Kuroshio Science **8**-1, 7-14, 2014

The Impacts of the Alteration in Agriculture on the Environment and Ecosystem in Sarawak, Malaysia

Sota Tanaka[1*], Mohd Effendi bin Wasli[2], Joseph Jawa Kendawang[3], Katsutoshi Sakurai[4]

[1] Kuroshio Science Unit, Multidisciplinary Sciences Cluster, Research and Education Faculty, Kochi University, Nankoku, Kochi 783-8502, Japan

[2] Department of Plant Science & Environmental Ecology, Faculty of Resource Science & Technology, Universiti Malaysia Sarawak, Kota Samarahan, Sarawak 94300, Malaysia

[3] Sarawak Planted Forest Sdn Bhd, Kuching, Sarawak 93660 Malaysia

[4] President Office, Kochi University, Kochi 780-8520, Japan

Abstract

In Sarawak, Malaysia, while large scale oil palm plantations have been rapidly expanding, shifting cultivation has been altering toward more intensified systems or reducing in its area or activities. Some local farmers prefer planting commercial crops such as rubber, pepper and oil palm rather than their traditional crop of upland rice. Issues relating to the influence of shifting cultivation and oil palm plantation on the environment and ecosystem are still disputable because the discussion is usually based on the stereotypical views lacking ecological evidence. In this keynote report for the 7th International Symposium on Kuroshio Science, several topics are presented related to the impacts of shifting cultivation and oil palm plantations on the environment and ecosystem in Sarawak, Malaysia, based on previous studies. We emphasize that further field research is needed with collaboration between multi-disciplinary international researchers to provide empirical data in order to reach conclusions and resolve the issues.

Key words: cash crops, oil palm plantation, Sarawak, shifting cultivation, soil fertility

Introduction

In Sarawak, Malaysia, while shifting cultivation is a traditional and primary form of agriculture for local farmers, large-scale oil palm plantations have been rapidly expanding. The impacts of this type of agriculture on the ecosystem, environment and society have been discussed widely but with opposing views, respectively; while shifting cultivation has been regarded as being a regressive type of agriculture and is believed by the government and forestry sector and occasionally by international organizations (such as the FAO) to cause tropical forest destruction and soil degradation, it has been positively accepted as a sustainable, environment-friendly, and highly resilient form of agriculture with fewer negative influences on tropical ecosystems and integral parts of culture and customs in local societies, in particular, by anthropologists and social scientists as well as related NGOs (Chin 1985; Crumb 1993, 2007). While conservationists and NGOs have strongly blamed the oil palm industry as being the main cause behind tropical forest destruction, the degradation of soil fertility, environmental pollution, biodiversity losses, land rights conflicts, human rights violation, and the collapse of indigenous cultural practices (Ngidang 2002; Cooke 2002; Fitzherbert 2008), the government, industries and stakeholders have praised the palm oil production because of its sustainable and careful management with high use-efficiency of input, lower costs and higher oil productivity as well as longer life-span and smaller land requirements compared with other edible oil and biodiesel production (Weng 2005; Basiron 2007).

However, most of such views come from a rather stereotyped impression, occasionally lacking in any ecological evidence, which brings about antagonism between the two sides and creates obstructions to solving the problems connected with these different forms of agriculture and with forest conservation. In this keynote report for the 7th International Symposium on Kuroshio Science, several topics are presented related to the

*e-mail address: sotatnk@kochi-u.ac.jp, Tel & Fax: +81-88-864-5183

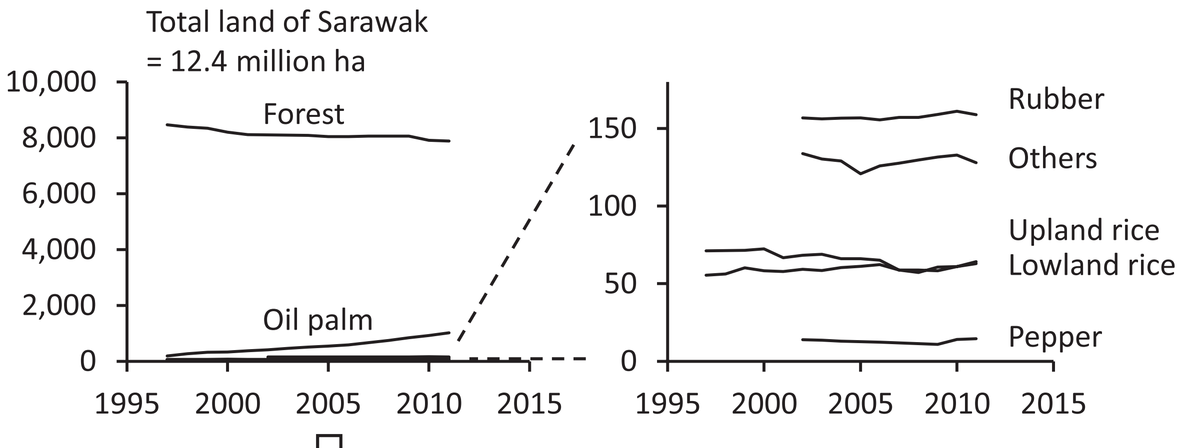
impacts of shifting cultivation and oil palm plantations on the environment and ecosystem in Sarawak, Malaysia, based on the previous studies.

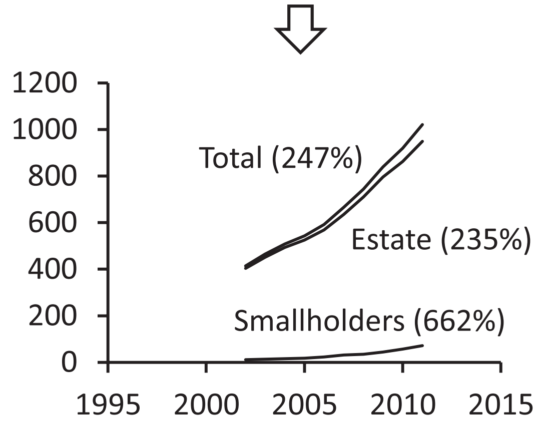
1. Alteration of agriculture in Sarawak

Based on Crumb (2007), the history related to the agriculture in Sarawak can be summarized briefly as follows. In the 16th century, the Iban, the biggest tribal group in Sarawak, migrated from West Kalimantan, leading to a rapid increase in the population, and the expansion of shifting cultivation with upland rice (*Oryza sativa*) as the main crop for subsistence. Pepper (*Piper nigrum*) and para rubber (*Hevea brasiliensis*) were introduced to Sarawak in 1870s and in 1900s, respectively; the important characteristics of these crops is that they were planted mainly on a small scale by local farmers as their main cash crops, unlike elsewhere where the crops are planted on a relatively large scale. The first form of effective regulation of shifting cultivation began with two laws, a forest ordinance enforced in 1953 and a land code put into practice in 1958. Commercial logging started to expand several decades later, in the 1970s. While a large scale oil palm (*Elaeis guineensis*) plantation was started in the 1980s by the governmental sector and in the 1990s by private companies, smallholders also began to choose to plant this crop since the beginning of the 21st century in cases where their lands were located close to a palm oil mill factory (Hansen and Mertz, 2006). In contrast, for peoples living in interior regions of the island, ecotourism developed and is currently the most popular activity for earning cash income.

Based on recent statistics (Department of Agriculture Sarawak), among the total area of 12.445 million ha, forests and farmlands consisted of 7.887 million ha and 1.45 million ha, respectively in 2011 (Fig. 1). Although the smallholder's agriculture with ordinary crops such as rice, pepper, para rubber, vegetables and fruits have stagnated in terms of area size, oil palm fields are expanding quite rapidly, and accounted for 71% of total farmlands in 2011. It should be noted that in spite of only occupying 7.0% of the total land area in 2011, the growth rate of oil palm fields of smallholders from 2002 to 2011 is 660 % compared with 235% for the estates.

Hansen and Mertzs (2006) investigated the alteration of agriculture in two villages, Rh. Ranggong and Nanga Sumpa. The former is located in the Miri Division. In the 1970s, local farmers relied on shifting cultivation for their subsistence. Later, in the 1980s, the area of shifting cultivation expanded along newly constructred logging





Agriculture land in 2011

	x1000 ha	% in total
Oil palm	1,022	70.5
Lowland rice	63	4.3
Upland rice	64	4.4
Pepper	15	1.0
Rubber	159	11.0
Others	128	8.8
Total	1,450	

Figure 1. Agricultural lands of Sarawak (x 1000 ha). Data source: Department of Agriculture Sarawak.

roads that were initiated by the commercial logging industry. Oil palm plantations developed on a large scale in the 1990s and expanded very rapidly, inducing local farmers to plant this profitable crop on their lands as oil mills buy the fruits and provide good income. Although large scale oil palm plantations were blamed before the year 2000, the situation has now changed with the participation of stallholders as producers. This alteration has resulted in the depression of shifting cultivation areas and activities. A number of farmers abandoned their shifting cultivation practices. Meanwhile, Nanga Sumpa was located in the upper Batang Ai area, a region not affected by oil palms. This place can be regarded as a hot spot of shifting cultivation because it was the first area of settlement for the Iban in Sarawak. However, although most of the farmers continued shifting cultivation practices until now, the sites for shifting cultivation were moved to nearby rivers and streams because of the lack of manpower due to the enthusiasm for ecotourism as the most important income activity. The river provided convenient accessibility to farming sites because river traffic dominated by small boats was still the main transportation system. As a result, shifting cultivation in Nanga Sumpa was conducted within a limited area close to river systems, resulting in intensified management with a longer cropping period and a shorter fallow period. Meanwhile, some of the remote sites were not used and remained as old secondary forest.

Although Hansen and Mertzs (2006) provide contrasting examples of regions with and without the influence of oil palm plantation, all shifting cultivation practices in Sarawak have been changed by the intricate relationship between land and labor shortages. The land shortage is ascribable to the expansion of forest logging concessions and oil palm plantations as well as the expansion of farmlands of local farmers for cash crops and the preferential use of lands near roads and rivers. Meanwhile, the labor shortage is due to enthusiastic cash crop farming, tourism and labor migration. A more developed infrastructure, an improved access to markets and compulsory education also have affected the changes.

2. Does the intensification of shifting cultivation lead to the degradation of soil fertility and the collapse of the system?

It is widely believed that the intensification of shifting cultivation causes the degradation of soil fertility and eventual collapse of the system. This topic is discussed based on the series of our studies for clarifying the site selection method for shifting cultivation used by the Iban (Tanaka *et al*. 2007a, b; Wasli *et al*. 2009). For the site selection method, many researchers have reported that various ethnic groups in Borneo Island investigate vegetation conditions of fallow forests to estimate land fertility and suitability when selecting new farming sites for shifting cultivation practices. In the case of the Iban, Padoch (1982) briefly noted that the Iban examine the species composition and the growth condition of secondary forests for site selection because of their ignorance of fallow duration and prior land use history.

This study was conducted in the Engkari and Mujong regions. These regions have similar environmental conditions such as a high annual precipitation exceeding 3,000 mm, an undulating hilly terrain and soils derived from sedimentary rocks. In both regions, most transportation takes place via the network of river systems and trails. However, the histories of migration and settlement are different; Engkari is one of the first places settled by the Iban who migrated from west Kalimantan while Mujong is relatively new, being where the Iban migrated in the early 19th century. Regarding shifting cultivation practices in Engkari, Padoch (1982) reported that in earlier times the system was characterized by one year cropping for rice with four to more than 16 years of fallow. Primary forest no longer remained. In contrast, according to our study conducted in 2005 to 2006, the shifting cultivation system was intensified with one to five years cropping followed by about five years of fallow. Continuous cropping without fallow was occasionally conducted. Remote lands were no longer used. The use of chemical fertilizers and herbicides were common practices. On the other hand, the shifting cultivation in Mujong reported by Freeman (1955) was one to three years cropping followed by fallow of more than 15 years. However, he also reported that the Iban there preferred to use primary forest because their customary law considers land tenure as being established by a household through felling primary forests. In contrast, our study from 2003 to 2004 revealed that the shifting cultivation was one year cropping followed about 10 years of fallow, which was similar to that reported by Padoch (1982) in the Engkari region. The use of chemical fertilizers and herbicides and the farming of para rubber and pepper were common but to a lesser extent compared with the Mujong region. Thus, the current shifting cultivation systems in Engkari and Mujong can be regarded as being intensified and still relatively traditional types, respectively.

According to interviews with Iban residents, the criteria used to select their farming sites in terms of fallow vegetation were the same in both regions. These criteria included trees with a stem diameter greater than a person's waist size (after 10 to 20 years of fallow), and the presence and healthy growth of indicator plants with dark green leaves. After such interviews, a field survey on vegetation and soils was conducted. During the field survey, we asked the Iban to bring us to their fallow land, and they classified the site into two types, suitable and unsuitable sites for shifting cultivation. Figure 2 depicts the result for the diameter of trees at breast height (DBH). While the DBH in Mujong was larger in the suitable sites than the unsuitable sites, no appreciable difference was found in the DBH between these categories in the sites in Engkari. The result indicates that in spite of the intensification of shifting cultivation, the Iban in Engkari still possessed perception and traditional knowledge for land evaluation and site selection. However, such knowledge was no longer practically important for the Engkari Iban. The Iban in Engkari seemed to put more priority on accessibility, resulting in the more intensive use of the lands close to the river or their residences. A memory of high production might also be an important criterion.

In both Mujong and Engkari regions, the soil properties did not differ between the suitable and unsuitable sites (Table 1). This result suggests that even though shifting cultivation was intensified, as was the case in Engkari, soil fertility itself was not appreciably degraded during the short term of one or two decades that was investigated. However, in the case of Mujong, taking into consideration the difference in the DBH of trees, more ash input, which is critical for the success of rice farming in shifting cultivation, could be expected in the suitable sites than the unsuitable sites. In this context, land fertility, but not soil fertility, can be regarded as higher in the suitable sites. Another important is the difference in soil properties between Mujong and Engkari. The soils in Engkari were more acidic with less nutrient contents than those in Mujong. This means that assuming that the original soil conditions were identical between the two regions, soil fertility would have gradually been degraded by repeated use of the land during the long history of settlements. However, even so, the fact is that

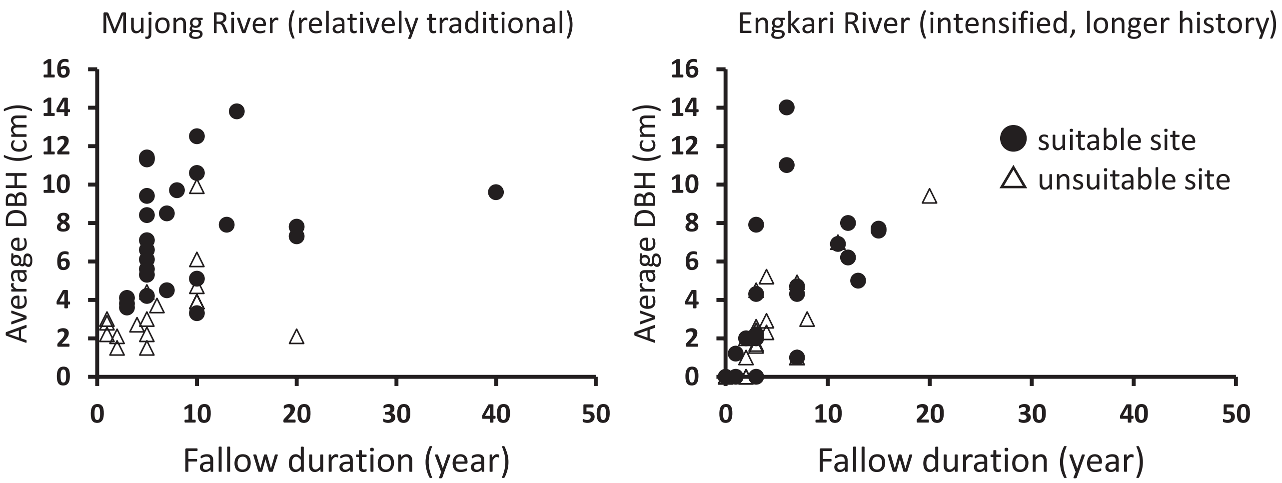


Figure 2. Comparison of average DBH (diameter of trees at breast height) between the suitable and unsuitable sites for shifting cultivation.

Table 1. Comparison of physicochemical properties of the surface 0-10 cm soils in suitable sites and unsuitable sites for shifting cultivation in Mujong and Engkari regions.

		Mujong River (relatively traditional)		Engkari River (intensified, longer history)	
		Suitable sites	Unsuitable sites	Suitable sites	Unsuitable sites
pH (H_2O)		5.0	4.9	4.4	4.4
Total C	**(g kg^{-1})**	32.1	32.5	31.5	35.1
Total N	**(g kg^{-1})**	2.75	2.51	2.02	2.2
C/N ratio		11.6	13.2	15.2	15.8
Exchangeable Ca	**($cmol_c$ kg^{-1})**	0.83	1.05	0.15	0.23
Exchangeable Mg	**($cmol_c$ kg^{-1})**	0.79	0.74	0.12	0.26
Exchangeable K	**($cmol_c$ kg^{-1})**	0.28	0.2	0.24	0.21
Available P		8	30	15	20
Clay	**(%)**	42	38	38	42

the collapse of the shifting cultivation system was not observed in Engkari. Crop production is likely to be sufficiently supported by chemical fertilizers instead of ash addition.

3. Which type of crops have more influence on soil properties and the environment?

As mentioned above, in Sarawak, in addition to rice plants and oil palm trees, pepper vines and para rubber trees are planted extensively as cash crops for local farmers. The alteration, present situation and related problems of upland agriculture in Sarawak have been studied mostly from socioeconomic viewpoints (Best, 1988; Cookie, 2002; Ngidang, 2002; Hansen, 2005; Crumb, 2007). However, in spite of numerous field trials to optimize land management practices including fertilizer application for each cash crop (Broughton 1977 for rubber; Raj 1972 for pepper; Agamuthu and Broughton, 1985 and Khalid *et al.,* 2002 for oil palm), no attention has been paid to how differently cash crop farming practices might influence soil fertility and the environment. Despite the lack of information, it is widely believed that oil palm plantations cause more degradation of soil fertility and environmental pollution, as compared with other farming by local farmers.

In this section, based on our previous study (Tanaka *et al.,* 2009), the influence of various types of crop production on soil properties and the environments is discussed. Compared with well-established rubber plantations elsewhere, the rubber farming by smallholders in Sarawak can be characterized by less intensive management, for example, lower amounts of fertilizer application upon planting as well as less clearing of underbrush, pathways being only made upon tapping, occasionally resulting in vegetation cover similar to secondary forests connected with shifting cultivation cycles. On the other hand, pepper farms are managed intensively with a relatively high rate of periodical fertilizer application below the canopy and complete weeding manually or with herbicides for the entire field. For oil palms, fertilizers, particularly on large-scale plantations, are applied at a radius of about 1 to 2 m around each palm tree. Weeding is conducted in some areas of the field to make passage for the workers, otherwise fronds pruned at harvest time are piled on to cover the soil surface. In case of a steep slope, terraced benches are constructed to prevent erosion and to allow workers to work more easily and safely.

Figure 3 gives a comparison of total N, available P and exchangeable K between soils in secondary forests, para rubber farms and pepper farms of local farmers and in a large scale oil palm plantation. The levels of these properties under para rubber farming were almost identical to those under secondary forests and the soil properties in both secondary forest and para rubber farming did not appreciably fluctuate in terms of age after fallow and tree planting, respectively (therefore, the averages are given in the figure). The levels, in particular, of available P and exchangeable K were absolutely low, which is typical for soil in a tropical humid climate. On the other hand, the soil under pepper farming showed increases in the levels of these properties with planting age not only below the canopy where fertilizers were applied but also between pepper vines without fertilizer application. In case of the oil palm plantations, the soil collected below the canopy with fertilizer application showed the increase in these properties with increasing planting ages while the soil collected between palm trees did not show appreciable changes. These results indicate that in regard to nutrient levels, soil fertility was not degraded but improved by pepper farming and oil palm farming compared with secondary forest and para rubber farming. However, in the case of pepper farming, as local farmers don't know soil nutrient conditions and believe that more fertilizer application provides more pepper yield, excessive amounts of fertilizers tend to be applied, leading to excessive accumulation of nutrients in soil. The increase in nutrient levels between the vines suggests that a portion of fertilizer nutrients are eroded from points along slopes below the canopy and that eroded nutrients may cause water pollution if water flow from farmlands is connected to river systems. In this sense, pepper farming may exert more influence on the surrounding environment than oil palm plantations although, of course, the difference in farmland size between stallholders and plantation should be taken into consideration.

4. Lack of ecological information about the impact of oil palms

Oil palms are one of the main concerns in the tropics in regard of biodiversity, forest conservation and global climate change. Therefore, one may believe that many studies have been conducted on oil palm plantations. However, even quantitative estimation of the extent to which oil palms have been a direct cause of deforestation is not an easy task because of a lack of reliable data on land cover change and an incomplete understanding of the complex causes of deforestation (Fitzherbert *et al.,* 2008). Turner *et al.* (2008) investigated the number of publications on oil palms by using the ISI Web of Science to assess the changing focus of

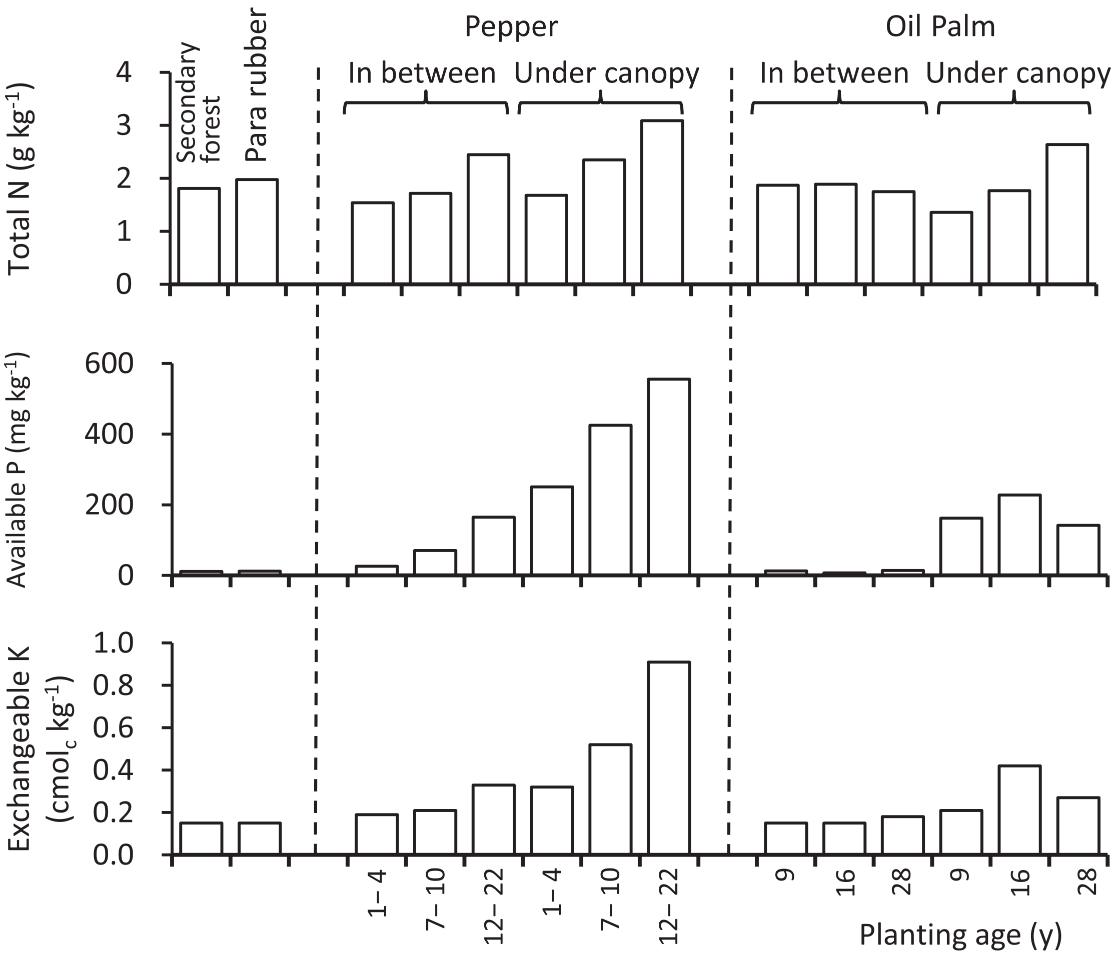


Figure 3. Total N, available P and exchangeable K of the sorface 0-10 cm soils under secondary forest, para rubber and pepper farming and oil palm plantation. The data of secondary forest and para rubber is the average of the sites after two to 44 years of fallow and after two to 60 years of planting, respectively.

oil palm research since 1970. They found a dramatic increase in the number of oil palm research papers, more than 3,000 during 1970 to 2006. However, most of them were related to food and the resultant health issues (22.19% of total, 678 publications) as well as industry improvements, oil palm biology, chemistry, engineering and biotechnology. In contrast, the number of publications on biodiversity (0.75% of total, 23 publications) and other environmental issues (2.06% of total, 63 publications) has been extremely low. These authors continued the investigation from 2007 to 2010 and found 1,722 new publications (Turner *et al*., 2011). Although with recent global trends, there has been a substantial increase in the number of publications on biofuel (280 papers, 16% of the total) and alternative uses of palm oil (153 publications, 9%), new publications on biodiversity and conservation (71 papers, 4%) and the environment (the figures not shown in the text) were still limited. Furthermore, the literature survey on biodiversity by Fitzherbert *et al*. (2008) could find no published studies of plants but only 13 of animals. Although they pointed out that biodiversity in oil palm plantations is certainly lower than that in primary forests, the number of studies which compare the extent of the influence of oil palms with other forms of land use such as rubber and pepper farms is quite lacking. As mentioned above, in terms of nutrient condition of soils, nutrient analyses in most cases have been conducted on a fertilizer trial basis with the aim at optimizing fertilizer efficiency and improving fruit and oil production. Since these studies were not concerned with nutrient dynamics in the plantation ecosystems, the impact of oil palms on surrounding environments such as freshwater and marine ecosystems cannot be clearly understood.

5. Concluding remarks

Agriculture in Sarawak has been changing very rapidly. An estimate of the global demand for edible oils (excluding biofuels) in 2050 is 240 million tons, corresponding to additional 12 million ha lands required for oil palms (Corley 2009). This enormously increasing demand seems to be an undeniable fact although estimated figures may fluctuate. However, the information about the impact of the alteration in the agriculture on the environment and ecosystem is still quite lacking as is shown in this paper. Further research is needed with collaboration between multi-disciplinary international researchers to provide empirical field data in order to help resolve the issues regarding shifting cultivation and oil palm plantations in Sarawak and also Kalimantan, Indonesia.

References

Agamuthu, P., and Broughton, W.J. (1985). Nutrient cycling within the developing oil palm-legume ecosystem. Agriculture, Ecosystems & Environment 13, 111-123.

Basiron, Y. (2007). Palm oil production through sustainable plantations. European Journal of Lipid Science and Technology 1019, 289-295.

Best, J.R. (1988). Change over time in a farming system based on shifting cultivation of hill rice in Sarawak, Malaysia. Agricultural Administration & Extension 29, 69-84.

Broughthon, W.J. (1977). Effect of various covers on soil fertility under *Hevea Brasiliensis* Muell. Arg. and on growth the tree. Agro-Ecosystems 3, 147-170.

Chin, S.C. (1985). Agriculture and resource utilization in a lowland rainforest Kenyah community. Sarawak Museum Journal 56, 1-322.

Cooke, F.M. (2002). Vulnerability, control and oil palm in Sarawak: globalization and a new era? Development and Change 33, 189-211.

Corley, R.H.V. (2009). How much palm oil do we need? Environmental Science & Policy 12, 134-139.

Crumb, R.A. (1993). Shifting cultivation and sustainable agriculture in East Malaysia: A longitudinal case study. Agricultural Systems 42, 209-226.

Crumb, R.A. (2007). Land and Longhouse. Agrarian Transformation in the Uplands of Sarawak. Nias Press, Copenhagen.

Department of Agriculture Sarawak. Sarawak Agriculture Statistics http://www.doa.sarawak.gov.my/modules/web/page.php?id=86&menu_id=0&sub_id=135.

Fitzherbert, E.B., Struebig, M.J., Morel, A., Danielsen, F., Brühl, C.A., Donald, P.F., and Phalan, B. (2008). How will oil palm expansion affect biodiversity? Trends in Ecology & Evolution 23, 538-545.

Freeman, J.D. (1955). Iban Agriculture: A Report of the Shifting Cultivation of Hill Rice by the Iban of Sarawak. H.M. Stationery Office, London.

Hansen, T.S., and Mertz, O. (2006). Extinction or adaptation? Three decades of change in shifting cultivation in Sarawak, Malaysia. Land Degradation & Development 17, 135-148.

Khalid, H., Zin, Z.Z., and Anderson, J.M., (2000). Soil nutrient dynamics and palm growth performance in relation to residue management practices following replanting of oil palm plantations. Journal of Oil Palm Research 12, 25-45.

Ngidang, D. (2002). Contradictions in land development schemes: the case of joint ventures in Sarawak, Malaysia. Asia Pacific Viewpoint 43, 157-180.

Padoch, C. 1982. Migration and its Alternatives among the Iban of Sarawak. Koninklijk Instituut voor Taal-, Land-en Volkenkunde, Leiden.

Raj, H.G. (1972). A comparison of the effects of organic and inorganic fertilizers on the yield of pepper, *Piper nigram* L. in Sarawak, Malaysia. Malaysian Agricultural Journal 48, 385-392.

Tanaka, S., Tachibe, S., Wasli, M.E.B., Lat, J., Seman, L., Kendawang, J.J., Iwasaki, K., and Sakurai, K. (2009). Soil characteristics under cash crop farming in upland areas of Sarawak, Malaysia. Agriculture Ecosystems & Environment 129, 293-301.

Tanaka, S., Wasli, M.E.B., Kotegawa, T., Seman, L., Sabang, J., Kendawang, J.J., Sakurai, K., and Morooka, Y. (2007b). Soil properties of secondary forests under shifting cultivation by the Iban of Sarawak, Malaysia in relation to vegetation condition. Tropics 16, 385-398.

Tanaka, S., Wasli, M.E.B., Seman, L., Jee, A., Kendawang, J.J., Sakurai, K., and Morooka, Y. (2007a). Ecological study on site selection for shifting cultivation by the Iban of Sarawak, Malaysia. A case study in the Mujong River area. Tropics 16, 357-371.

Turner, E.C., Snaddon, J.L., Ewers, R.M., Fayle, T.M., and Foster, W.A. (2011). The Impact of Oil Palm Expansion on Environmental Change: Putting Conservation Research in Context. In Environmental Impact of Biofuels, ed. by Santos Bernardes, M.A., pp. 19-40, In Tech, Rijeka.

Turner, E.C., Snaddon, J.L., Fayle, T.M., and Foster, W.A. (2008). Oil palm research in context: identifying the need for biodiversity assessment. PLoS ONE 3, e2572.

Wasli, M.E.B., Tanaka, S., Kendawang, J.J., Seman, L., Unang, B., Lat, J., Abdu, A., Morooka, Y., and Sakurai, K. (2009). Vegetation conditions and soil fertility of fallow lands under intensified shifting cultivation systems in Sarawak, Malaysia. Tropics 18, 115-126.

Weng, C.K. (2005). Best-developed practices and sustainable development of the oil palm industry. Journal of oil palm research 17, 124-135.