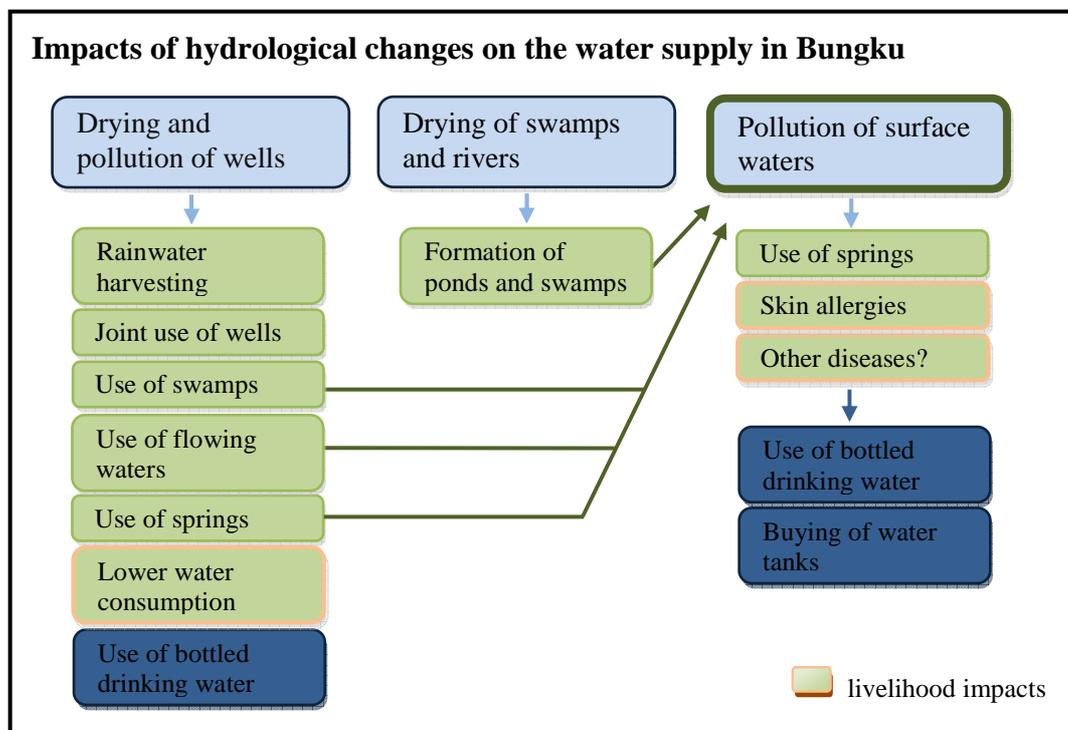


Fig. 61: Impacts of hydrological changes on the water supply in Bungku (own representation)

6.3.3. Money, vehicles and social bonds as determinants for livelihood impacts caused by increasing water shortages

As Fig. 61 shows clearly, there are basically two developments that impact the livelihoods of the local people: the increasing scarcity of water resources and the deteriorating pollution of surface waters. Thus, people can only access clean water by driving to the spring in Meker Jaya or by buying bottled drinking water. Both options are expensive or require existing capital like a car or a water barrel. The other choice is to continue using water which is of questionable quality. While most villagers of Bungku clearly have no problems in buying bottled water for drinking and cooking, the use of bottled water for all daily purposes would increase costs significantly. As described above, a woman told us that her family sometimes uses up to ten 5-gallon bottles of water for all daily purposes including showering. The same amount of water was consumed by a single man who owned a street restaurant (*warung*) in Johor Baru, as he even used bottled water for washing dishes and other purposes. Thus both households have costs of a minimum 1.5 million IDR per month just for the purchase of water (this roughly equaled 115.40€ at the time of research).¹⁵

While these two households proactively used drinking water as a precaution, those that already suffered from skin allergies did not have a choice. As was the case with one woman we met in Johor Baru. Ever since the small river behind her house had stopped flowing during dry season, she had developed problems with a skin allergy whenever she washed herself in the river. In the community health center she was given the recommendation to use bottled water when taking a shower. Thus, she had to use two 5-gallon bottles per day just to shower (I27R2, this equals costs of about 360,000 IDR (\approx 27.70€) for taking regular showers). Furthermore, although the average villager is relatively rich, there were a few poor households that could not afford to buy bottled water, not even for drinking.¹⁶ One woman told me that if she could not afford bottled water for drinking she cooked rainwater instead. But if there was no longer any rainwater she had to drink the water from the river (I15). The

¹⁵ It has to be kept in mind that the average monthly income of 2 ha oil palm plantation is about 2 million IDR. For 2 ha rubber a typical monthly income lies within the range of 5 to 6 million IDR. Yet, as rubber has to be harvested more frequently, one person can only take care of about 2 ha rubber plantation. Cultivating oil palm, one farmer can roughly take care of up to 10 ha land. Most people interviewed owned about three to four hectare land. While people owning only two to three hectare land normally owned rubber or oil palm, people holding more than three hectare land, normally cultivated both rubber and oil palm or only oil palm. Thus, average household incomes from farming activities (not including additional incomes from other jobs like kiosks) probably ranged from three to seven million IDR.

¹⁶ While the richest household interviewed had an income of about 12.5 million IDR/month from farming activities (10 ha oil palm plantation), the poorest household one only earned about 770,000 IDR/month from a very young 2 ha rubber cultivation which was actually not suitable for tapping at the time of research.

same applied to collecting water at distant rivers. While most households owned a motorbike which was used to obtain water, they could only carry small canisters and probably had to repeat the trip several times a day. On the other hand, a richer family that was interviewed reported that they went to Meker Jaya by car taking a huge water barrel with them which cost 1.2 million IDR and had a volume of at least 1000 liter. In order to fill this water barrel at the roadside they also brought their water pump and diesel generator to pump the water from the distant spring. This definitely was an effort only affordable by a few selected households. As many houses in Bungku are spread far apart, not all households can easily access clean water as bottled drinking water is only sold along the main road. On the other hand, the few households that were interviewed further removed from the center, reported having significantly fewer water problems.

In Bungku Indah it appeared to be natural that people helped their poorer neighbors to get water. Yet, people without motorbikes or good wells increasingly depended on the goodwill of their neighbors. While most comments suggested strong social bonds in the community, other remarks seemed less positive. Especially in narrations about the extreme drought of 1997, it became clear that people had really struggled to find water. One woman, for example, recounted that while many swamps ran dry in 1997, her family still had some water left in their well. But, in order to prevent other people from coming and taking the water from the well they always locked it with a key (I16). Another woman explained that during the same drought she often went to the well at 3 am in the morning. Because, the well they used at that time was a communal one and whoever came first, was served first (I18R2).

As during the time of field research there was virtually no lack of water in Bungku, the real extent of the impacts on livelihoods couldn't be grasped completely. This was reinforced by the fact that many people gave the impression they preferred not to talk about personal problems. Furthermore, to talk about conflicts within the neighborhood certainly would have required a much deeper level of trust and intimacy than two researchers from outside could have gained within these few weeks. As in the examples shown above, severe water scarcity can indeed lead to a struggle for water among villagers. A further aggravation of the problem by ongoing high migration flows to Bungku or environmental changes like climate change or the next strong El Niño events could impose major challenges to the social cohesion in the village. This might be even more applicable for Johor Baru, where there seems to be a deep distrust between SAD people and those villagers working for PT Asiatic Persada.

6.4. Review and outlook: Responsibilities and possible solutions

After the evaluation of livelihood impacts by increasing water scarcity, this section displays adequate measures to be taken to improve local water supply as assumed and presented by villagers and different stakeholders.

6.4.1. "There should be forest again" – village perspectives on future land use developments

The most common answers to the question, "What should be done to solve the water problems in the village?" were "reforestation" or "plant trees again". At the same time people commented rather desperately, that there was no area left for reforestation. That's the reason why the government is often blamed for the existing water problems, because politicians issued the land use permits and established the TaHuRa forest reserve. Some people therefore even argued that oil palm should be destroyed or the concession of PT AP should be taken away to reforest the area. Another solution to the problems, as stated by many, was the idea of planting rubber instead of oil palm. Even the introduction of a HGU (Hak Guna Usaha), a land use concession for rubber, was proposed by some people including SAD people. Several interview partners also suggested planting other new trees, apart from rubber, that are "good to keep the water". Suggestions included the planting of banana, bamboo, cocoa, Borneo ironwood or ficus trees. While the idea of replacing oil palm with other crops, or the replanting of trees was forwarded by the great majority of the interview partners, only a couple of people proposed technical solutions to improve the water supply in the village. These included ideas like digging wells deeper, opening a water depot in Bungku or building a dam to store water. Other suggestions referring more to the political environment were: an educational program to increase environmental awareness in order to reduce the garbage problem in the village or strengthening the control of TaHuRa land by stricter monitoring by the forest police.

Regarding the management of oil palm plantations, few people saw real potential there to improve the water situation. They perceived that some improvement could come from: protecting the area near the river, planting cover crops or letting grass grow between the oil palms. The use of organic fertilizer was also believed to keep water in the soil by one interviewee, but as this had to be transported from the factories, it was simply too expensive for the farmers. As a subproject EForTS-CRC 990 is conducting an experiment on intercropping in oil palm plantations, I also tried discussing the possible advantages of this

technique with the villagers. However, all of them proved to be very skeptical about this idea as they suspected that intercropping would decrease oil palm harvests significantly.

As mentioned before, people mainly found the government to be responsible for the different water-related problems because although the government decided about the land use it didn't control this afterwards. Therefore, it was possible that people sold the land in TaHuRa or that PT Asiatic Persada disregarded the protection of the riverbed. Furthermore, it was suggested that the government should pay more attention to the people's need. Many claimed that the government ignored the issue of population growth and the subsequent need for land. Instead the government issued plantation permits that benefited individual persons or companies but never the population in general. The company PT AP was also blamed for the water problems because it didn't serve as a good example for the people by not protecting riparian areas. Whereas some local people had been involved in the selling of TaHuRa land, nobody really blamed them for this. In general, it must be remarked that only very few of the interviewees talked about responsibility for the water problems, but those who did, overwhelmingly blamed the government (i.a. I4, I6, I18, I28). In their opinion, neither local people nor local government could do anything to improve the situation due to their lack of money.

6.4.2. Obstacles and solutions to sustainable oil palm cultivation - stakeholder views

The views of the experts interviewed presented a less radical and pessimistic view of the future, although those of the NGO representatives were very negative, too.

The representative of **Sawit Watch** was very skeptical about the implementation of best management practices on oil palm plantations. While he thought that the severity of water problems very much depended on the management of the plantations, he expected common practices such as planting cover crops to provide only little improvement and to be limited to flat areas. The certification program of RSPO was evaluated rather critically by him as it was designed "by the market". NGOs only make up 3% of the members. Furthermore, he criticized the lack of good monitoring and strict sanctions in case of non-compliance with the criteria. He considered the protection of upstream areas of rivers and the maintenance of conservation areas as more promising measures.

WARSI members also emphasized the important role of the forest in storing and filtering water and in preventing soil erosion. Further, they emphasized the importance of stopping the issuance of new licenses for oil palm plantations as well as the expansion of oil palm

plantations in general. In their view, the activities of independent farmers were much more difficult to control than companies. Therefore, they posed a greater threat to the remaining forests. Especially migrants, who had the necessary financial means, often bought land from the villagers and thereby spurred deforestation. The interview partners further regarded sustainable management of oil palm plantations to be a good solution. But this, they argued, depended very much on the government issuing the appropriate laws.

The **NGO Setara**, represents the most pessimistic view. According to the director

"[...] the independent farmer and the companies have to be aware that if they plant oil palm they will lose the water. And then there is no answer, because if the land is already planted with oil palm then you will have a black future: No water anymore." (EI4).

Thus, the most important sustainability measure, according to her, is to not convert any further land into oil palm plantations. In any event, a practice that could improve degraded soil quality is the application of organic fertilizer. According to her, chemical fertilizers caused a "dead topsoil" which was hard, red and without any faunal activity. The application of cow manure instead has proven to contribute to browner topsoils with much more faunal activity. Further it helped to loosen the hard topsoil and increase water infiltration. Regarding the planting of legume cover crops she was rather pessimistic about their long term effect for nutrient provision.

The **forestry professor** at Bogor Agricultural University highlighted instead the general importance of environmental management. He is convinced that, "if plantation owners stick to best practices in soil and water conservation there is no big influence on the hydrological cycle, or better said it is within the threshold levels." (EI1). While RSPO would be a good solution to forward soil and water conservation in oil palm plantations, the problem is that until now, due to low demands of certified palm oil, a higher price for certified rather than for not-certified palm oil is not always guaranteed.

The representative of the **center for watershed management** also stressed the importance of environmental management and soil conservation. Planting cover crops or the application of organic fertilizer constituted promising agricultural practices to him. Apart from these measures the center for watershed management recommended building different types of infiltration wells. Infiltration wells are used to recharge groundwater with rainwater which is collected from roads, roofs or other sealed areas. However, at the moment the government only provides funds to construct these wells for the provincial districts. At the village level

there are no such projects yet. Furthermore, the representative also stressed the problem of monitoring and regulation. While private companies can be regulated relatively easily, independent farmers are much more complicated to control. Local people, he considers are less of a problem, as they also cultivate other crops and apply some conservation measures. But people coming from other regions often don't apply these measures and their proportion of land possession is increasing constantly.

The importance of soil conservation was duly emphasized by the **oil palm company representative**. He admitted that the application of herbicides might impact water availability as the humus is being eroded. Other measures to prevent erosion would be the protection of the riverbed. Furthermore, his own company planted trees on the slope area inside the plantation to prevent erosion. As his company is RSPO certified, he had a very positive opinion about RSPO as it also includes a number of important social criteria. Yet, he argued, that environmental criteria were often too strict. That's why in his view, most of the companies did not apply all of the criteria.

The views explained formerly are basically also reflected by the representative of the **plantation agency**. While the governmental official also stressed the problem of herbicide application, especially if applied on larger areas and not only around the stem, he recommended the planting of cover crops and the use of organic fertilizer. While intercropping with vegetables in his opinion was good at the early stages of a plantation, he wouldn't recommend the intercropping of wood because of nutrient competition and lower oil palm harvests.

Both employees of the **community health center** stressed instead the importance of the general environmental awareness. Villagers should keep the surroundings of their houses cleaner and should refrain from dumping waste in the environment. The use of antiseptic soap when taking a shower in surface waters was recommended in preventing problems related to skin allergies.

7. DISCUSSION OF RESULTS

As outlined in the foregoing chapter a number of hydrological changes have been related to current oil palm expansion by villagers as well as by regional and national stakeholders. This part of the thesis summarizes the findings of the field research and presents the most important outcomes of how environmental problems are locally understood and how they are represented and communicated to outside parties. The chapter is structured as follows: Initially the DPSIR framework is applied based on the local social-ecological problem perception; secondly the discourse on hydrological changes is analyzed by categorizing the respondents and by displaying the social construction of water supply problems in Bungku; thirdly possible long term livelihood impacts are discussed taking into account positive and negative implications of current development of oil palm plantations.

7.1. Applying the DPSIR framework

As the discussion among villagers of Bungku shows, there are a number of different factors that all might contribute directly or indirectly to changes in the local hydrological cycle (cf. Fig. 47, p. 74). While many of them are directly related to land use change, others, such as road construction are more indirect expressions of the general agricultural and economic development of the area. This section shall give a detailed overview of the different causal factors and their interconnections, by integrating them within the DPSIR framework. Fig. 62 summarizes observations and interpretations of villagers regarding the hydrological changes in Bungku. As the different lines of arguments by villagers show, the system appears to be too complex to be depicted in a simple causal-effect-chain as the DPSIR framework suggests. Therefore, a network approach was used instead to highlight the multiple interconnections. This approach was also recommended by NIEJMEIER & GROOT (2008) to give credit to the complexity of social-ecological systems. Especially important elements are highlighted by a bold frame. The more people named a certain element, the thicker the frame. Although the framework includes numerous causal factors, processes and impacts, one must keep in mind that its focus lays on the hydrological causal chains. Detailed feedbacks of factors such as the villagers *Responses*, the income effect of oil palm cultivation or the social differentiation of impacts could not be displayed owing to the aspired clarity of the diagram.

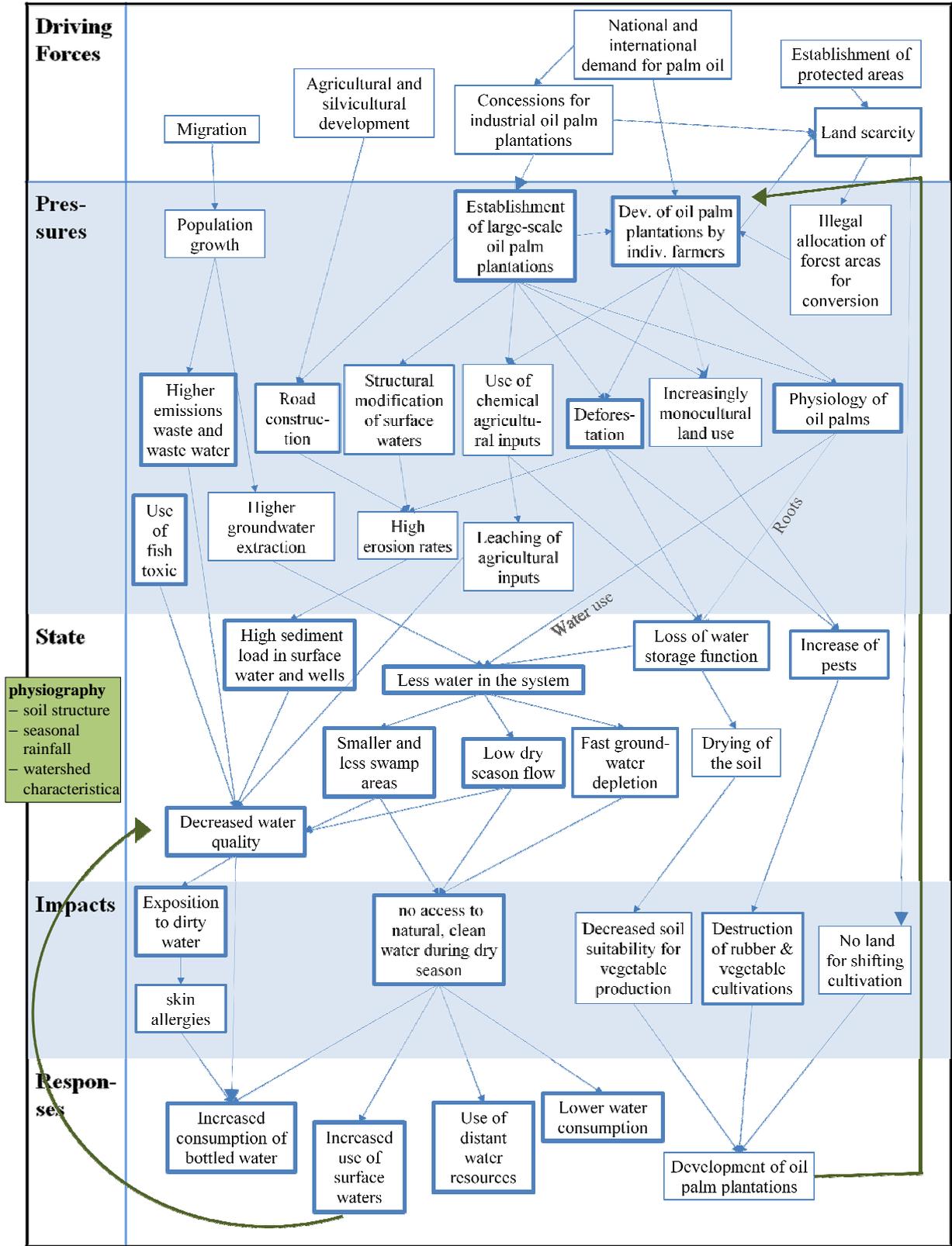


Fig. 62: The DPSIR framework of hydrological changes in Bungku (own representation)

7.2. The local discourse on hydrological changes

7.2.1. A typification of the respondents - the community division into oil palm advocates, opponents and "rationalists"

Although the depicted DPSIR-framework appears to be complex due to the diverse factors that all may contribute to the observed changes in local water resources, it only represents a sum of all the different lines of argument, not allowing for controversies or counter-arguments. Instead, its strength lies in its focus on the interconnection of different developments and the clear illustration of a certain crisis phenomenon. The extent to which this phenomenon is embedded in interpretative contexts and social constructions cannot be taken into account (cf. chapter 3.2.2). Thus, this section shall give a short interpretation of how the land-use-water nexus is being communicated by villagers. As can be derived from the foregoing chapters, the lines of argument as well as the observations of hydrological changes sometimes differed significantly among villagers. This chapter shall therefore try to put the obtained data into some viable order and give a typification of the respondents and their individual views on the research topic. Interview partners were therefore compared regarding to their observation of hydrological changes and their explanations for these. Furthermore, the peoples' attitudes towards oil palm cultivation and the general manner in which these issues were discussed were analyzed. Three main prototypes were developed, which shall be explained in detail as follows.

Oil palm opponents. At least at first glance these people seem to be rigorous adversaries of oil palm development in Bungku. They are local SAD people or people that have lived in Bungku for decades. They have observed changes in quality and quantity of surface waters and most of them have also noticed a faster depletion of their wells during dry seasons. In their view, these processes are clearly related to land use change and especially to the large-scale expansion of "water-greedy" oil palms. Further causes of changes in the hydrological cycle such as modified surfaces water and increased erosion are related mostly to activities of the PT Asiatic Persada company. Nevertheless after closer examination, attitudes towards oil palms are not as negative as they appear at first glance. Many of those belonging to this group also planted oil palms, although generally on only very small areas (< 1 ha). They didn't see why they shouldn't be allowed plant one or two hectares of oil palm if the company was allowed to plant almost 30,000 ha. Although some of them wanted to keep their oil palm plantations, most were not satisfied with the outcome of their plantations. They complained about not being able to plant fruit trees or rubber within the cultivation areas, as well as low

harvests and expensive fertilizer applications. The main scope of negative resentments towards oil palms was primarily addressed towards the oil palm company PT AP. This company has expelled many of them violently from their ancestral lands and is a main reason for land scarcity in Bungku. Opinions on oil palms and water problems are therefore often emotionally charged, argued dejectedly, and depicted in exaggerated manners. The ideal representative of this category was a man who is actually from Palembang but married to a SAD woman and who is actively involved in the land conflict with PT AP. Although he has only lived in Johor Baru for ten years, he talked about traditional SAD lifestyles before the company came as if he had experienced everything himself. The following excerpt represents how he sees the situation today.

R2: And if we plant oil palm – if we change the land from forest to oil palm, the oil palms need a lot of water. And if the land is already planted with oil palm we cannot plant any other kind of crops anymore...they are defeated...and if we look at the soil today, it seems yellow. In the past the soil where we live now was good. But now the soil seems like sand, it is dry. The soil has died. And we cannot plant any other crops. If we want to plant cassava, it doesn't want to grow, and if we want to plant chili, it doesn't want to grow, and if we want to plant vegetables, they don't want to grow...

[...]

I: Do you buy drinking water?

R2: Now there is nothing free anymore, we even have to buy water. We buy the bottled water for drinking since 2010. All people here buy drinking water now. If we have money then we buy the water, but if we don't have money anymore then we will go to the depot and break all the pipes there.

[...]

I: So who should act to improve the water situation?

R2: We don't expect anybody to do anything. We just hope there will be a tsunami so that we have a lot of water. (*joking*)

(I28).

Another ideal example for this group is a Javanese man who migrated to Bungku in 1974. He has one hectare of oil palm under cultivation but has tried to intercrop it with fruit and rubber trees. He recounted that people told him to cut the fruit trees to improve the oil palm harvests. But he said he preferred to keep the fruits and the water on his plantation, because if he only planted oil palm, then the water in his well on the plantation would be gone.¹⁷ When he was asked when the drying and the pollution of the river started, his answer was, "since BDU [today PT AP] came here in 1986". As we know the plantation was developed gradually and

¹⁷ Today the well on his plantation is one of those that provided water for the longest time during the dry season.

large-scale oil palm cultivation only started much later, this answer seems a bit provocative. NGO representatives, due to their consistently negative attitude towards oil palms and especially towards international oil palm companies, are also part of this group.

The second group is comprised of the **oil palm advocates**. They represent the complete opposite position to the group above, as they are the vocal advocates of oil palm development. Typically, they have a very positive attitude towards oil palms and try to negate any environmental impact of the plantations. They mainly claim that there has been no change in the water resources, or, if they cannot deny certain environmental changes, they try to find other explanations or give rather inappropriate comparisons like:

"[...] in Jakarta there is no oil palm but it's also hot and there is flooding" (EI6), or

"[...] in 1997 there was a strong drought although people didn't plant oil palm yet." (I20R4).

Often this strategy is accompanied by the evasion of questions:

I: What do you consider to be the most important environmental impacts of oil palm development in the area?

R1: According to me the positive impact of the development of oil palm is bigger than the negative impact [...].

(EI6).

Most of these people have a certain interest in oil palm development, because they are village authorities that profit from the development, company representatives or representatives of the plantation ministry. Some local oil palm farmers also belong to this group. These were mostly migrants who were actively engaged in oil palm farming, holding several hectares oil palm. It often seemed they really felt that they had to defend oil palms against the widespread negative discourse concerning its cultivation and the subsequent impacts on the environment.

The third important group shall be called "**the rationalists**". They are oil palm growers, mostly migrants that cultivate several hectares and generally have a positive attitude towards oil palm. They appreciate the high income that their plantations offer and the little effort they need to make regarding their management. Yet, they are aware of the environmental impacts of large-scale land use change in Bungku. They have observed changes in the dry season flow and in the groundwater depletion and directly relate these changes to oil palm expansion. As they seem to have rather good agricultural knowledge, they are aware that some agricultural practices, such as ground cover crops or protection of the riverbed, are helpful to the reduction of water-related problems. Therefore, they harshly criticize the current management of PT AP that does not comply with environmental legislation. Although they are convinced that rubber

cultivations are more environmental friendly, they wouldn't want to change their plantations' crops. Even if somebody would bear the costs for these conversions of cultivation they would prefer to continue growing oil palm. Interviewed experts who would also belong to this group are the professor of forest hydrology who acknowledged that the lack of environmental management is the most important problem for sustainable land use development as well as the representative of the watershed agency who criticized the lack of monitoring and law enforcement by the government. The ideal types of representatives belonging to this group are the farmers that participated in the group discussion in Johor Baru:

I: Do you think that rubber is better for the water?

R: Rubber is good.

R: Rubber is very good.

[...]

I: So why don't you plant rubber?

R5: If we start to plant rubber now, when we will get the harvest? We need income now. I have three children that go to school. It's too late now.

[...]

I: When you started to plant oil palm did you already know that it needs a lot of water?

R5: Not yet. We know that oil palm needs a lot of water from the company. From researchers under the English management of the company.

R: They said that oil palm needs many liters of water per day.

[...]

R4: Even if I know that oil palm needs a lot of water, I would still plant it. But it's better to plant both, oil palm and rubber. I changed rubber to oil palm because of pests. Pests for rubber are monkeys. They always eat the leaves of rubber. But only if the trees are still small.

R: And if there is a forest fire, the rubber trees are gone, but oil palms can still grow after a fire.

(I31).

Another man also belonging to this group is a man who lives in a village near Bungku.

R2: *Talking about PT AP having planted oil palm directly in the buffer zone of the river Sungai Bahar..*

I: When were these palms planted?

R2: Before 2000.

[...]

I: But before there was a buffer zone?

R2: Yes... But now if there is a long drought then it's becoming difficult to get water.

R1: Very difficult! Then the wells run dry.

I: When did the wells run dry?

- R2: Last year. During the long drought.
- R1: It was extremely dry. All the people around here went to the river to get water.
- I: How long was the drought?
- R1: 7 months.
- R2: Almost 8 months.
- I: What did that change in the river since the buffer zone is gone?
- R2: The river is getting shallow. It's not deep anymore because of soil erosion. Because the fibrous oil palm roots cannot hold the soil.
- R1: There is no bamboo anymore at the river. The roots of bamboo and banana can keep the water!
- R2: Because from the government there is also no kind of socialization on how to protect the watershed.
- [...]
- I: Do you have oil palm, too?
- R2: I have 2 ha oil palm, but I still keep the area near the river. I didn't plant oil palm there. I just let the vegetation near the river grow.

(I24).

While these are the main and most striking types of respondents, not all villagers could be classified according to these groups. Thus two additional, but significantly smaller groups were identified:

The rubber farmer. They never actually cultivated oil palm but know of some of the negative characteristics, such as the high water demand or that harvesting cannot be carried out by women and the elderly. Thus, they prefer to continue on with their rubber plantations and do not wish to change to oil palm. They also observed a drying of rivers and wells and relate it directly to oil palm development and deforestation.

The newly migrated people. All participants of this group recently migrated to Bungku in the year 2011 and thus haven't observed any changes in the water resources. Their reasons for water scarcity in the dry season remain speculations on soil parameters, oil palms or other factors.

Finally, not all interview partners could be categorized according to these types, because not all interviews were conducted with the same depth (e.g. informal interviews). Some people participated less than others in group interviews or group discussions. As far as that is concerned four persons didn't mention land use change as a cause for the observed changes in water resources, but rather population growth. As it were, although apart from the group of oil palm advocates most people clearly related water scarcity to land use change, this doesn't mean that they didn't state further reasons for changes in local water resources as well (cf.

chapter 6.2.2). But due to the focus of the research topic and the wide consensus on the influence of land use change on water resource the emphasis was put on this argument.

7.2.2. The social construction of water supply problems in Bungku

Taking a closer look at the different types of groups and how they communicated changes in water resources and water supply problems it becomes imminent that there are actually two different discourses led by the villagers and the involved stakeholders. The first is the *real* discourse¹⁸. It is formed by *what* people actually say. The second one is the *symbolic* discourse, formed by *how* people say things.

By analyzing what people said, it is easy to see that indeed there have been changes to the hydrological cycle, mainly within the last fifteen to twenty years. While some people only gave imprecise descriptions of rivers and wells running dry faster, others had a real story to tell. A young woman for example remembered that she often went swimming in a river near her house during her primary school years. But when she went there during the drought in 2012 to get water, she was surprised to see it wasn't flowing any longer. Another woman, having lived in Bungku for several years reported how she had got a skin allergy after the river next to her house stopped flowing during the dry season some years ago. These narratives leave no doubt that in the last years dry season flow has diminished significantly. Moreover, discussions with villagers about their water supply can be attributed to what can be called the *real* discourse. The efforts the villagers have to take when their wells ran dry affected every single household, although in different magnitude. They had to search for water, often in quite distant places or to buy bottled water. No matter who was asked about problems concerning the local water supply, difficult access to water in the dry season was immediately claimed by almost all villagers.

The *symbolic* discourse of *how* people talked about changes in their water supply reveals the social embeddedness of the problem. In fact, the discourse about hydrological changes corresponded almost exactly to the general discourse on oil palm cultivation. The way problems related to water supplies or changes in water resources were narrated by the people displayed their individual attitudes towards oil palm development. The typification of respondents depicts this clearly. Those who complained most about water problems have in turn the most negative attitude towards oil palms, while some in favor of oil palm

¹⁸ Discourse in this context is defined as “a shared way of apprehending the world’ [Dryzek 1997: 8] that rest on shared ideas, judgments and contentions about an issue, and are constructed out of basic terms which support debate, analysis and agreement upon a given issue [...]” (RODELA 2012: 28)

development tried to negate any hydrological changes. Water is thus being used as an argument to substantiate the personal view in a wider discourse on land use change. The discourse on water thus embeds and expresses societal relations. Or as LINTON and BUDDS (2013) would argue, this represents the "social construction of representations of water" (ibid.: 6).

In this discourse on oil palm development, we can identify several groups or lines of argument that correspond with discourses on a global level. While some of the local farmers clearly defended the development of oil palm plantations and wanted to participate in this rapid economic development, others were more conservative. They complained about environmental destruction and demanded reforestation by the government. While this can be argued to be a conservationist discourse, these individuals are mainly concerned about conserving their former land use system, especially rubber cultivations. Another group represents an indigenous rights discourse which is strongly forwarded by NGOs and local SAD groups in Bungku. Thus, Bungku, although only a small, but complex village, showcases the kinds of environmental discourses led all over the world, representing its globalized context.

These different examples of how the discourse on oil palm development and water is led reflect the social structures in the village. This is especially supported by the fact that mostly the poor and/or local indigenous people suffered most from water scarcity and pollution. As they did not have the capital to collect water from distant sites or buy large amounts of bottled water locally, they increasingly depended on the help of their richer neighbors and relatives. As this development clearly increases the gap between those that profit from oil palm development and those that don't, one yet could expect an even much more polarizing form of communication concerning the water problem. As a matter of fact, there were only a few oil palm growers in Bungku that fiercely defended oil palms and tried to downplay any negative environmental developments. This is maybe owed to the fact that, although richer villagers do profit a lot from their oil palm cultivations, the development in the local water supply and especially water scarcity, did have a strong impact on their daily life, too. Even if they owned a car or were able to buy bottled drinking for all of their daily uses, the costs are substantial. And also the time spent to collect water represented a significant burden in their daily lives.

On the other side, these farmers and other representatives of the oil palm sector wanted to continue profiting from oil palm cultivation. They know that oil palm is often accused for causing several environmental problems and thus turned to defending it against its negative

stigma. This often occurred in spite of a knowledge that the environment had indeed been degraded due to rapid land use change. If and when these people talked about their true convictions supposedly depended a lot on the level of trust between the interviewee and respondents. At least this would explain why respondents of the plantation ministry or the oil palm company representative became more open towards the end of the interview. At that point of the discussion they admitted that PT Asiatic Persada is a crazy company, or that the roots of oil palm impede water infiltration.

This seems to be the reason why many respondents, including oil palm farmers, clearly admitted that land use change has led to a more difficult access to water. This is due to the fact that they were personally concerned about finding ways to solve these problems in the future. Thus, with reference to the concept of the hydrosocial cycle, water in Bungku has been widely recognized as a *scarce resource*. And water scarcity has been communicated by many as a negative side effect of land use change. While big companies as well as individual farmers have contributed to the alteration of the local water balance, the material aspect of water in turn now influences the societal organization of the village water supply system. At the time of research new ways of accessing clean water were being developed, such as the collaboration between neighbors or the commercialization of bottled water. Yet, for the future more sustainable long-term solutions will have to be found to decrease the people's exposure to dirty surface waters.

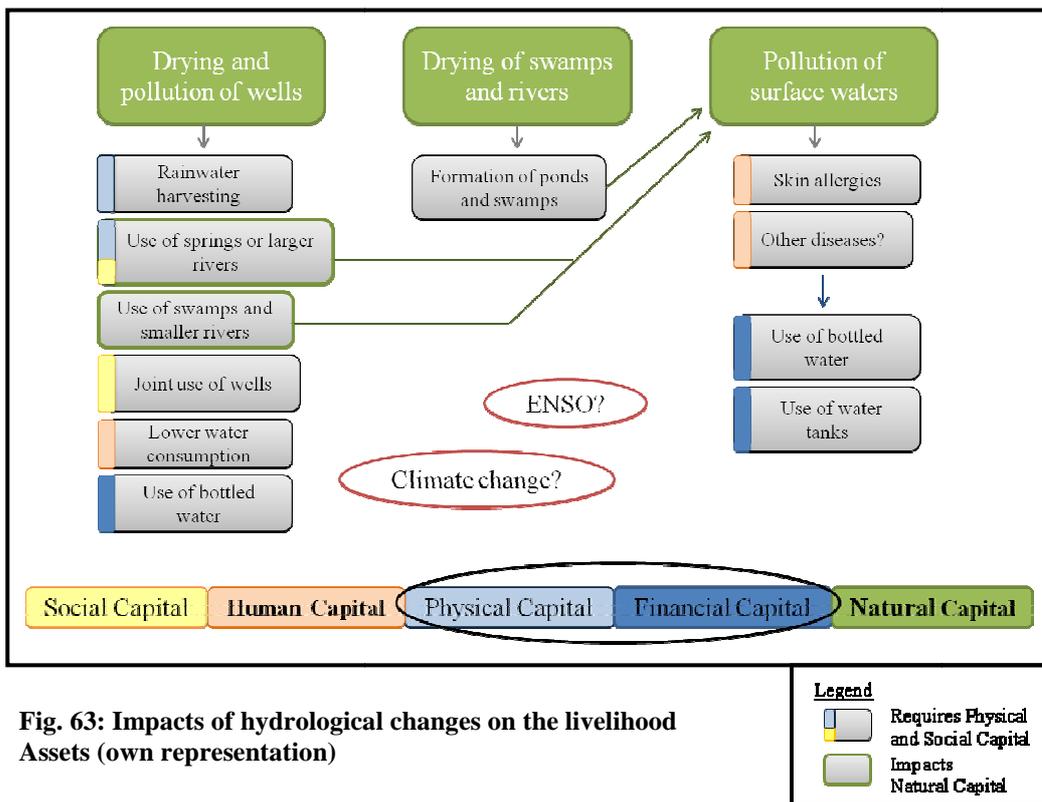
Thus, to sum up the idea of societal relations to nature or of the hydrosocial cycle, the case study Bungku clearly showed how, "despite the social construction of representations of water, the material properties of water play an active role in the hydrosocial process, sometimes structuring social relations and sometimes disrupting them [...]" (LINTON & BUDDS 2013: 6).

7.3. Discussion of long-term impacts to local livelihoods

According to CHAMBERS & CONWAY (1991), a livelihood "comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living [...]" (ibid.: 6). Embedded in the vulnerability and institutional context the *Sustainable Livelihood Approach* is based on the assumption that people require a range of assets to achieve positive livelihood outcomes (DfID 1999). The assets are categorized as following:

- Human Capital: including skills, knowledge, ability to labor and good health
- Social Capital: including social resources like networks, memberships or relationships of trust
- Natural Capital: which is composed of natural resource stocks from which resource flows and services are derived
- Physical Capital: consisting of basic infrastructure and producer goods
- Financial Capital: which comprises financial resources (DfID 1999).

Trying to sum up the impacts of a changed water supply to the individual households within this livelihood framework, Fig. 63 shall depict which livelihood assets are required or changed due to changing hydrological conditions. While Physical and Financial Capital has become more important to access clean water, Human Capital and Natural Capital decrease if people do not have the necessary resources and continue using water from surface water.



To sum it up, the degradation of water resources has led to the fact, that clean water, formerly a public good is increasingly becoming an expensive commodity and a very scarce resource at the village level. Due to its decreased availability, access to water has become even more difficult for unprivileged groups of the society, like the poor or the elderly, while richer households can mobilize their capital to buy bottled water for the entire family.

Furthermore, water scarcity not only poses a problem for daily uses like washing and showering but might also impose further obstacles for social events and cultural habits. As the great majority of the villagers are Muslims they should perform the *wudhu*, the ritual washing, before every prayer (five times a day). It is further a Muslim tradition to take a shower before a funeral. Thus, a woman recounted, that several years ago during dry season the people had to bring water from the river Sungai Bahar before performing the funeral ceremony.

On the other hand, the positive impacts of the economic development in the village cannot reasonably be ignored. While in the past people sometimes had to walk to Sungai Bahar to get water, today almost everyone owns a motorbike. And while in the past, if wells ran dry, other water resources had to be used for drinking, today there are several kiosks selling bottled drinking water. Without the asphalted road which was built to aid the economic and agricultural development of the village, bottled water possibly wouldn't be sold even today. Furthermore, the fact that many people nowadays travel to the spring in Meker Jaya to get water, might also be owed to the fact that the bathing place was cemented and that it is easily accessible with a motorbike.

The only positive impact of depleting water resources named was the fact that former swamp areas could now be used for cultivation. Still, water scarcity might also produce a couple of negative impacts to the agricultural development in the village. Especially SAD people had complained that in the last couple of years the soil had dried out. Hence, they argued that the cultivation of any other crops like vegetables were no longer possible. Additional problems like pests made people turn to oil palm rather than to rubber cultivation. Lower harvests due to water scarcity might constitute further environmental impacts on the people, as oil palm and rubber have high water requirements (cf. COMTE et al. 2012; VIJAYAKUMAR et al. 1998). While harvests decrease significantly in dry season, until now, however, none of the interview partners had noticed a general decline in harvest over the years. Yet, if future data of the EFForTS-CRC 990 confirms decreasing water storage capacities of the soil, this effect might become important in the future. As rubber was reported to be more susceptible to water scarcity, this might constitute an additional driver for people to turn to oil palm rather than to rubber cultivation in the future.

Finally, it is important to further note that the peoples' way of adapting to water scarcity has yet remained purely reactive. The absence of proactive measure taken to address the problems at source, by reducing water pollution or by improving environmental management, might contribute to even more difficult access to clean water in the future.

8. COMPARISON WITH OTHER STUDIES

The results of the case study in Bungku showed that important changes in the hydrological balance have been observed by local people. Nevertheless, all of these claims are based on in-depth interviews with villagers about their personal perception of changes and are not backed by any hydrological data. Therefore, this section shall provide room for a discussion of how these observations can be explained with existing scientific knowledge. First results of other subprojects of the EForTS collaborative research center seem to provide further support to the results gained from field research.

8.1. Community grievances in Jambi, Kalimantan and Papua

The few studies that have taken into account community grievances of water resource degradation related to oil palm development have found very similar conditions as in Bungku. A decreasing dry season flow and a drying of community wells were also reported by KLØCKER LARSEN et al. (2012). While all research villages in the study by KLØCKER LARSEN et al. were located in areas with peat soils, OBIDZINSKI et al. (2011) also reported a decreasing water quantity in a village with non-peat soils. Similar to Bungku, in the case studies of KLØCKER LARSEN et al. (2012), people had to rely on distant water resources or on water that was provided by the oil palm companies. Erosion and high sediment loads of water were also reported by both studies. Further degradation of water quality was related to the release of toxins through pesticide application and oil palm waste into water bodies. The release of sewage from oil palm factories was further harshly criticized by NGOs (i.a. FoE, Sawit Watch & Life Mosaic). In Bungku no such pollution has been found due to the absence of an oil palm factory. The nearest such plant is located in the southern part of Bungku and was not accessible to outsiders. A further issue, cases of skin diseases as a consequence of degraded water quality were also found by KLØCKER LARSEN et al. (ibid.). Complaints were mainly referred to the overflow of sewage ponds of oil palm factories during the rainy season. Although during rainy season water seemed to be heavily loaded with sediments, in Bungku water quality has been reported to be better than during dry season, relatively seen by local villagers. Further complaints of villagers reported by OBIDZINSKI et al. (2011) and KLØCKER LARSEN et al. (2012) were related to an increase of floods and resulting damage to local agriculture and infrastructure. In Bungku, a change in the flood regime with a faster time-to-peak has also been observed. But as the flooding doesn't usually cause any damage to the

houses, this was of secondary importance. Furthermore, the reduction or redirection of water flows by oil palm companies was denounced by the villagers in all studies.

Within the scope of the collaborative research center EFForTS a large-scale household survey was carried out in forty villages in Jambi province. This survey was conducted by the subproject "Determinants of land use change and impact on household welfare among smallholder farmers" led by Prof. Dr. Matin Qaim. Within the six core plot villages of EFForTS-CRC 990 – including Bungku - farmers were additionally asked about climate changes during the last ten years.¹⁹ The results of the survey are represented in Fig. 64, Fig. 65 and Fig. 66. Of a total of 121 respondents, 86 respondents answered that they had observed changes in precipitation patterns over the last ten years. 67 of them argued that there has been a decrease as well as an increase in precipitation depending on the season. As can be derived from Fig. 64, most respondents observed a decrease of rainfall during the months March to August and an increase in precipitation from September to February. This suggests an increased intensity of both dry and rainy seasons. Strong support for this rationale is given by Fig. 65. In total, 82 respondents claimed that droughts or seasonal water shortages were an issue in their region. A comparison of the months in which droughts normally occur today and in which droughts have occurred ten years ago is shown in Fig. 65. While a clear increase in droughts becomes evident during the months June to September, a decrease in the risk of droughts has been observed for the rainy season from November to March. Fig. 66 further shows that the intensity of droughts or seasonal water shortages has increased significantly, especially during the months July, August and September.

On the other hand, several answers are contradictory in nature. While 40 respondents claimed that there has been a decrease of rainfall in August, 20 respondents claimed that precipitation had increased in the same month. And while Fig. 64 shows an increase in rainfall for September, Fig. 65 and Fig. 66 show the contrary. One explanation for these confusing claims might be that several residents in Bungku reasoned that the seasons were no longer predictable with occasional strong rainfalls occurring during the dry season and an occasional deficit of them during the rainy season. Another explanation might be that the respondents became less concentrated towards the end of the questionnaire, which, depending on the household characteristics varied from 25 to 52 pages.

¹⁹ For more information on the experimental design of EFForTS see <https://www.uni-goettingen.de/de/study-site/416784.html>; The relevant parts of the questionnaire can be found in the Fig. 77 in the appendix.

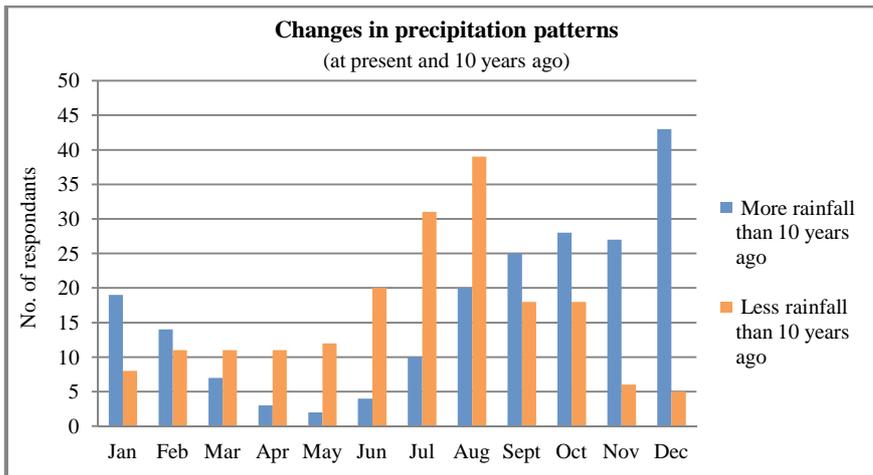


Fig. 64: Changes in precipitation patterns observed by villagers (own representation)

(n = 86; 35 of 121 respondents answered that the annual pattern of precipitation hadn't changed; 67 respondents marked increases of rainfall as well as decreases of rainfall in different months; 11 marked only decreases in rainfall and 8 marked only increases in rainfall)

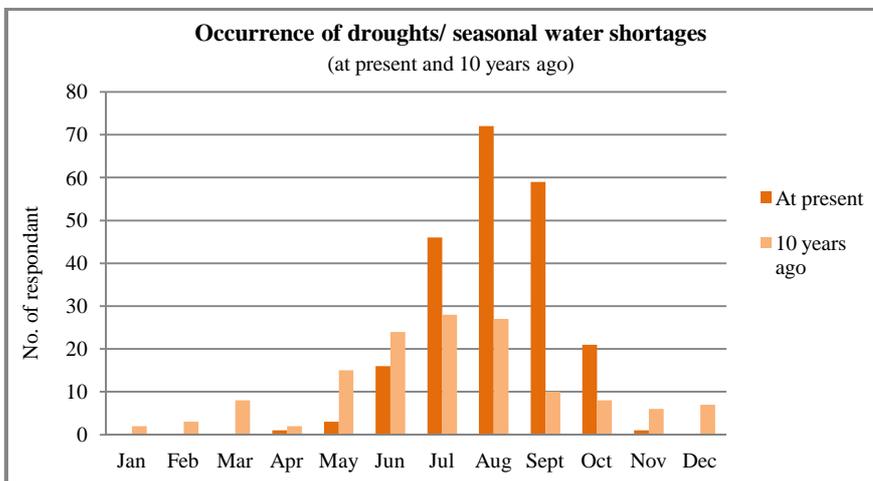


Fig. 65: Occurrence of droughts/ water shortages at present and ten years ago (own representation)

(n = 82; 39 of 121 respondents answered that droughts/ seasonal water shortages are no issue in their region)

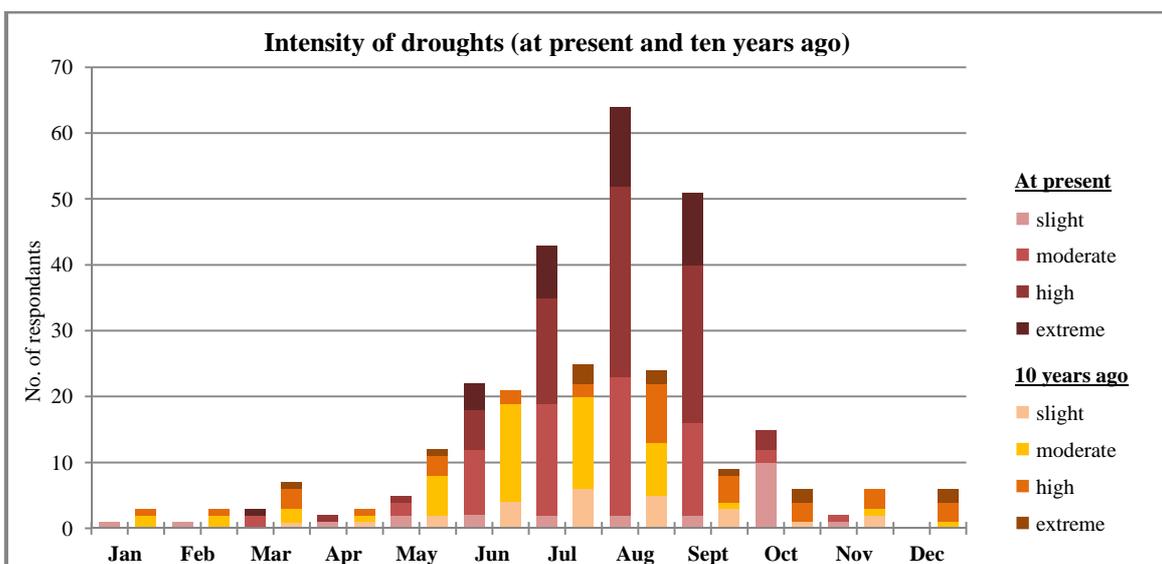


Fig. 66: Intensity of droughts at present and ten years ago (own representation)

(n = 74; 8 invalid answers)

8.2. Making sense of the hydrological changes and their explanations encountered in Bungku – the roles of soil degradation, population growth and climate change

A decrease of water quality can be obviously explained by an increase in waste and waste water emissions, the use of fish toxins, erosion or the discharge of oil palm waste into surface waters. Although there are no water quality data available, backing up the given claims and helping to evaluate the degree of pollution, this in itself is not imperative to an understanding of the problematic developments. On the other hand, the leaching of pesticides or fertilizers is by far more difficult to verify. As COMTE et al. (2012) summarized in their review, the few existing studies on nutrient leaching and groundwater quality reported low leaching losses (i.a. TUNG et al. 2009). This was also confirmed by a one year multi-site monitoring by COMTE (2013: II). However, the author further argued that sensitivity to nutrient losses varies in different soil types and that the application of organic fertilization can help to reduce nutrient losses to streams (ibid.) Only BABEL, SHRESTHA & PERRET (2011) found significant increases in nitrate and phosphorus depending on different scenarios of oil palm expansion.

The possible explanations for the decrease of dry season flow or the faster depletion of the groundwater reservoir during dry seasons seem to be even more complex. While the household survey questionnaire was based on the assumption that changes in drought length and intensity can be explained by changed precipitation patterns it failed to ask the respondents for their personal conclusions. The villagers of Bungku gave mainly five explanations for the increase of water shortages: the loss of the water storage function of the forest, the high water use rates by oil palms, road construction, structural modifications of water bodies by oil palm companies and population growth (cf. chapter 6.2.2). The typical fibrous oil palm roots were further blamed for reducing water availability by several of the experts interviewed.

While the construction of roads can certainly change the course of rivers it shouldn't have had a direct impact on the sum of water available in the system. One of the respondents explained that the small river behind his house had stopped flowing because the channel under the road was not "good" because it was too high (I30R1). This probably indicates that the stream flow was still higher before the road was build and then decreased afterwards. The arguments that oil palm companies have modified water bodies appear reliable as these claims were confirmed by former and current workers of PT Asiatic Persada (i.a. I26R1, I31) as well as by

NGO representatives (EI2, EI4). Furthermore, a comparison of Google Earth Satellite Images (cf. Fig. 78 & Fig. 79 appendix, p. 136) provides strong evidence that a drainage of swamp areas and the redirection of rivers have taken place.

As elaborated on in chapter 2.1, a decreased dry season flow can indeed be the consequence of deforestation, if surface soil has been eroded or compacted and water infiltrability has been reduced as a consequence to these actions. The ongoing deforestation of the last remnant forest areas in Bungku might lead to constant soil erosion (cf. Fig. 67 & Fig. 68, p. 112). Additionally, the practice of burning land may degrade surface soils severely and reduce infiltration capacity due to the compactation of these soils (BRUINJZEEL 2004: 204ff). In Indonesia, clear-cutting with fire is still common practice which in turn, resulted in forest fires in June 2013. Google Earth Images also show evidence of the development of oil palm plantations on burned land in Bungku area (cf. Fig. 80 & Fig. 81 appendix, p. 137).

Although infiltration rates can recover and resume their pre-disturbance levels after the development of oil palm plantations (MDID 1989: 59), this depends a great deal on the management practices of the individual oil palm plantations. The planting of legume cover crops on the one hand was said to be particularly important to improving soil quality (ibid.). Herbicide use on the other hand, especially when applied outside of weeding circles, may increase erosion significantly. While no farmer in Bungku reported planting cover crops, many of them let grass grow between the trees because they are aware of the fact that exposed topsoils will lead to soil degradation. Yet, other examples showed that herbicides were often used without any knowledge of their impacts. One farmer who owned eight hectare oil palm plantation used herbicides two to three times a year and sprayed it everywhere on the plantation in order to facilitate harvesting (Fig. 70). Another example was a SAD man who was occupying land of PT AP at the time of research, He proved to have very poor knowledge of the management of oil palms in general. Although he had no money to buy important fertilizers for oil palm cultivation he used herbicides. According to him, this was the cheaper alternative as he only needed to purchase one liter of herbicides whereas he would have to buy a 50 kg bag of fertilizer.

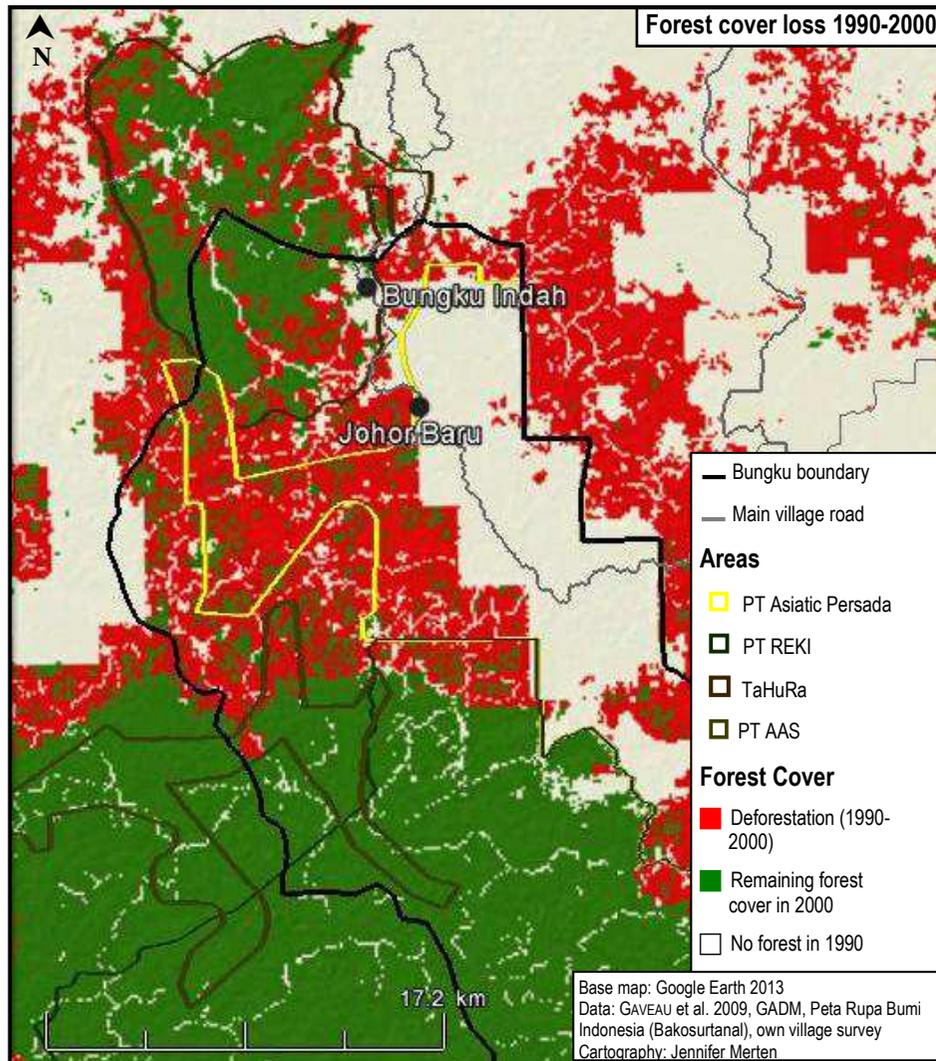


Fig. 67: Deforestation in northern Bungku between 1990 and 2000

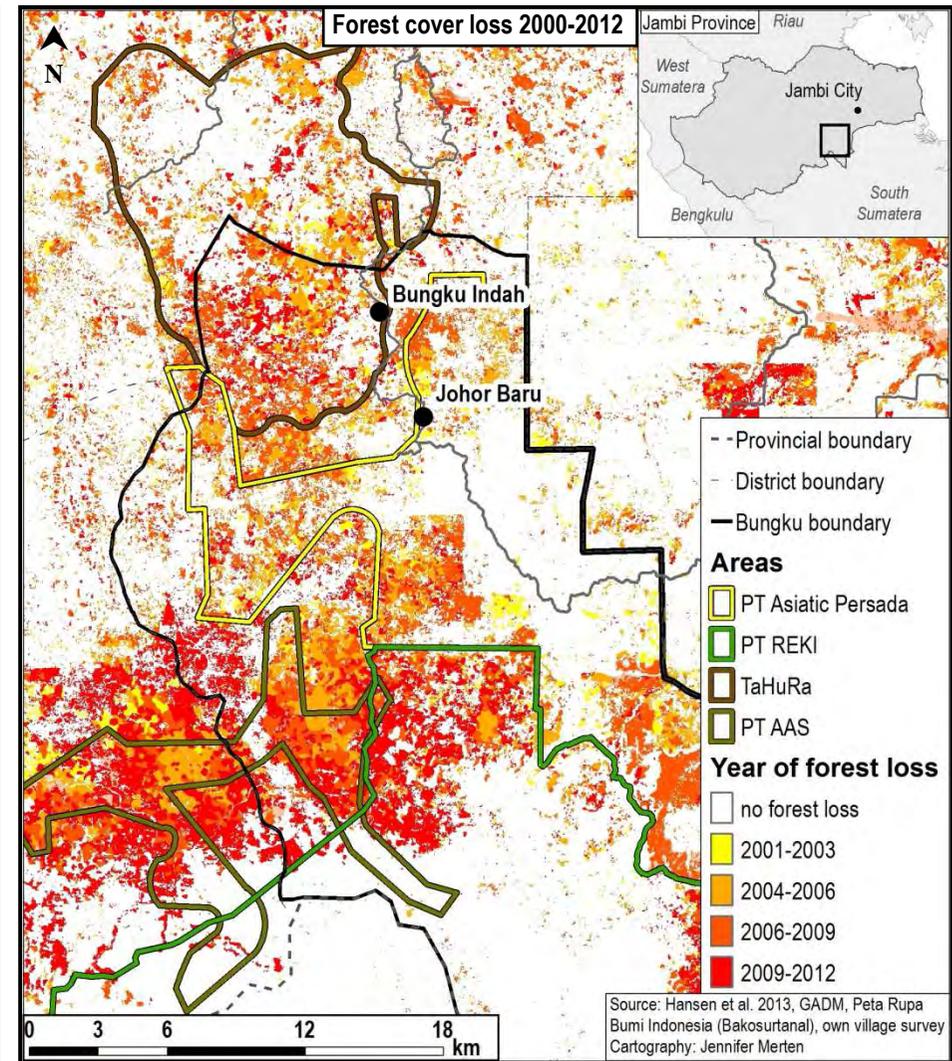


Fig. 68: Deforestation in northern Bungku between 2000 and 2012

Additionally, the common soil type in Bungku (Acrisols) is particularly susceptible to erosion and compactation (TRIPATHI & PSYCHAS 1992). This was also confirmed by a study of the Malaysian Department of Irrigation and Drainage (1989: 59) that found higher compactation rates for soils with weak structures and high clay contents. Furthermore, VAN DER WEERT (1994) suggests a more rapid diminishing dry season flow in the case of deep soils – such as Acrisols - with large storage capacities (qtd. in BRUIJNZEEL 2004: 203).



Fig. 69: Newly developed oil palm plantation in Bungku Indah (own picture)



Fig. 70: Clean weeded oil palm plantation (own picture)

These facts provide some evidence that the reduced dry season flow in Bungku might indeed be explained by the "infiltration-trade-off" hypothesis as stated by BRUIJNZEEL (1989) (cf. chapter 2.1).

Recent results by the EFForTS-CRC 990 subproject B10 ("Landscape-level assessment of ecological and socio-economic functions of rainforest transformation systems in Sumatra") confirm this evaluation. TARIGAN et al. (2014, in prep.) investigated on the hydrological impacts of oil palm plantations by measuring streamflow data from two catchments, one dominated by oil palm plantations (14.2 ha; 50% weeded, 41% unweeded and 9% secondary forest) and one covered entirely by a mix of jungle rubber and plantation rubber (4.9 ha; jungle rubber 25%, 8-yr old rubber 19%, 30-yr old rubber 56%) (ibid.; personal communication TARIGAN, S., 03/12/2014) Additionally, they carried out plot-scale measurements of interception, bulk density, infiltration capacity and surface runoff on five different land use types: weeded and unweeded oil palm, rubber monoculture, jungle rubber and secondary forest. All field measurements were carried out around Bungku village.

At the catchment areas they found higher fluctuations in the oil palm dominated catchment with lower baseflow during dry periods and higher peak flow during wet conditions as compared to the rubber catchment (cf. Fig. 71). The average runoff coefficient was 0.65 for the oil palm dominated catchment and 0.53 for the rubber catchment (meaning 53% of the

rainfall became direct runoff). At a plot-scale they measured high bulk density on all land-use types as consequence of a heavy soil texture (clay loam). Infiltration rates were reported to be high ($> 30 \text{ cm hr}^{-1}$) under frond piles in oil palm plantations²⁰ and low ($< 10 \text{ cm hr}^{-1}$) in harvest paths, oil palm circles (weeded and unweeded) and rubber harvest paths. Surface runoff rates on the plot scale showed highest values for oil palm followed by rubber plantations. Interestingly enough, unweeded oil palm plantations, jungle rubber and secondary forest produced very low surface runoff. Thus, TARIGAN et al. (2014, in prep.) highlight the important role of weeds in runoff generation.

High runoff coefficients and higher streamflow fluctuation in the oil palm catchment as compared to the rubber catchment, according to TARIGAN et al. (ibid.) can be further explained by the rainfall partitioning by the typical crown allometry of oil palms. The leaf structure leads to high amounts of water reaching the ground as stemflow and concentrated throughfall, which is highest at about four meter distance from the stem. "Additionally soil compaction and preferential flow on harvest paths led to low infiltration and high surface runoff." (ibid.: 19). High surface runoff, they argued reduced baseflow and therefore might create low dry season streamflow and water shortages. Another factor reducing groundwater recharge is the high rainfall interception by oil palms which is caused by water storage in the hollow spaces between fronds and trunk (ibid.).

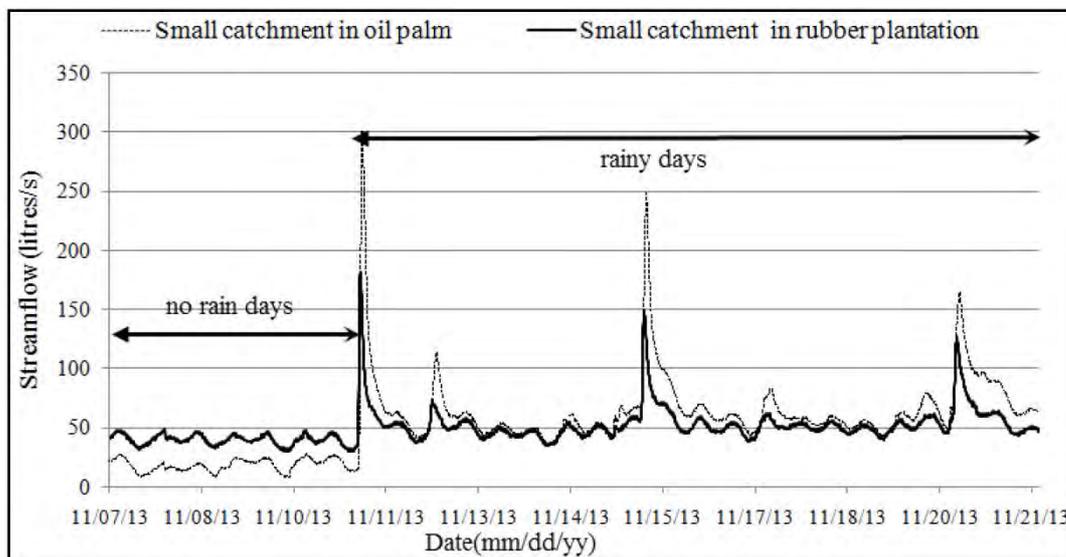


Fig. 71: Streamflow patterns in oil palm and rubber catchments on dry and rainy days (TARIGAN et al. 2014, in prep.)

Further proof for soil degradation on oil palm plantation comes from SUNARTI et al. (2008, qtd. in TARIGAN et al. 2014, in prep.) who reported infiltration capacity on oil palm plantations to be only half of the infiltration capacity in natural forests in Bungo district

²⁰ Frond piles are formed by farmers when stacking the pruned leaf fronds in the middle of the row between two trees. The width of frond piles is normally about two meters (TARIGAN et al. 2014, in prep.).

(Jambi). Bulk density in oil palm plantations (1.05 g/cm^3) was also significantly higher than in forest soils (0.81 g/cm^3). An indication for severe soil degradation as a cause of oil palm expansion might come from the subproject A04 ("Stock, turnover and functions of carbon in heavily weathered soils under lowland rainforest transformation systems"). Preliminary results from $\delta^{13}\text{C}$ -measurements indicate high erosion rates after forest conversions to oil palm plantations. In some cases, these probably even add up to 20 cm (personal communication GUILLAUME, TH., 02/11/2014).

Further reports on a lower baseflow on oil palm plantations are rare. BABEL, SHRESTHA & PERRET (2011) reported a declining baseflow of 7% after forest conversion to oil palm. YUSOP et al. (2007, qtd. in COMTE et al. 2012: 108f) showed a high baseflow proportion as 54% of the total runoff on oil palm plantations. But COMTE et al. (2012: 108f) argued that baseflow in forest catchments could reach as much as 70% of the total runoff.

The villagers' claims that oil palm needs a lot of water remains without real explanation. Indeed, the water use or evapotranspiration rates of a tree can influence the baseflow (cf. chapter 2.1). Thus, several studies reported on water scarcity due to the cultivation of exotic tree species, that have high water use rates such as eucalyptus (BRUIJNZEEL 2004: 207). However, only very few studies exist on the evapotranspiration of oil palm plantations. These, in turn, suggest values of $1000\text{-}1300 \text{ mm year}^{-1}$ (2.7 to 3.5 mm day^{-1}) which are similar to the ET in tropical forests (COMTE et al. 2012: 95f). Preliminary results of the EFForTS subproject, "tree and palm water use characteristics" also suggest similar values of oil palm transpiration as compared to tropical forest, but final results have yet to be awaited (personal communication with ROELL, A. (02/14/2014) & HÖLSCHER, D. (12/11/2013)). A study of TARIGAN and SUNARTI (2012, qtd. in TARIGAN et al. 2014, in prep.) confirms these results. Evapotranspiration on a 14-year-old oil palm plantation was about 4.5 mm day^{-1} , values which are only slightly higher but in the same order of magnitude as those reported by COMTE et al. (2012) (TARIGAN & SUNARTI 2012, qtd. in TARIGAN et al. 2014, in prep.).

The only evidence for the contribution of specifically oil palm roots to decreased water holding capacity of the soil comes from HARTEMINK (2005: 14). He argued that if erosion occurred on oil palm plantations, this caused a removal of the soil between feeding roots near the surface. As a consequence the exposed roots dried up and died, so that the water and nutrient-uptake capacity of the root system was reduced. This proved to be especially true for the weeded circle (ibid.)

Apart from soil degradation, an increased extraction of groundwater can also contribute to a faster depletion of water resources. The population growth rates in the region can only be estimated roughly. While in 1982, Bungku registered 980 households today, almost 10,000 people live there (Desa Bungku 2010). These 10,000 persons, according to the village head, live in approximately 4.000 households.

Climate change might be a further important factor to be considered as responsible for changes in the local water balance. While several interview partners reported that precipitation regimes have changed and that seasons were no longer predictable, they didn't further mention that the dry seasons have actually become drier or longer. Data from the household survey of an EForTS-CRC 990 subproject however suggested a general increase in the intensity of the dry season (cf. Fig. 65 & Fig. 66, p. 109). A comparison of the climate diagrams of the last years (Fig. 72-75, appendix, p. 134) and the one presented by LAUMONIER (1997) (Fig. 22, p. 40) provide some supports for these reports. Yet, an analysis of climate patterns over a broader time span is needed to provide for solid background data for this assumption.

Climate change analysis and projections for Jambi are very rare and imprecise. KAIMUDDIN (2002, cit. after BOER & FAQIH 2004: 124) reported a general decrease in the mean annual precipitation for Jambi, based on mean rainfall data from two periods, 1931 to 1960 and 1961 to 1990. Clear evidence of precipitation change during rainy or dry season cannot be derived from this data. Future climate change is projected to bring an increase in annual precipitation across the majority of Indonesia's islands (HULME & SHEARD, 1999, qtd. in CASE, ARDIANSYAH & SPECTOR 2007: 4). In any event, other calculations project considerable variance in rainfall for different climate models. Parts of Sumatra, for example, might become 10 to 30 % wetter during the December-February season. Rainfall change during the June-August season is negative for some parts of Indonesia, but no changes could be observed for Jambi (cf. Fig. 82, appendix; HULME & SHEARD, 1999, qtd. in CASE, ARDIANSYAH & SPECTOR 2007: 4). Another analysis suggests that there is an increased likelihood that the annual monsoon could be delayed and would cause substantial decrease of rainfall during July-September (NAYLOR et al. 2007). But as the focus of that study lies in East and West Java, again no detailed projection can be given for Jambi.

Even if predictions about climate change are not specific, another development has to be taken into consideration. A very recent study by CAI et al. (2014) suggests that the occurrence of extreme El Niño events will double in the future, in response to greenhouse warming. The

shock of the last El Niño event in 1997/98 is still deeply rooted among all the villagers of Bungku due to the forest fires, crop failures and water scarcity that it produced. As most villagers asserted that in 1997 rivers and swamps hadn't yet decreased significantly, a future extreme El Niño event will probably have disastrous impacts on the village, including its water supply.

To sum up the different arguments in a personal conclusion, the most probable explanation for a decrease in water availability in Bungku can be attributed to the rapid large-scale deforestation. Especially in Bungku Indah where oil palm is not yet as dominant as in other village parts, changes of water availability might be attributable to deforestation activities and the subsequent increases of surface runoff. However, final results of $\delta^{13}\text{C}$ -measurements and other studies assessing soil degradation subsequent to deforestation have yet to be awaited. TARIGAN et al. (2014, in prep.) provided evidence that there are significant differences in streamflow fluctuation between rubber and oil palm catchments. Together with the results from other studies, these data show that after land use conversion the establishment of oil palm plantations might further aggravate soil degradation and thus contribute to lower groundwater recharge if no adequate soil and water conservation measures are taken. This might be especially important for Johor Baru where the landscape is dominated entirely by oil palm plantations and management practices of PT Asiatic Persada have often been criticized (cf. i.a. EI7 at the plantation department). The fact that more villagers reported of rivers running dry as opposed to the depletion of groundwater can probably be explained by the faster response of streamflow to rainfall events or the absence of these occurrences. Regarding the roles of specific characteristics of oil palms such as water use rates or root water uptake, further research is urgently needed to fully understand the hydrological processes in oil palm plantations. The effects of climate change on the local water supply in Bungku are difficult to separate as no detailed climate data is available. Yet, current projections demonstrate that climate change might further contribute to local water shortages.

9. CONCLUSION AND OUTLOOK

In conclusion, the initial research questions can be answered as followed: During the last twenty to twenty-five years residents of Bungku have observed a higher fluctuation of streamflow with particularly low dry season flows, a faster depletion of groundwater levels in their wells and an increasing pollution of surface waters. The explanations given for these changes are manifold. On any account, all of them were directly or indirectly related to the current land use change which has largely been driven by oil palm farmers and companies. Most importantly villagers blamed deforestation and high water use rates by oil palms for having caused water shortages during dry season. The experts interviewed, instead rather emphasized the pronounced influence of different agricultural practices on the local water balance. Pollution of surface waters was mainly attributed to erosion and high waste and waste water emissions to the environment. The local water supply is affected in a way that clean water has become extremely scarce during prolonged periods without rainfall. Subsequently, clean water has increasingly turned into a commercial commodity difficult to access. For individual households this implied that they have to spend significant amounts of money to purchase drinking water or that they had to collect water at distant springs. In any other case they would have exposed themselves to water of dubious quality. It is hard to specify when exactly clean water became scarce. Most people indicated that developments became problematic at the beginning of the 21st century, which coincides with the major boost in oil palm development in Indonesia (cf. Fig. 1, p. 6) and the decentralization process which has led to uncontrolled deforestation in large areas of Jambi (cf. DJOGO & SYAF 2004). However, the decrease of dry season flow and groundwater replenishment seems to be a gradual and ongoing process which coincides with gradual local deforestation trends (cf. Fig. 68, p. 112).

In order to evaluate future developments, some positive and negative factors should be taken into account. The attitude towards oil palm in Bungku is predominantly positive due to the low labor input requirements and high income generation from oil palm cultivation. Although the environmental impacts are widely acknowledged by the population, the positive factors of oil palm cultivation currently still outweigh any negative developments. Additional problems in the cultivation of other crops, like an increase in pests further contribute to this. The awareness of the importance of certain environmental management methods, such as refraining from herbicide application outside the weeded circle, gives some hope for the future development. In the end, though, not the smallholders but rather large oil palm

companies as well as independent farmers with large land possessions, e.g. in TaHuRa, will impact the environment the most. Additionally, environmental awareness alone does not necessarily lead to an environmentally sound management of plantations. Although people recognize the contribution of oil palm cultivation to increased water supply problems, their expectations for solutions lie with the government alone. Similar to other environmental problems, like climate change in Germany, many people know how to contribute to emission reduction but often prefer to await government decisions, especially as most of the blame is given to the big companies (in this case PT Asiatic Persada). In Jambi this attitude is even more problematic as law enforcement is very weak, making ongoing deforestation and disrespect of compulsory environmental management measures on oil palm plantations possible. Since increasing international demand for palm oil secures high palm oil prices and the soil remains productive enough to ensure profitable cultivation, the expansion of oil palm plantations is likely to continue in the future. An indicator showing that this land use development is not sustainable from a social point of view is the adaptation of the population to water scarcity. Despite this situation, in Bungku, the people's response remains purely reactive. While residents turn to buying bottled water, the village authorities consider digging drilled wells or opening a water depot. A real mitigation of the problem, it seems, has not yet been taken into account by any local stakeholder. Additionally, Bungku has to deal with several other problems related to the environment, most of all the lack of waste and waste water treatment. Although an adequate treatment would constitute an important measure in improving the water quality of surface waters, the priority given to this issue by the village authorities has been low (cf. Desa Bungku 2010).

The extent to which the increasingly difficult access to clean water will, in future, shape the village social structure depends mainly on two factors: the actions taken by the village government to secure local water supplies as well as the level of solidarity among the people themselves. On one hand, the rising expenses for water supply increase disparities between rich and poor and create dependencies for the poor or people with restricted mobility. On the other hand, it has to be acknowledged that oil palm as well as rubber cultivations have led to significant increases in household incomes. Today, most families own a motorbike or a car and can easily afford to buy bottled water for drinking and cooking. Social cohesion in Bungku seems to be strong regarding access to water during the dry season. However, during the period of field research no severe restrictions on water supply occurred so the full impact on society during extreme water scarcity cannot be completely understood. Additionally, in Johor Baru the atmosphere among SAD people and migrants is much tenser than in other

areas. People that were occupying land of PT Asiatic Persada during the last year have now, in part, been forced from their claimed land (cf. PARKER 2013; CONANT 2013). Thus, today many of them remain without access to land and possess hardly any other financial or physical capital. Any water scarcity in the next years will certainly affect them most severely.

With regard to the environment, it can be concluded that the drastic and rapid land use change that is taking place in Bungku and Jambi is definitely not sustainable and the long-term degradation of resources constitutes an urgent challenge. If the decreases in dry season flow observed by the people were indeed caused by intense soil degradation, these damages will be extremely difficult to repair. Until now, according to BRUIJNZEEL (2004: 206ff) no forest catchment experiment could prove an increase in dry season flow after reforestation. On the contrary, a further diminution of dry season flow was observed caused by the high water use rates of newly planted trees. Even if reforestation measures would slowly increase, water infiltration rates would still be outweighed by high water requirements (ibid.). The same goes for the restoration of riverbed areas. SALEMI et al. (2012) summarize in a review on riparian vegetation and water yield that riparian forest plantation or regeneration promoted reduced water yields.

In order to prevent a further increase in streamflow fluctuation and subsequent water shortages at the village level the most important step to be taken in Jambi is the strict protection of the last forest areas. Additionally much greater attention has to be paid on soil and water conservation on all monoculture plantations (oil palm and rubber). Measures that can be taken are manifold, ranging from the planting of leguminous cover crops, the use of organic fertilizer or soil protection by the use of frond piles (cf. TARIGAN et al. 2014, in prep.). Equal importance should be assigned to several governance aspects. Careful land use planning and watershed management is urgently needed to consider hydrological impacts of land use changes at the landscape level. A stricter regulation and control of management practices on oil palm plantations as well as agricultural training are further urgently needed. While Indonesia has recently declared that all oil palm plantations will have to comply with the principles and criteria of the Indonesian Sustainable Palm Oil certification system (ISPO) by 2015 (SUHARTO 2012), its success will depend a lot on monitoring and sanctioning in cases of non-compliance. The same goes for the certification by RSPO which has good intentions but seemingly often lacks strict monitoring.

Finally, it must be emphasized that hydrological processes are complex and depend on a number of local physiographic factors. Land use mosaics, demographic structures as well as

local water supply systems all work together, influencing the specific impacts of land use change for the water supply of rural societies. As this thesis is based only on a case study, the urgent need for further research on this issue has to be underlined. The scope of research should encompass such diverse disciplines as of natural scientists, in order to better understand the hydrological impacts of land use conversion and oil palm plantation establishment, as well as of social scientists, in order to investigate the vulnerability, resilience and adaptation of different rural villages and social groups.

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APPENDIX

Tab. 10: Environmental impacts observed by all stakeholder groups in each research site (% of respondents reporting issues of concern)

Parameter	Site 1 (n = 137)	Site 2 (n = 150)	Site 3 (n = 97)
Decreased water quality	32%	50%	58%
Decreased water quantity	18%	79%	50%
Decreased forest cover	69%	70%	53%
Increase in crop pests	5%	22%	22%
Air pollution	7%	28%	37%
Soil erosion	53%	5%	33%
Soil stabilization	15%	23%	8%
Increase in human disease	24%	27%	31%
Flooding	0%	44%	0%

(OBIDZINSKI et al. 2012)

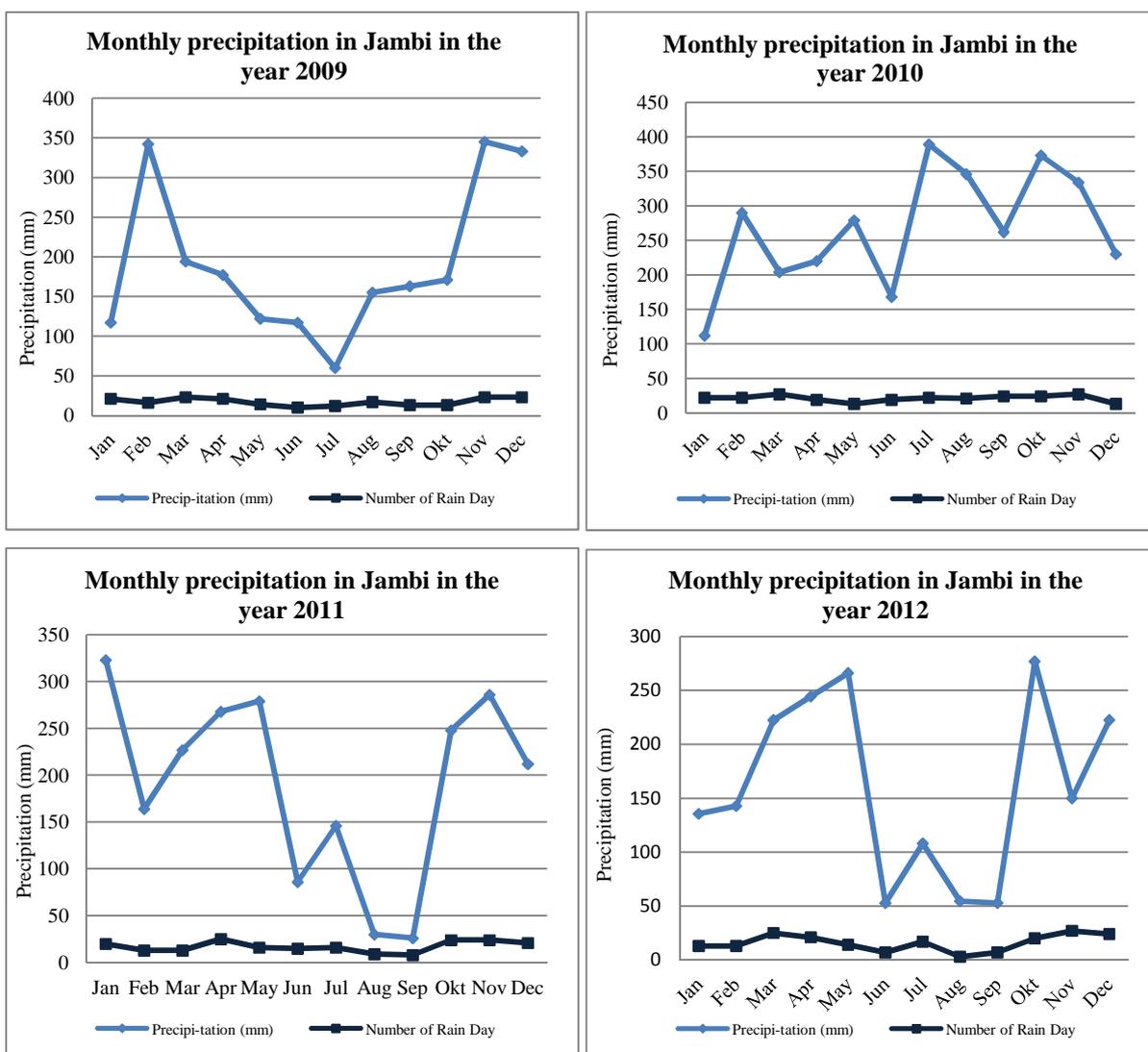


Fig. 72, Fig. 73, Fig. 74, Fig. 75: Monthly precipitation in Jambi during the years 2009-2012 (at Sultan Thaha Climate Station) (BPS Jambi 2009, 2010, 2011, 2012) (annual precipitation: 2009: 2296 mm; 2010: 3207 mm; 2011: 2295 mm; 2012: 1928.5 mm)

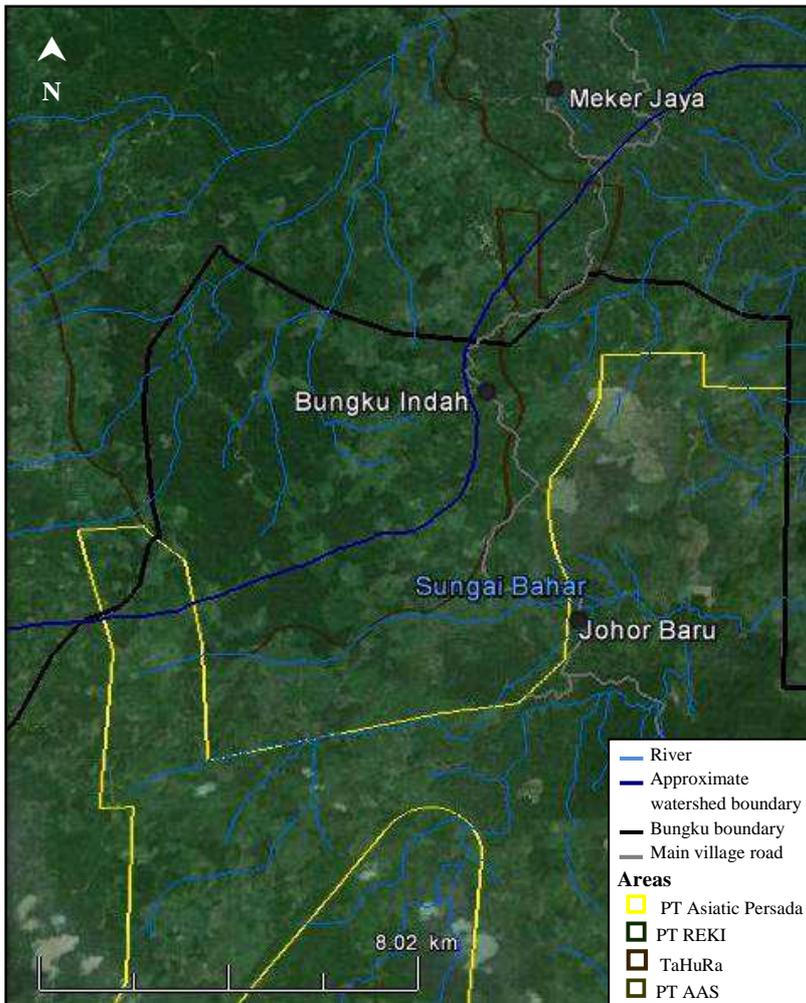


Fig. 76: Watershed of Bungku (base map: Google Earth 2013; data: Zuhdi (based on Landsat 2000), GADM, Peta Rupa Bumi Indonesia (Bakosurtanal); Cartography: Jennifer Merten)

4. Water resources

- Has the annual pattern of precipitation changed over the last 10 years? (Yes/No)*
- If yes, please tick which are the months that are getting:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
More rainfall than 10 years ago?												
Lesser rainfall than 10 years ago?*												

* If the household was not in the village 10 years back, avoid this question.

4.1. Drought

a) Are droughts/seasonal water shortages an issue in the region? (Yes/No)

If yes, in which months do they usually occur?

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
At present												
10 years back*												

Please tick the columns below the months.

* If the household was not in the village 10 years back, avoid this question.

b) Intensity of drought in the abovementioned months (Code)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
At present												
10 years back*												

Code: No drought = 0; Slight = 1; Moderate = 2; High = 3; Extreme = 4.
 * If the household  was not in the village 10 years back, avoid this question.

Fig. 77: Excerpt of the household survey questionnaire (EFForTS-CRC 990 subproject C07)

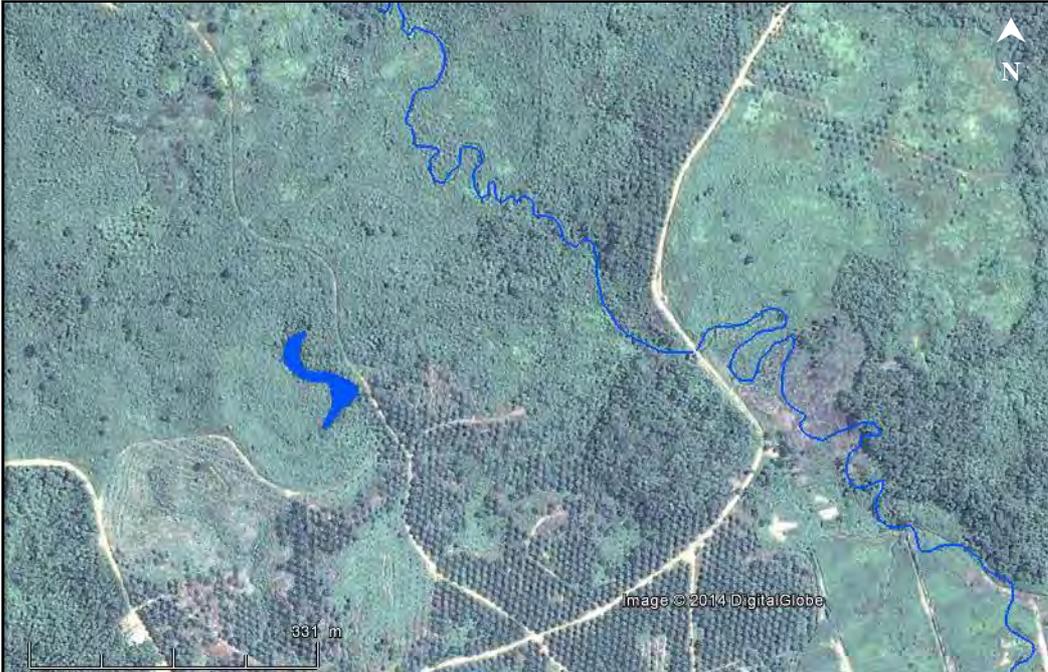


Fig. 78: A satellite image of the year 2002 shows surface waters in Johor Baru prior to the establishment of the oil palm plantation by PT Asiatic Persada (modified after Google Earth 2002) (apparent water resources were traced in blue)



Fig. 79: A satellite image of the year 2007 shows surface waters in Johor Baru after the establishment of the oil palm plantation by PT Asiatic Persada (modified after Google Earth 2007) (apparent water resources were traced in blue)



Fig. 80: A satellite image of the year 2002 shows recently burned land near Bungku (Google Earth 2002)

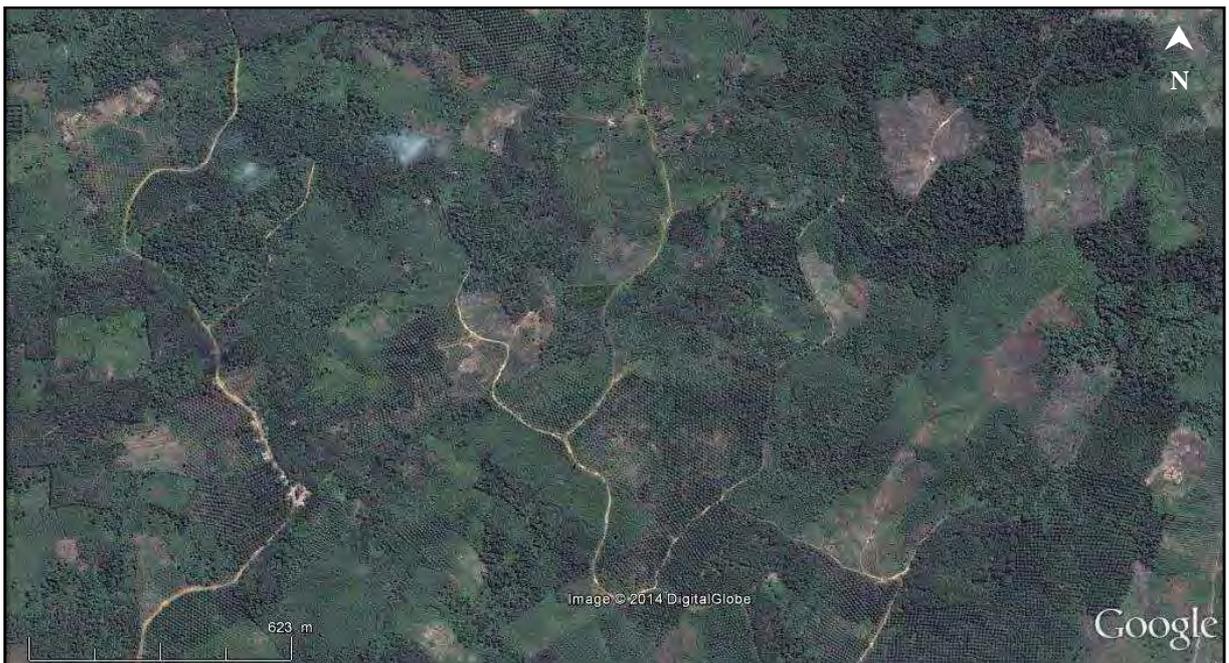


Fig. 81: A satellite image of the year 2007 of the same area showing the establishment of oil palm plantations on formerly burned land (Google Earth 2007)



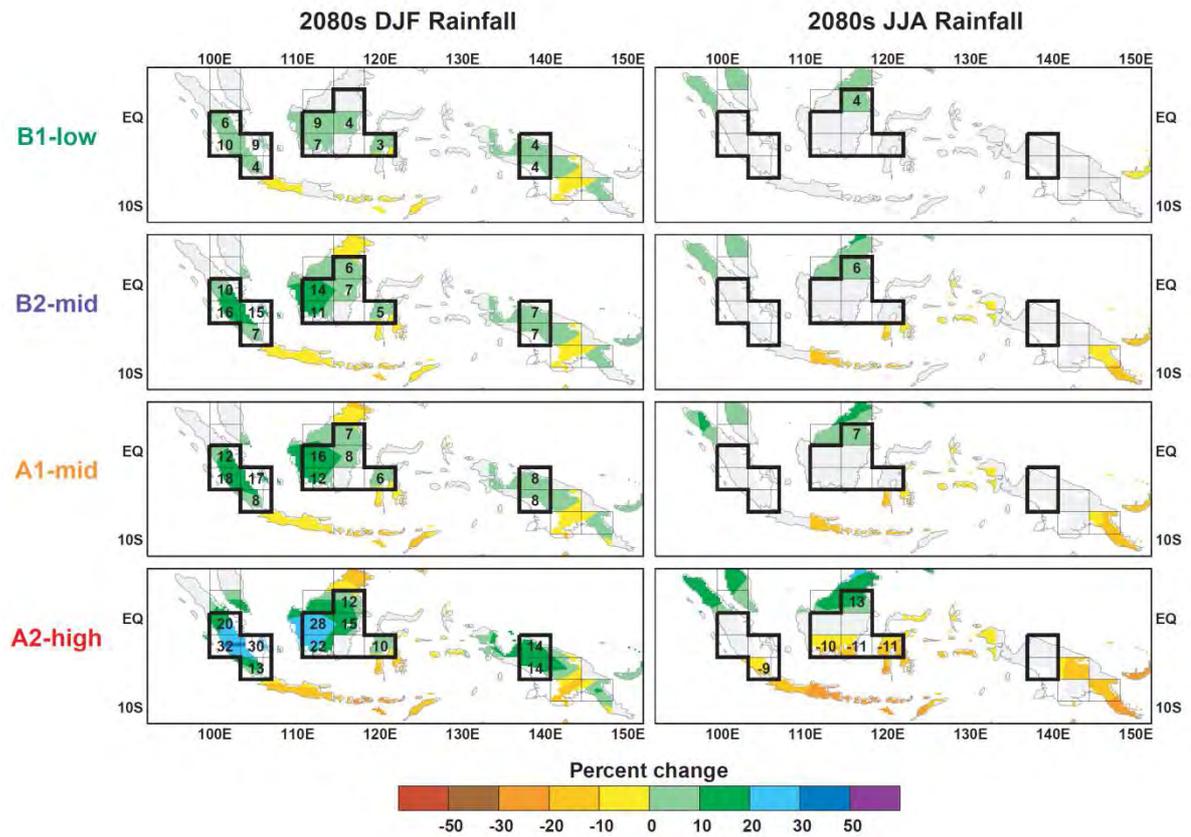


Fig. 82: Change in December-February and June-August rainfall (per cent change from the average 1961-90 climate) for the 30-year period centered on the 2080s for the four scenarios (HULME & SHEARD 1999).

Interview guideline for household interviews in Bungku

1. Household characteristics

- 1.1. When were you born?
- 1.2. What is your ethnical and religious background?
- 1.3. Where were you born?
- 1.4. For how many years have you lived in Bungku? / When did you move to Bungku?
 - 1.4.1. Why did you move to Bungku?
- 1.5. What is your occupation?
- 1.6. How many years did you go to school?
- 1.7. How many people live in this household? When were they born?
- 1.8. What is the occupation of the other household members?
- 1.9. Do you own land? If yes, how much?
- 1.10. Which crops do you cultivate at the moment?
 - 1.10.1. When did you start cultivating them?
- 1.11. Have you cultivated other crops in the past?
 - 1.11.1. If yes, which and for how long?
 - 1.11.2. Why did you change?
- 1.12. Do you have any other sources of income? (*animals, business...*)
- 1.13. What is the average income of your household? (*ask at the end of the interview*)
 - 1.13.1. If not known / understood: What is your personal average income? / What is your income per hectare?

2. Land use and environmental change

- 2.1. How would you describe your dusun and the area surrounding it when you first came here?
- 2.2. What do you consider important changes in your dusun and the area surrounding it since you came here?
 - 2.2.1. *If not understood, give examples: number of people living here, crops being planted, forest area etc.*
 - 2.2.2. When did that change?
 - 2.2.3. Have there been any special events that led to a rapid change in the village?
- 2.3. Have there been any animals that you do not see anymore today?
 - 2.3.1. When did they start to disappear?
- 2.4. What did the oil palm development change for you and the village in general?
- 2.5. What is the consequence for you that the forest is gone?
- 2.6. What do you consider to be a major environmental problem in your dusun? / What is the consequence for you that the forest is gone?
- 2.7. How would you describe the rivers or ponds/lakes in your dusun when you first came here?
 - 2.7.1. Did you notice any changes in them? If yes, please describe.
 - 2.7.2. Where and since when did you observe these changes?
 - 2.7.3. What do you think is responsible for the changes in the water resources?
 - 2.7.3.1. *If not understood: Did you notice any changes in quantity or quality of the water?*
 - 2.7.4. Did you notice any changes in the surrounding of the river? (*e.g. vegetation, soil*)
- 2.8. Did you notice any changes in the temperature or rain since you moved here? If yes, Please describe.

- 2.8.1. *If not answered yet:* Have you noticed any changes of time and length of dry and rainy seasons?
- 2.8.2. If yes, why do you think the climate has changed like that?

3. Water Supply

- 3.1. How does water supply work in Bungku?
 - 3.1.1. Does everybody have a well? If not, who does not?
- 3.2. What do you consider to be major problems for the water supply in Bungku?
 - 3.2.1. Have these problems always existed?
 - 3.2.2. If not, when did these problems arise?
 - 3.2.3. Can you imagine why that became a problem?
- 3.3. Where do you get your water from?
 - 3.3.1. If from a well: How deep is it? Is it made of soil, cement or wood?
- 3.4. Where did you get your water from when you first came here?
 - 3.4.1. If different than today: Why did you change that?
- 3.5. How do you evaluate the current water quality?
 - 3.5.1. Has it always been like that?
 - 3.5.2. If not, when did it change?
 - 3.5.3. Is the water quality different in rainy and in dry season?
- 3.6. Do you buy bottled water?
 - If yes,*
 - 3.6.1. What do you use it for?
 - 3.6.2. Why do you use water per gallon? (*instead of using water from well/river*)
 - 3.6.3. Since when do you buy it?
 - 3.6.4. How many gallons do you buy per week?
 - 3.6.5. Does the amount of gallons you use differ between dry and rainy season?
- 3.7. For what do you use the water of your well?
 - 3.7.1. Do you drink it?
 - 3.7.2. Do you use it for cooking?
- 3.8. Where does your waste water go?
 - 3.8.1. Is it being treated? If yes, how?
- 3.9. What do you do with your garbage?

4. Water supply dry season

- 4.1. Does your well run dry during dry season?
 - If yes,*
 - 4.1.1. After how many months without rain does your well run dry?
 - 4.1.2. Does it run dry completely or is there still some water in the well?
 - 4.1.3. Did it always run dry or did that change?
 - 4.1.4. How often does your well run dry?
 - If no,*
 - 4.1.5. Is the water still enough for the daily needs of your family?
- 4.2. Do some wells in the village run dry faster than others?
 - 4.2.1. If yes, which? Can you imagine why?
- 4.3. Do wells also run dry in other villages around Bungku?
- 4.4. Where do you get your water from if your well runs dry?
 - 4.4.1. Is that the same for drinking and cooking water?
 - If water is being collected:*
 - 4.4.2. Where do you get water?
 - 4.4.3. How do you get there?

- 4.4.4. How often do you get water?
- 4.4.5. Who is responsible for collecting water?
- 4.5. Did you ever take water from other wells?
 - 4.5.1. How do people prevent that not too many people take water from their well?
- 4.6. Did you always get your water from... during the dry season or has that changed since you moved here?
- 4.7. How do you prevent water shortages?
 - If not understood....*
 - 4.7.1. Do you collect rainwater? If yes, did you always do that?
 - 4.7.2. Did you ever buy water from a tank? If yes, when and why?
- 4.8. Have you experienced periods of serious drought or floods?
 - 4.8.1. Do you remember when that was?
 - 4.8.2. For how many months didn't it rain at that time?
 - 4.8.3. Did the flooding cause any damage in the village?
 - You said, that in dry season you have to take water at....*
- 4.9. Do all people get their water there?
 - 4.9.1. Who not? Why? Where do they get there water?
- 4.10. What do people without motorbike do?

5. Livelihood Impacts

5.1. Evaluation of impacts of changed water resources at household level

Before you have told us that certain things regarding water supply, water resources have changed since you moved here...

- 5.2. How do these changes in water resources affect your daily life?
 - 5.2.1. *If no answer:* Do you have to use less water for your daily activities?
- 5.3. What do you do to reduce these impacts?
- 5.4. Are there further measures you would like to take to cope with these changes?
 - 5.4.1. If yes, what hinders you in taking these measures?
- 5.5. Do households exist that are impacted more severely than others?
 - 5.5.1. If yes, why is that? What characterizes these households?
- 5.6. Can you describe how droughts and floods have impacted your household in the past?
 - 5.6.1. What did you do to reduce the impacts?
- 5.7. How do you think bad water quality could influence your health?
 - 5.7.1. *If answer given:* Did you notice any health problems with your household members?
- 5.8. Have you observed or heard of any conflicts about water in your dusun? If yes, please explain.

6. Water management (for independent farmers only)

- 6.1. Do you apply fertilizer, herbicides and or pesticides on your plantation?
 - 6.1.1. If yes, please describe type and quantity used.
 - 6.1.2. How often/when do you apply?
 - 6.1.3. Do you consider rain in the application of...?
 - 6.1.4. Does the time of application differ during dry and wet season?
- 6.2. How do you ensure that the plantation gets enough water during the dry season?
- 6.3. Could you please describe the vegetation on the soil in your plantations?
 - 6.3.1. Is it planted or naturally grown?
- 6.4. Are there any other crops grown in your plantation, apart from the main crop?
 - 6.4.1. If yes: Are they grown separately or mixed?

- 6.5. Are there any rivers or lakes/ponds on your plantation?
 - 6.5.1. Could you please describe the vegetation growing around the river/lake?
 - 6.5.2. *If plantation is not reaching the water:* How many meters of natural vegetation do you leave between the water and the plantation?
- 6.6. *If the plantation has a steep slope:* Did you build terraces on your plantation?
- 6.7. Is your harvest the same in dry and rainy season? If not, how much is it less in....?
- 6.8. Did you observe any changes in the productivity of your crops since you came here?
 - 6.8.1. If yes, since when? Why do you think this has changed?

7. Future development

- 7.1. How do you think water resources will change in the future?
- 7.2. Do you think there is a need to improve water management in your dusun?
 - 7.2.1. If yes, where do you think is a lack of action?
 - 7.2.2. *If no answer yet:* What would make it easier for you to access clean water?
- 7.3. Whom do you regard responsible for solving these problems? Please explain.

For independent farmers only:

- 7.4. Can you imagine that certain management methods in the plantations could decrease water problems?
 - 7.4.1. *If not understood, give examples: planting ground cover crops or intercropping of other trees*
- 7.5. If certain management methods like intercropping or ground cover crops would improve water problems, would you consider changing your cultivation methods?
- 7.6. Would you be willing to accept an initial investment or a decrease in yields when changing to these management methods?

DECLARATION OF ORIGINALITY AND CERTIFICATE OF OWNERSHIP

I, Jennifer Merten, hereby declare that I am the sole author of this thesis entitled „Land use change and rural water supply in the tropics. Perceptions and impacts of oil palm expansion in Sumatra, Indonesia." All references and data sources that were used in the thesis have been appropriately acknowledged. I furthermore declare that this work has not been submitted for a higher degree to any other University or Institution.

Göttingen, March 21st, 2014 _____

(Jennifer Merten)