FORESTRY IDEAS, 2023, vol. 29, No 2 (66): 207–215

Deciphering the anthropogenic challenges of peat swamp forest degradation to improve awareness and emphasis on restoration in South Sumatra

M. Edi Armanto[1*], Elisa Wildayana[1], and Bella Syakina[2]

[1]Faculty of Agriculture, Sriwijaya University, South Sumatra 30820, Indonesia.
[*]E-mail: mediarmanto@unsri.ac.id
[2]Centre for Global Sustainability Studies, Universiti Sains Malaysia, 11800 Penang, Malaysia.

Received: 07 June 2023 / Accepted: 04 August 2023 / Available online: 18 August 2023

Abstract

Peat Swamp Forest (PSF) belongs to a unique ecosystem and will be very difficult to be recovered if already degraded, thus we need to be fully realised about this ecosystem. The research aimed to analyse the anthropogenic challenges of PSF degradation, to improve awareness and to make urgent emphasis in providing their restoration. This research was conducted within 2020–2023 in South Sumatra Indonesia. The research method applied field survey and laboratory work. Current PSF was threatened its existence, its various practical functions were neglected and favoured the economic benefits of oil palm (*Elaeis guineensis* Jacq.). The peat thickness is for determining its agriculture suitability, peat depth is allowed for agriculture if its thickness is < 100 cm (classified as marginally suitable, S2), peat thickness > 300 cm must be conserved (classified as not suitable, N). Patterns of PSF degradation are creating impermeability layers of water; changing plant type and density; and modifying plant types of land cover. The pattern of changing plant type and density (executed by land speculators) determined two-third the PSF degradation. Hence, the government has to make policy decisions based on PSF vulnerability and the negative impact of its degradation at global, state, provincial, district, sub-district and local levels and followed by agricultural programs on how to improve income of local people.

Key words: impermeable layers, land cover, patterns, plant density, plant type.

Introduction

Common functions of peat swamp forest (PSF) include biomass production (agriculture, fishery, forestry etc.); providing biodiversity (species, variety and gene); storing, filtering, buffering and transforming; physical media (roads, infrastructure etc.); sources of raw materials (water, peat, fuel, energy etc.); and cultural heritages (Armanto and Wildayana 2022; Armanto et al. 2022, 2023; Le Goff et al. 2022). All functions have to be maintained, so that PSF can actually function as a life supporting system for humans. Some PSF benefits in our daily life are various ranging from fertilisers, power sources, fuel producers and other benefits (Holidi et al. 2019, Guth et al. 2022, Vilas-Boas et al. 2022).

PSF belongs to a unique ecosystem and will be very difficult to be recovered if they are already degraded, thus we need to be fully aware of this ecosystem (Negassa et al. 2019, Suab and Avtar 2020, McGuire et al. 2022). About 77 % of South Sumatra PSF have been cleared for plantation and agricultural purposes in a broad sense. This way of clearing largely did not follow conservation methods, i.e., by cutting, burning, and continued conversion to oil palm (*Elaeis guineensis* Jacq.) (Armanto 2019a, 2019b). In the last twenty years, there has been considerable release of carbon into the atmosphere from land and affecting the global carbon cycle. It was estimated at least 5 % of the total anthropogenic carbon emissions was contributed from fires (Wildayana and Armanto 2018a, 2018b; Armanto and Wildayana 2023).

The negative impacts of biological environments arise and PSF loss is not fully realised by the local assessors because of the lack of overall data on it, particularly on biodiversity, physical and chemical characteristics. The research aimed to analyse the anthropogenic challenges of degradation, to improve awareness and to make urgent emphasis in providing PSF restoration.

Materials and Methods

This research was conducted within 2020–2023 in Ogan Komering Ilir (OKI) District, South Sumatra Indonesia (Fig. 1). Geographically the research location is located to the North with coordinates 104°57'13.23" E and 3°19'55.95" S; East 105°3'21.72" E and 3°24'0.99" S; South 104°57'13.20" E and 3°30'7.64" S; and West of 104°53'16.70" E and 3°25'38.62"

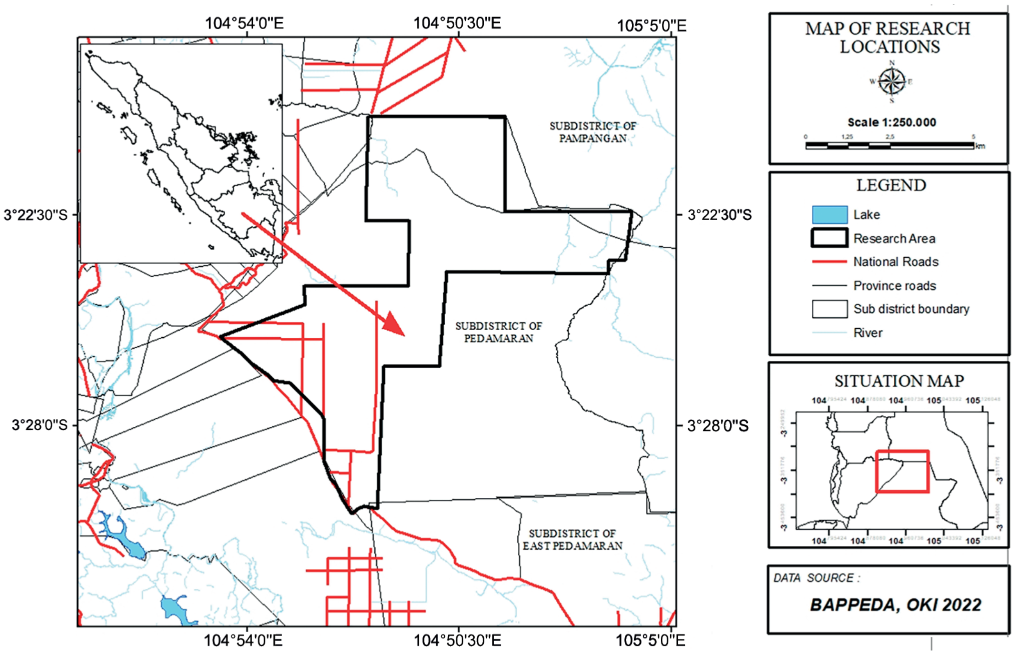

Fig. 1. The location of research area in OKI District, South Sumatra.

S with a research area of 10,000 ha. The research method applied was a field survey method. Sampling method was carried out by three types of PSF land uses (i.e., oil palm; secondary forest; bush and natural grass). Data collection was conducted through three techniques, namely direct field observation, in-depth interviews with respondents and field documentation. Interviews with respondents were carried out using questionnaires. From each land use, 20 respondents were determined by random sampling. The total number of respondents interviewed from the three land uses was 60 households (15 % of the total population of 400 households). In-depth interviews were done with key informants, most of whom came from community leaders consisting of sub-district heads, village leaders and NGOs. The collected data were analysed, presented and performed in forms of tables and charts.

The general description of the respondents is presented in Table 1. The PSF thickness was measured using a peat drill at randomly selected viewing points and mapped to determine the area by planimetry. Land suitability was carried

Table 1. General characteristics of selected 60 PSF respondents.

Variables	Parameters	Description and unit	Average ±StDev
Physical PSF	Land suitability	Suitable (S2, peat depth < 100 cm), %	6.46 ±2.88
		Marginally suitable (S3, peat depth of 100–300 cm), %	85.15 ±14.65
		Not suitable (N, peat depth > 300 cm), %	8.39 ±4.70
	Area	PSF size, ha	5.02 ±4.92
Socio- economics	Age	Age at conversion, years	40.51 ±7.34
	Education	Education length, years	12.55 ±1.87
	Trading	Involvement in trading at the time of PSF acquision, years	26.06 ±4.21
	Public service	Involvement in public service at the time of PSF acquisition, years	15.53 ±3.37
	Subsistence	Involvement in subsistence farming at the time of PSF acquisition, years	20.66 ±6.72
	Commercial plants	Involvement in commercial plants at the time of PSF acquisition, years	27.75 ±5.91
Respondents	Local	Identification with local tribe group, %	27.09 ±8.97
	Non-local immigrants	First generation immigrants from non-local tribes, %	32.73 ±6.63
	Not local farmers & not immigrants	Second or more generation immigrants from non-local tribes, %	40.18 ±5.88
Previous experience	No PSF experience	Experience through plantation, %	5.70 ±4.92
	Upland agriculture experience	Experience through other plantations, %	44.02 ±7.73
	Plantation labourers	Experience through oil palm plantation, %	50.28 ±6.11
	Conversion start age	Years since planting the PSF	10.42 ±3.99

out according to Regulation of the Agriculture Ministry of Concerning Guidelines for Land Suitability in Agriculture Commodities Nr 79/Permentan/OT.140/8/2013.

Results and Discussion

General characteristics of selected respondents

In general, more than 74 % of farmers have an average PSF size of < 5 ha, only a small proportion of farmers have > 5 ha. It means that most of the owners only fulfil their own family needs (Table 1). The respondents' age at the time of conversion was approximately 41 years with an average length of education of 12 years. They have been involved in trading (average 26 years); or domiciled as a civil servant (15 years); or subsistence farming (20 years); or cash crops (27 years).

The respondents' socio-economic status was adequate, in general they were not beginners in business. However, this data appeared to be gender biassed because almost all of the respondents were male (99 %). These respondents generally had permanent jobs, had sufficient capital and this PSF conversion was only an extension of their work to increase income. In general, respondents converted PSF using their own capital, without banking assistance.

PSF respondents in general were dominated by non-immigrants non-local farmers (40 %); followed by non-local immigrants (33 %); and local farmers (27 %). The few respondents who came from local farmers were caused by a lack of motivation and a lack of understanding of PSF developments. The results of the field and laboratory data analysis are presented in Table 1.

About 45 % of respondents were Javanese, Banjar and Bugis because PSF are generally located in immigrant villages occupied by Javanese, Banjar and Bugis. These tribes are ethnic groups who moved to South Sumatra to develop PSF. Javanese who migrated could come directly from Java or who migrated from other provinces in Sumatra. Banjar, Bugis and local groups moved to the PSF location due to difficulties in obtaining agricultural lands. Previous experience described the activities of farmers prior to PSF conversion, including working as plantation labourers or through ownership of other PSF farming. The main respondents played an important role in driving PSF expansion.

PSF extent and land suitability

The research site has an area of about 10,000 ha having four PSF thicknesses, i.e., less than 100 cm (6.46 %), 100–200 cm (24.90 %), 200–300 cm (60.25 %), and above 300 cm (8.39 %). Commonly, PSF was used for oil palm and pineapple (*Ananas comosus* (L.) Merr.), rice fields and uncultivated fields. Generally, the PSF thickness of < 100 m was commonly utilised for gardening, fishery, housing, offices and industry. PSF thickness of 100–200 cm was used for food plants, 200–300 cm for plantation plants, oil palm and above 300 cm for groundwater infiltration, conservation and protected area (Fig. 2).

PSF suitability for agriculture is mainly determined by the thickness and maturity of peat, peat depth is still allowed to be cultivated for agriculture if the thickness is < 100 cm, and even then it is included in the marginal appropriate class (S2). If the thickness is > 300 cm, then the peatland must be conserved (classified as not suitable, N).

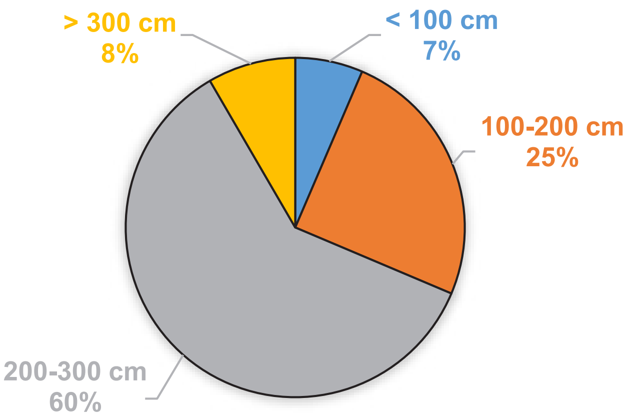

Fig. 2. PSF extent and distribution based on their peat depths.

From year to year PSF undergoes land conversion for oil palm, settlements, and agriculture in general. Similarly to the condition of the people, farmers are more likely to sell land to the industry sectors for the development and opening of new oil palm. The number of food plants' farmers from year to year decreased compared to large industry plantations. This change occurs because farmers choose other work skills to meet their current life interests, so they prefer to work as tenants of other land farmers. The status of conservation areas (peat depths > 300 cm) was now becoming increasingly unclear and have not been categorised as a protected area by the government. Some protected areas were licensed by the government as a concession area for oil palm. Therefore, the main management objectives for the conservation area (PSF thickness > 300 cm) are becoming increasingly unknown. Even though the area declaration has been established by the government as a National Park, it was still unable to provide long-term conservation guarantees due to illegal logging, forest and fire, as well as land conversion. Consequently the naming of the area as a conservation area was confused, but peat degradation action occurs in a planned and structurally planned manner.

According to Ministry of Agriculture Nr. 38/2020 (Ministry of Agriculture 2022) concerning Implementation of Indonesian Sustainable Oil Palm Certification, oil palm plantations are required to provide 30 % conservation areas of the total concession area. The reality showed that oil palm plantations are only able to provide less than 30 %, resulting in negative impacts on the environment, such as floods, droughts and decreased biodiversity.

Anthropogenic challenges of PSF degradation

Based on our observation results, PSF areas that have been logged and burned repeatedly have resulted in lower density and diversity of stems compared to areas that have only been burned once and with no history of logging. PSFs that have been burned before have the potential to burn again because of the availability of dead, unburnt biomass and existing vegetation that can become a reserve of biofuels for subsequent fires. Analysis of fires in the field shows that repeated fires are mostly found in areas with non-forest secondary vegetation. The high intensity and frequency of fires has fuelled vegetation that is dominated by pioneer vegetation, low-growing herbaceous plants, with few trees. Forest and land fires have reduced the surface elevation, resulting in burning areas with vegetation and PSF, which have had a serious impact on flooding and hindered plant regeneration.

Types of anthropogenic challenges of PSF degradation in the research area are summarised in Figure 3, and are generally divided into two types, namely instinctive ones and permanent challenges. Permanent ones are very difficult or impossible to fix, rather than instinctive that are often technical or economic in nature and easier to overcome. In this research, permanent challenges are dominantly concerned due to field reality.

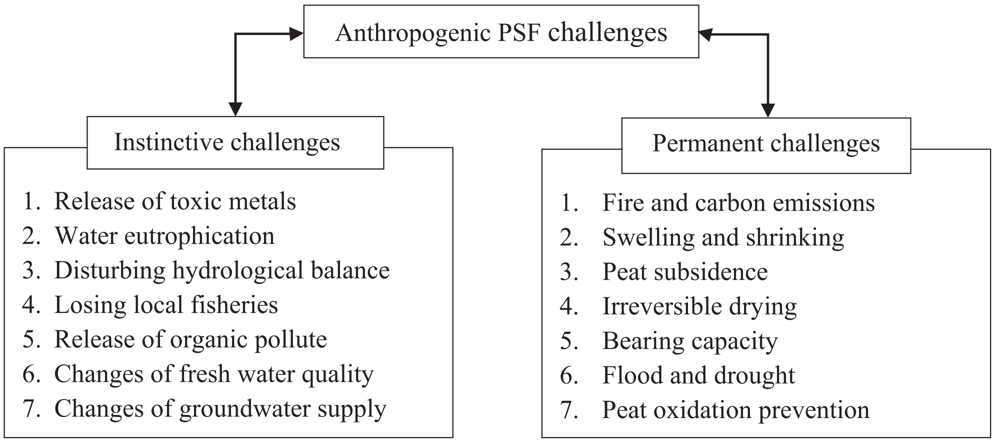

Fig. 3. Types of anthropogenic challenges of PSF degradation.

Patterns and executors of PSF degradation

There are three patterns and executors and each had different characteristics in terms of the executors. They are presented in Table 2.

Creating impermeable layers of water

The impermeable layers of water are made through PSF hardening and compaction processes for roads, industries and residentials (Zuhdi et al. 2019). Impermeability means that water cannot penetrate the PSF vertically due to the presence of impermeable layers on the surface. This pattern is generally carried out by powerful investors, government, state officials with a total area of 2123 ha (21.23 %). It is difficult for the government to regulate as policy makers, because they have strong access to policy makers at any level (sub-district, district, provincial and national).

Changing plant type and density

Changing plant type and density is generally carried out by land speculators (businessmen who want to monitor their land ownership) by conducting land clearing, illegal logging and cultivating oil palm plantations. As a result, several PSF areas were neglected and dominated by oil palm, shrubs and natural grasses. This pattern makes a dominant contribution of 5978 ha (59.77 %) and has the most global impact on the hydrological cycle, water production and in the long term can trigger acute and prolonged water shortages and flooding.

Table 2. Patterns and executors of PSF degradation.

No	Patterns	Respondents		
		Speculators (businessmen)	Governments	Local farmers
		A. Creating Impermeable layers of water		
1	Making road	√	√	-
2	Making industries	√	√	-
3	Making residentials	√	√	-
		B. Changing plant type and density		
1	Land clearing	√	-	-
2	Illegal logging	√	-	-
3	Oil palm plantation	√	-	-
		C. Modifying plant types of land cover		
1	Subsistence farming	-	-	√
2	Sonor system	-	-	√
3	Local fisheries	-	-	√

Note: Sonor system means the way how to produce food farming based on the local treatments.

Modifying plant types of land cover

This pattern was generally carried out by local people living in the surrounding PSF areas to meet their needs of firewood and sustaining their life. PSF degradation through this pattern was relatively minimal (1899 ha or 18.99 %). Firstly, PSF areas were cleared by using fire and cultivated for food plants agriculture (sonor system). Although the land clearing was relatively small, the fire use for land clearing was widely used because harvesting of agricultural products (e.g., rice and corn) was carried out by farmers each three months. The harvesting residues were all destroyed by burning, the farmers did not put the harvesting residues into the soils because it was so expensive and required a lot of manpower. Consequently, impacts on PSF degradation also needed to be considered. This could be seen from the number of hotspots in the region of the sonor system, which was the maximum. The government needed to make some solutions on how to manage PSF areas in order to control all of them properly. If all patterns could be controlled, then they could be automatically controlled.

The executors of PSF degradation are given in Figure 4, showing that businessmen played important roles compared to others, who were 60 %, 21 %, and 19 % respectively. The role of local people in causing PSF degradation occurred because they were unable to carry out large-scale land clearing, while businessmen were able to conduct macro-scale land clearing efforts which were only mostly aimed at economic development. This was exacerbated by the government's relatively small role (only 21 %), so that

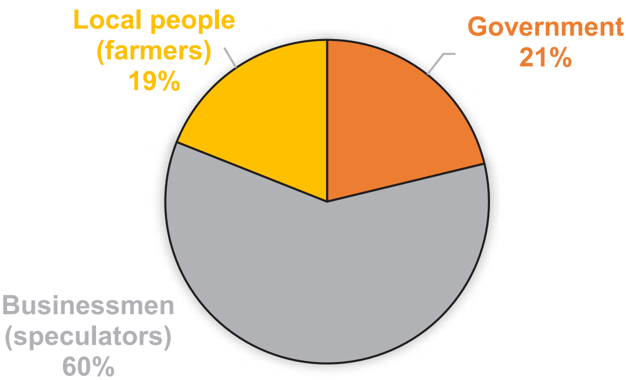

Fig. 4. Executors of PSF degradation.

most of the businessmen's efforts to develop economic activity in PSF were very difficult to be controlled both by the government and local people.

Conclusions

The current peat swamp forest status was threatened its existence, the various functions of practical PSF were neglected and favoured the economic benefits of oil palm. The peat suitability for agriculture is mainly determined by its thickness and maturity, peat depth is still allowed to be cultivated for agriculture if the peat thickness is < 100 cm, and even then it is included in the marginal appropriate class (S2). If the peat thickness is > 300 cm, then the PSF must be conserved (classified as not suitable, N). Patterns of PSF degradation are creating impermeability layers of water; changing plant type and density; and modifying plant types of land cover. Thus, it is imperative to restore and conserve the PSF areas. The pattern of changing plant type and density (executed by land speculators) determined two-third the PSF degradation. Hence, the government has to make policy decisions based on PSF vulnerability and the negative impact of PSF degradation at global, state, provincial, district, sub-district and local levels and followed by agricultural programs on how to improve income of local people.

Acknowledgements

The authors say thank you to the academic staffs of Sriwijaya University for a fruitful discussion of PSF, students as well as local people for helping in the field research activities.

References

Armanto M.E. 2019a. Improving rice yield and income of farmers by managing the soil organic carbon in South Sumatra landscape, Indonesia. Iraqi Journal of Agricultural Sciences 50(2): 653–661. https://doi.org/10.36103/ijas.v2i50.665

Armanto M.E. 2019b. Comparison of Chemical Properties of Peats under Different Land Uses in South Sumatra, Indonesia. Journal of Ecological Engineering 20(5): 184–192. https://doi.org/10.12911/22998993/105440

Armanto M.E., Hermawan A., Imanudin M.S., Wildayana E., Sukardi, Triana A.N. 2023. Biomass and soil nutrients turnover affected by different peat vegetation. Journal of Wetlands Environmental Management 11(1): 31–42. http://dx.doi.org/10.20527/jwem.v11. i1.292

Armanto M.E., Mohd Zuhdi, Setiabudidaya D., Ngudiantoro, Wildayana E., Hermawan A., Imanudin M.S. 2022. Deciphering Spatial Variability and Kriging Mapping for Soil pH and Groundwater Levels. Journal of Suboptimal Lands 11(2): 187–196. https://doi.org/10.36706/jlso.11.2.2022.577

Armanto M.E., Wildayana E. 2022. Accessibility impact to government programs on the household income contribution at the various livelihood sources of farmers. Agriekonomika Journal 11(1): 62–75. https://doi.org/10.21107/agriekonomika.v11i1.13191

Armanto M.E., Wildayana E. 2023. Predictive mapping for soil pH and Phosphate based on Kriging interpolation. ICOSEAT 2022, ABSR 26: 254–262. https://doi.org/10.2991/978-94-6463-086-2_33

Guth M., Stępień S., Smędzik-Ambroży K., Matuszczak A. 2022. Is small beautiful? Techinical efficiency and environmental sustainability of small-scale family farms under the conditions of agricultural policy support. Journal of Rural Studies 89: 235–247. https://doi.org/10.1016/j.jrurstud.2021.11.026

Holidi, Armanto M.E., Damiri N., Putranto D.D.A. 2019. Characteristics of selected peatland uses and soil moistures based on TVDI. Journal of Ecological Engineering 20(4): 194–200. https://doi.org/10.12911/22998993/102987

Le Goff U., Sander A., Lagana M.H., Barjolle D., Phillips S., Six J. 2022. Raising up to the climate challenge – understanding and assessing farmers' strategies to build their resilience. A comparative analysis between Ugandan and Swiss farmers. Journal of Rural Studies 89: 1–12. https://doi.org/10.1016/j.jrurstud.2021.10.020

McGuire R., Longo A., Sherry E. 2022. Tackling poverty and social isolation using a smart rural development initiative. Journal of Rural Studies 89: 161–170. https://doi.org/10.1016/j.jrurstud.2021.11.010

Ministry of Agriculture 2022. The agriculture sector – Achievements for 2022. https://agriculture.gov.gy/2022/12/30/the-agriculture-sector-achievements-for-2022/

Negassa W., Baum C., Schlichting A., Müller J., Leinweber P. 2019. Small-scale spatial variability of soil chemical and biochemical properties in a rewetted degraded peatland. Frontiers in Environmental Science 7(116): 1–15. https://doi.org/10.3389/fenvs.2019.00116

Suab S.A., Avtar R. 2020. Unmanned Aerial Vehicle System (UAVS) applications in forestry and plantation operations: experiences in Sabah and Sarawak, Malaysian Borneo. In: Avtar R., Watanabe T. (Eds), Unmanned Aerial Vehicle: Applications in Agriculture and Environment. Springer, Cham: 101–118. https://doi.org/10.1007/978-3-030-27157-2_8

Vilas-Boas J., Klerkx L., Lie R. 2022. Connecting science, policy, and practice in agri-food system transformation: the role of boundary infrastructures in the evolution of Brazilian pig production. Journal of Rural Studies 89: 171–185. https://doi.org/10.1016/J.Jrurstud.2021.11.025

Wildayana E., Armanto M.E. 2018a. Dynamics of landuse changes and general perception of farmers on South Sumatra wetlands. Bulgarian Journal of Agricultural Science 24(2): 180–188. http://www.agrojournal.org/24/02-02.html

Wildayana E., Armanto M.E. 2018b. Utilizing non-timber extraction of swamp forests over time for rural livelihoods. Journal of Sustainable Development 11(2): 52–62. https://doi.org/10.5539/jsd.v11n2p52

Zuhdi M., Armanto M.E., Setiabudidaya D., Ngudiantoro N., Sungkono S. 2019. Exploring peat thickness variability using VLF method. Journal of Ecological Engineering 20(5): 142–148. https://doi.org/10.12911/22998993/105361