ENVIRONMENTAL ECOLOGY OF SEDIMENTATION IN THREE STREAMS IN TEMENGOR CATCHMENT AREA, PERAK

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ENVIRONMENTAL ECOLOGY OF SEDIMENTATION IN THREE STREAMS IN TEMENGOR CATCHMENT AREA, PERAK

by

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ABSTRAK

Kompleks Hutan Hujan Belum dan Temengor merupakan baki hutan dara yang kedua terbesar di Utara Semenanjung Malaysia iaitu bersaiz kira-kira 300,000 hektar. Sebahagian dari kompleks hutan ini telah diancam dengan pelbagai aktiviti manusia terutamanya di Hutan Simpan Temengor. Dalam kajian ini, tiga sungai telah dipilih mengikut ciri-ciri yang tersendiri berdasarkan aktiviti manusia dan sedimentasinya. Dalam kajian ini, Sungai Telang merupakan kawasan yang kurang aktiviti manusia. Sungai Enam pula adalah kawasan yang dijadikan tapak perkemahan. Manakala Sungai Air Banun adalah kawasan yang pernah dibalak dan kawasan penempatan Orang Asli. Secara umumnya, kadar kepekatan sedimen tertinggi dicatatkan di Sungai Air Banun iaitu 22.11 ± 14.68 g/L diikuti dengan Sungai Enam iaitu 8.15 ± 3.95 g/L dan 4.07 ± 2.33 g/L di Sungai Telang. Ciri-ciri bagi ketiga-tiga sungai adalah berbeza. Sungai Air Banun merupakan kawasan yang tinggi aktiviti manusia seperti aktiviti pembalakan, pembinaan jalan raya, perladangan getah dan juga pembakaran hutan secara terbuka. Tahap gangguan manusia terhadap sungai dan kawasan tadahan memainkan peranan penting yang menyebabkan kejernihan dan kualiti air terkesan melalui beberapa parameter persekitaran. Suhu air adalah berkait rapat dengan pengurangan kadar oksigen terlarut dan pH sungai. Kadar oksigen terlarut secara umumnya lebih tinggi di Sungai Telang iaitu 7.46 ± 0.63 mg/L berbanding di Sungai Enam dan Sungai Air Banun iaitu masing-masing pada 7.18 ± 0.73 mg/L dan 6.67 ± 0.30 mg/L. Nilai pH di Sungai Enam adalah yang tertinggi secara umumnya iaitu pada pH 8.12 ± 0.40.

Kadar pepejal terlarut (TDS) di Sungai Air Banun adalah lebih tinggi berbanding Sungai Enam dan Sungai Telang iaitu pada 30.70 ± 2.12 mg/L disebabkan oleh luluhawa batu dan pencairan tanah. Suhu di Sungai Air Banun juga lebih tinggi berbanding sungai-sungai yang lain iaitu pada 26.35 ºC. Kadar pepejal terampai (TSS) di Sungai Air Banun adalah yang tertinggi secara umumnya berbanding sungai-sungai yang lain iaitu pada 9.44 ± 3.98 mg/L. Nitrogen nitrat secara umumnya adalah lebih tinggi di Sungai Enam iaitu pada 0.82 ± 0.08 mg/L. Nitrit-nitrogen dan orto-fosfat secara umumnya adalah lebih tinggi di Sungai Air Banun iaitu 15.5 x 10^{-3} ± 1.01 x 10^{-3} mg/L dan 33.89 x 10^{-3} ± 8.86 x 10^{-3} mg/L. Di samping itu, pengaruh bermusim juga membantu untuk meningkatkan kualiti air melalui kesan pencairan berdasarkan beberapa parameter yang diukur telah dipengaruhi oleh perubahan musim. Dalam kajian ini, 109 rumpai daripada 59 famili telah direkodkan dari Sungai Enam, Sungai Telang dan Sungai Air Banun. Di Sungai Enam, 59 spesies rumpai telah dikenal pasti diikuti oleh Sungai Air Banun (38 spesies) dan hanya 12 spesies rumpai direkodkan di Sungai Telang. Spesies yang paling dominan dalam ketiga-tiga sungai ini adalah *Ageratum conyzoides, Hyptis capitata, Ludwigia hyssopifolia* dan *Mimosa pigra*. Dalam kajian ini, terdapat juga benih bercambah dari sampel sedimen. Kiraan percambahan anak benih tertinggi ialah di Sungai Enam iaitu 11 anak benih manakala di Sungai Air Banun 10 anak benih. Pemerhatian selama 13 minggu telah dijalankan terhadap anak-anak benih ini. Sungai Telang tidak menunjukkan sebarang percambahan benih dari sampel sedimen sepanjang tempoh kajian.

ENVIRONMENTAL ECOLOGY OF SEDIMENTATION IN THREE STREAMS IN TEMENGOR CATCHMENT AREA, PERAK.

ABSTRACT

The Belum and Temengor Rainforest Complex is the second largest remaining virgin forest in Northern Peninsular of Malaysia; the size is about 300,000 ha. This forest complex partly being threatens by various human activities especially at Temengor Forest. In these studies, three rivers were selected according to their characteristics particularly the human activity and sedimentation. In this case, Sungai Telang has less human activities. Sungai Enam is a base camp area. The third river is Sungai Air Banun which is subjected to logged over area and orang asli settlements. Generally, the highest suspended sediments concentration was recorded in Sungai Air Banun at 22.11 ± 14.68 g/L following by Sungai Enam at 8.15 ± 3.95 g/L and 4.07 ± 2.33 g/L at Sungai Telang. The characteristic of these three rivers are comparatively difference. Sungai Air Banun subject to heavy human activities such as logged activities, road construction, rubber plantation extension and also forest burning. Disturbance levels of rivers and forest catchment play important roles that subsequently affect the water clarity and quality have affect some other environmental parameter. Water temperature was related to the reduction of dissolve oxygen levels and pH of the river. Dissolve oxygen in generally higher in Sungai Telang at 7.46 ± 0.63 mg/L compared to Sungai Enam and Sungai Air Banun at 7.18 ± 0.73 mg/L and 6.67 ± 0.30 mg/L respectively. The pH value in Sungai Enam was the highest among the three streams generally at pH 8.12±0.40. TDS in Sungai Air Banun was higher compared to Sungai Enam and Sungai Telang at 30.70 ± 2.12

mg/L due to rock weathering and soil dilution. Temperature in Sungai Air Banun also higher than other streams at 26.35 ºC. Total suspended solid in Sungai Air Banun was the highest among the three streams at 9.44 ± 3.98 mg/L. Nitrate nitrogen was higher in Sungai Enam at 0.82 ± 0.08 mg/L. While Nitrite nitrogen and ortho-phosphate was higher in Sungai Air Banun at 15.5 x 10^{-3} ± 1.01 x 10^{-3} mg/L and 33.89 x 10^{-3} ± 8.86 x 10^{-3} mg/L. Canopy layers were important in controlling temperature in rainforest such as comparing Sungai Telang and Sungai Air Banun. In addition, seasonal influences also help to improve the water quality through dilution effect based on several parameters and the measured parameters were consequently affected by seasonal changes. In this study, 109 weeds from 59 families were recorded from Sungai Enam, Sungai Telang and Sungai Air Banun. In Sungai Enam, 59 species of weeds was identified while in Sungai Telang 12 weed species identified and Sungai Air Banun 38 species of weed was identified. The most dominant species in this three stream was *Ageratum conyzoides, Hyptis capitata, Ludwigia hyssopifolia* and *Mimosa pigra*. In this study, there are seeds germinate from sediment sample. The highest seedling count was in Sungai Enam at 11 seedlings while in Sungai Air Banun 10 seedlings were counted. This observation was done for 13 week. Sungai Telang does not showed any seed germination from the sediment sample throughout the study period.

CHAPTER 1

GENERAL INTRODUCTION

1.1 Background

Good and clean quality water is essential for all living beings, even modern technologies until today cannot change our dependency on water. Nowadays, natural resources becoming lesser than before and pollution is on the increase. Recently, the quantity of water was not an issue in the country, except in the dry regions of the Peninsular of Malaysia. Sabah and Sarawak did not face any serious shortage of raw water (Mamun and Zainudin, 2013). In Malaysia, development has inevitably resulted in adverse changes in the hydrology and ecology of wetland ecosystems that associated with land usage increase, consequently increases in population urbanisation and industrialisation, and the expansion of irrigated agriculture (Wan-Maznah, 2010). Concerning the nature and aquatic ecosystems, limnological studies now increasingly studied over the Malaysia based on several scope including fisheries, water insects, water quality, water plants and the ecological concept of aquatic biodiversity. National Hydraulic Research Institute of Malaysia (NAHRIM) in 2005 mentioned that the most focused limnological studies were done on fisheries and aquaculture, water quality, plants and animal biodiversity.

Lakes are inland water bodies that lack any direct exchange with an ocean and the ecosystems are made up of the physical, chemical and biological properties contained within these water bodies (Hairston and Fussman, 2002).

Lakes are very important to human for water security storage basin for water supply, agriculture and hydropower. In Malaysia, there are about 90 lakes all around Malaysia and not less than 73 man-made lakes was recorded and were used as water supply, hydro-electric power, irrigation, flood mitigation and others use (Zati and Salmah, 2008).

Temengor Lake is second largest lake in the Peninsular Malaysia, and a well-known place for tourists and sport fishing area (Karim and Mansor, 2013). Temengor Lake is man-made lake, formed when part of the Perak River was dammed and the bare upper branches emerging from the lake indicate that the water level was once much lower and that a surrounding by rainforest. This location is situated in Northern of Peninsular of Malaysia and bordering with Thailand. Temengor Lake is surrounding by Belum-Temengor Rainforest Complex that rich in biodiversity (Hashim *et al.*, 2011a). According to Malaysia Nature Society (1995), the size of this area is over about 300,000 hectares; almost four times bigger than Singapore, in one of the least accessible or developed areas of the Peninsular of Malaysia.

Temengor is gazetted as the Permanent Forest Reserve but this does not constitute permanent protection and over half of the Temengor Permanent Forest Reserve is allocated as Production Forest (Krishnasamy, 2009). Logging activities is major threat to Temengor rainforest because it rich in biodiversity and it could destroy wildlife habitats that need trees as a shelter and the outcomes, it will reduce the forest size, lead to habitat fragmentation and eventually reduce the lake water quality by increasing turbidity from sediment

re-suspension when the heavy rains hit the bare soil (Abdullah *et al.*, 2011). In other study by Kasran (1988), he found that the mean annual suspended sediment yield increased significantly after logging particularly a year after completion of logging and the increments were up to 70% under close supervision and up to 97 % under current practice.

Streams is clean and clear watery area that provide essential nutrients and supply ecosystem services, including nutrients, organic matters, invertebrate, woody debris, refugia and sources for biodiversity (Hashim *et al.*, 2011). Logging in highland areas has created a number of environmental problems, so stream discharge during the peak flow carried 8 — 17 times higher sediment load than it was before logging (Kasran, 1988).

Sedimentation is nonpoint source pollutants that come from various sources and flow to into our waterways by surface runoff and when land disturbing activities occur, soil particles are transported by surface water movement (Wolf, 1999). The faster the current, the greater the size of sediment particles in a stream can move (Oberrecth, 2004). According to Abella *et al.*,(2013) soil seed banks are important to many ecological research and plant conservation, so far seed banks are among the hardest plant community attributes to accurately quantify. Invasions of alien plant species significantly affect biodiversity and ecosystem functioning. Investigations of the soil seed banks of invasive plant species and changes in the composition and structure of resident seed banks following plant invasions can provide valuable insight into the long-term implications of plant invasions. Soil seed banks play a major role as reservoirs

of species and genetic diversity and allow for the persistence of a species at a locality, buffering environmental changes that may occur over time (Gioria *et al.*, 2012).

1.2 The Importance of the Study

The effect from logging will increase the sediment flow and soil erosions will increase the water turbidity and will settle down at the bottom of the lake or stream and it will become shallower than before (Ongley, 1996). In Temengor Forest, the sediment and soil erosion from logging area will increase the turbidity of streams water and it will brought to lake and the deposition of sediments become a streambank as example in Sungai Enam. In this streambank, plant especially weeds will grow and block the waterway. In this study, the discharge of the stream and the discharge of sediment can be identified and the data can be used to predict the flow rate of sedimentation in the Temengor Lake causing lakes become shallow in future. The comparison of water quality and sedimentation rates in the dry season and the wet season is also underway to identify the differences in both seasons. According to Mansor, (2013), ecologists have to play major role especially in studying and probing deeper into the biodiversity issue.

1.3 The Scope of the Study

In this study, three approaches were utilised to investigate the sedimentation rate and water quality of streams in Temengor Forest and to study plant

germination from sediments. Based on this study, sedimentation rate data can be obtained from the three streams and comparison can be done to identify the changes that occur on the streams. Water quality also plays very important role to environment and all living things. Poor water quality can also have a negative impact on aquatic life such as fish and aquatic plants. Water quality monitoring studies need to be done continuously to ensure that any initial steps can be taken if occur any changes in water quality. In this study, sediment that collected from sediment traps can be identified either carry any plant seeds from upper streams or not.

1.4 Objectives

The core of this study was based on these objectives:

i. To understand the pattern of sedimentation in small streams that deposit in lake and streambank in Temengor Forest.
ii. To analyze the water qualities in small streams and differentiate between three streams in Temengor Forest.
iii. To studies the seeds germination from sediment that bring nutrient and seed that contribute to plant growth in stream bank.

Based on overall outcomes of the study, the effect of sedimentation on three streams in Temengor Forest could be determined statistically.

CHAPTER 2

LITERATURE REVIEW

2.1 Forest and Water Catchment Area

Forest consist with trees is a complex ecosystem that buffer the earth and rich in biodiversity covered with tall trees, warm climate, and lots of rain (Neef *et al.*, 2006). Tropical rainforests encompass the serenely beautiful rainforest, cloudy, and equally endangered, otherwise they are not only one ecosystem, but they contain millions of unique ecosystems (Kim *et al.*, 2012). Besides that, fearsome jungle of our fantasy and the fertile Eden of our myth and they are the central nervous system of our planet as a hotbed of evolution, life and diversity (Rainforest Alliance). The orang asli in Malaysia stay in forests and they used the raw material from forest for daily uses like rattan, bamboo, wood, firewood, meats and others (Poh, 1994).

Catchments area is a drainage area of land surface that contribute flow to a single stream. According to Cottingham *et al.,* (2000), catchment area must be protected and let it undisturbed because it supply most of the clean water to us for daily use and a protection for endangered species includes plants and animals. Catchment is a topographic area that is drained by a stream, that is, the total land area above some point on a stream or stream that drains past that point and it is often used as a planning or management unit (Safeeq and Fares, 2012). According to Abdullah *et al.*, (2011), the total area of Belum-Temengor Complex is about 300,000 ha

consisting Gerik Forest Reserve, Royal Belum State Park, Amanjaya Forest Reserve and Temengor Forest Reserve. This area is one of the last remaining and largest tropical rainforest in northern Peninsular Malaysia. Located in Northern Perak, it consists of the Belum Forest Reserve and the Temengor Forest Reserve and is bordering with the Hala-Bala Wildlife Sanctuary and Bang Lang National Park in southern Thailand. At its centre lies the Temengor Lake. The lake is the result of the damming of several streams for the purpose of irrigation, water catchment and generating hydroelectricity (Loh *et al.,* 2010).

2.2 Stream Order

Stream systems have been classified according to their relative position within a stream network that is the smallest headwater tributaries are called first-order streams; when two first-order streams meet, a second-order stream is created; where two second-order streams meet, a third-order stream is created; and so on (Ward *et al*., 2008).

2.3 Importance of Reservoir

Reservoirs provide a variety of benefits to human such as municipal and industrial water supply, navigation, flood control are among the primary purposes for construction of larger dams, recreation, amenity uses, and agricultural water supply are the most common primary purposes of smaller reservoirs (Cowie, 2002). Temengor Lake is large reservoir with 15,000 ha

wide, located Northern of Malaysia and closed to Thailand that rich in biodiversity (Abdullah, 2011). Temengor Lake is the second largest lake in the Peninsular Malaysia, which is a source of income of a big number of peoples through fish culture, education, training, recreation and others (Karim and Mansor, 2013).

2.4 Sediments

Sediment size range are from small rocks and coarse gravel to silt and clay. Particles as fine as talcum powder enters the water where currents carry them downstream, if current faster, greater sediment particles size can move (Oberrecht, 2004). Sediment can change a stream from a clean gravel bed to become a muddy bottom that can affect many of our native fish and aquatic life because gravel bottom of a stream provide important spawning areas for many aquatic life. Besides that, excess sediment will increased the turbidity levels in stream and at the same time will increase the water temperatures, reducing light penetration and plant growth (Wolf, 1999). According to Iskandar *et al.*,(2012), in his study, sediment assessment was conducted in before, during and after harvesting of timber. Total sediment accumulation in catchment area during storm event higher compared to normal event and the accumulation of sediment also increased more than 100 times during harvesting process and decreased 10 times in the following year after harvesting processes completed. According to Chikita (1990), fine suspended sediment is deposited as a result of decreasing bottom friction with a relative decrease of turbulent energy.

2.5 Soil

Soil can be defined as the solid material on the Earth's surface that results from the interaction of weathering and biological activity on the parent material or underlying hard rock (Gauld and Dawson, 2008). Soil is comprised of minerals, soil organic matter (SOM), water, and air; and these components composition and proportion greatly influence soil physical properties, including texture, structure, and porosity, the fraction of pore space in a soil (McCauley, 2005). According to Soil Map of Malaya year 1962, Belum-Temengor Rainforest complex soil type is lithosols and shallow latosols on steep mountainous and hilly land considered unsuitable for extensive agricultural development.

2.6 Water Quality

The term of "Water quality" is used to express the suitability of water to sustain many kind of uses or processes in particular use will have certain requirements for the physical, chemical or biological characteristics of water such as limits on the concentrations of toxic substances for drinking water use, or restrictions on temperature and pH ranges for water supporting invertebrate communities (Bartram and Balance, 1996). According to Cordy (2001), natural water qualities are varies from all places, because of seasonal changes, climates, types of soils and rocks through which water moves. Water from rain or runoff from the land groundwater may bring the dissolve minerals from

rocks and soil, percolate through organic material such as roots and leaves, and react with algae, bacteria, and other microscopic organisms. According to Hashim *et al.,* (2011), stream flow, hydrologic pathways, geomorphology, physical and environmental characteristics are essential elements in understanding the dynamics of water systems in Sungai Enam and Sungai Telang. Those stream also recovered from logging and these two headwaters are thus suitable for fish conservation and restoration sites.

2.7 Water Quality Standards for Malaysia

Water quality status of streams in Malaysia has always been concern for various local authorities, government agencies as well as the public at level. The Interim National Water Quality Index (INWQS) was used to measure the class of stream in term of quality level. According to Zainuddin (2010), INWQS defined six classes (I, IIA, IIB, III, IV and V) referred to for classification of streams or stream segments based on the descending order of water quality Class I being the good water quality and Class V being the worst water quality.

Table 2.1 Water Quality index of Malaysia based on Interim National Water Quality Standards for Malaysia. (Source: Environmental Quality Report 2006)

		CLASS					
Parameter	unit	I	IIA	IIB	III	IV	V
DO	mg/L	7	5-7	5-7	3-5	<3	<1
pH		6.5- 8.5	6-9	6-9	5-9	5-9	
Conductivity	µS/cm	1000	1000	-	-	6000	
Total Dissolved Solid	mg/L	500	1000	-	-	4000	

Total Suspended solid	mg/L	25	50	50	150	300	300
Temperature	°C	-	Normal + 2°C	-	Normal + 2°C	-	-

CLASS	USES
Class I	Conservation of natural environment. Water Supply I - Practically no treatment necessary. Fishery I - Very sensitive aquatic species.
Class IIA	Water Supply II - Conventional treatment. Fishery II - Sensitive aquatic species.
Class IIB	Recreational use body contact.
Class III	Water Supply III - Extensive treatment required. Fishery III - Common,of economic value and tolerant species;livestock drinking.
Class IV	Irrigation
Class V	None of the above.

2.8 Logging Activity

Logging was a large industry contributes to the state and nation economy support, but there are limitations when an economy can no longer depend on exploiting virgin forests and the current laws on forest management focussed only on the exploitation of timber resources, legislation needs to be passed to ensure that conservation values of our forests are given the high priority they deserve (Lebedys and Li, 2010). According Abdullah *et al.*, (2011), the legal logging activities aim to supports state government finance, but in reality, legal logging creates a problem and contributes to deforestation and change in the landscape. Besides that, illegal logging is even worse as it operates in unsustainable manner which it could destroy wildlife habitats with the abundant of biodiversity that seek shelter in the trees specifically and the area generally.

2.9 Weeds

Weed species are general and depend on the location, time and the environments. Weeds are stated that species are plants that grow and lead to negative impact in the areas (Reichard, 2011). These weed species are problem-causing plants that disrupt the lake and stream ecosystems and as well as plantation areas. According to Mansor, (1996), *Eichhornia crassipes, Salvinia molesta, Lemna perpusilla,* and *Pistia stratiotes.* Are four problematic weeds in Malaysia and among these weeds, *E. crassipes* and *S. molesta* are distributed widely throughout Malaysia. *E. crassipes* generally dominates canals and streams although, recently, this species has spread to man-made lakes. The favourable tropical climate of Malaysia and conducive environmental factors help to trigger the massive growth of these weeds. The high nutrient concentrations of phosphate initiate a high productivity of weeds.

2.10 Management of Aquatic Ecosystem

Aquatic ecosystems are very important for human being. Water sources are deriving from aquatic ecosystem. To manage an aquatic ecosystem, we need to manage people rather that manage the ecosystem because most of disturbances are from humans. Management of aquatic ecosystems is important in terms of maintaining water quality for human utilisation, harvesting resources, and for species conservation (Barton, 2001). A lake ecosystem is structured according to how much light is available because most of the life form in lake needs light

to support their life and do photosynthesis, but, if the pollution or logging activities occurs within this area, the turbidity of water will increase and light can't penetrate the water (Chapin *et al*., 2004)

CHAPTER 3

METHODOLOGY

3.1 General Description of Study Area

Sungai Perak is the second longest river in Peninsular Malaysia, flowing 427 km from the North-East Province of Hulu Perak district mountainous to Bagan Datoh and flow out to Strait of Malacca located between 4˚ 00’ 76” N, 100˚ 44’ 81” E and 5˚46’63”N, 101˚ 36’04”E (Muzzalifah , 2012). Temengor Lake is situated in upstreams of Sungai Perak and formed a lake when the dam constructed within this area. Royal Belum is the second-largest protected area in Peninsular Malaysia after Taman Negara (431,435 ha) and larger than 85% of all the protected areas in the world classified by the International Union for Conservation of Nature (IUCN) as strict nature reserves, wilderness areas, or national parks, and it is larger than 90% of such protected areas created after year 2006 (Schwabe *et al.*, 2014). Creek area in Temengor forest is a focus area for the tourists from Malaysia and outside (Abdullah *et al.*, 2011). There are a group of orang asli living around the lake and some of them are nomadic (Karim and Mansor, 2013). This study was conducted in three streams located in Temengor catchment area as shown in Figure 3.1.

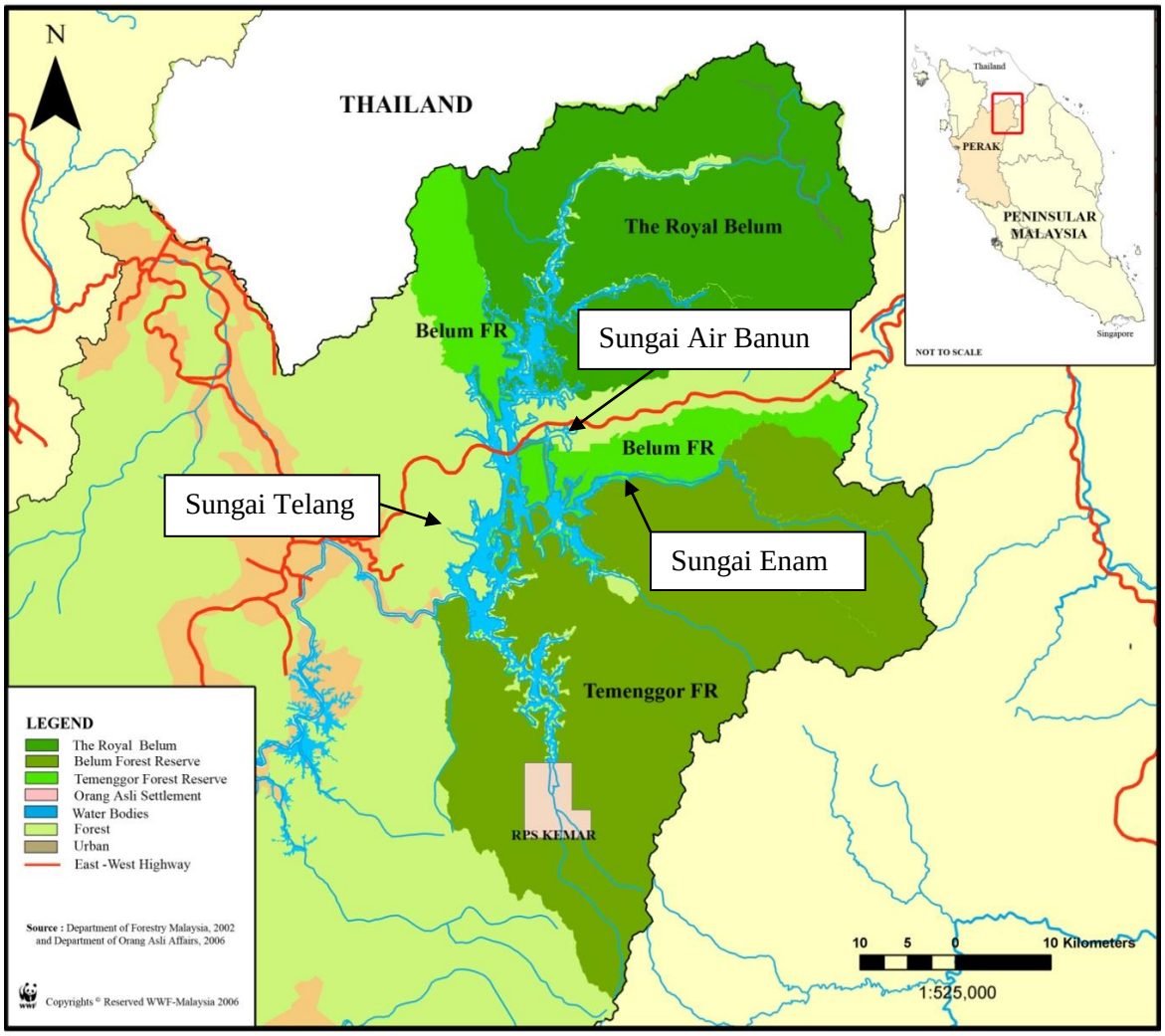

Figure 3.1 Map of Temengor. Sungai Enam, Sungai Telang and Sungai Air Banun. (modified from WWF, 2006)

3.1.1 Criteria of Study Area.

According to Aiman-Hanis *et al.,* (2014), Sungai Telang is undisturbed natural forest area in Temengor Forest area. While Sungai Enam, an area of camp site and tourist site (Hurzaid *et al.,* 2014), while Sungai Air Banun is an area of orang asli village, rubber plantation and passed logging activities sites (Krishnasamy, 2009). Details of study area shown in Table 3.1. Figure 3.2 show the Sungai Enam river order and catchment area, Figure 3.3 Sungai Telang river order and catchment area and Figure 3.4 Sungai Air Banun river order and catchment area.

Table 3.1 The details of study area.

Streams	**Coordinate**	**River Order**	**Catchment area size**
Sungai Enam	5º 30’ 47.90” N 101º 27’ 14.31’ E	3	8.34 km²
Sungai Telang	5º 28’ 09.32” N 101º 24’ 49.32’ E	4	8.9 km²
Sungai Air Banun	5º 33’ 39.52” N 101º 27’ 14.31’ E	3	26.12 km²

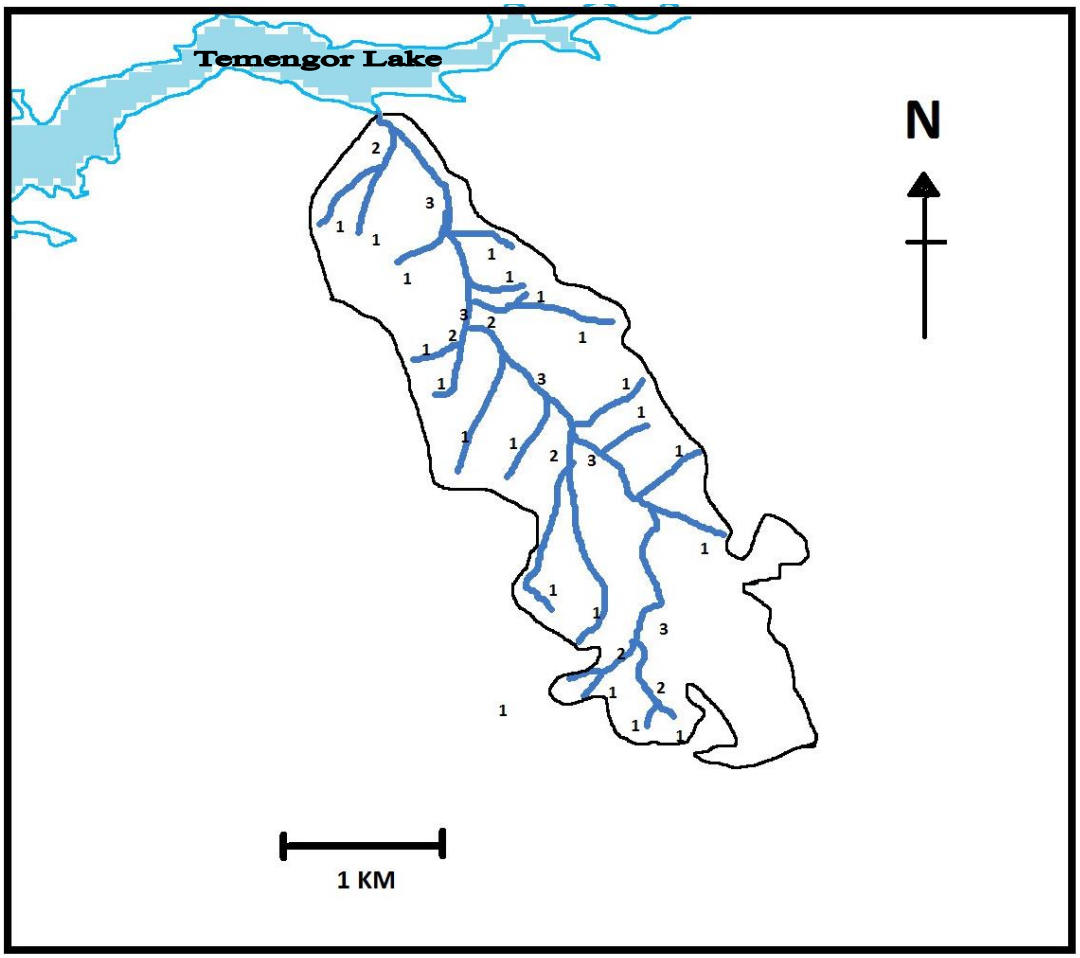

Figure 3.2 Map of Sungai Enam river order and catchment area.

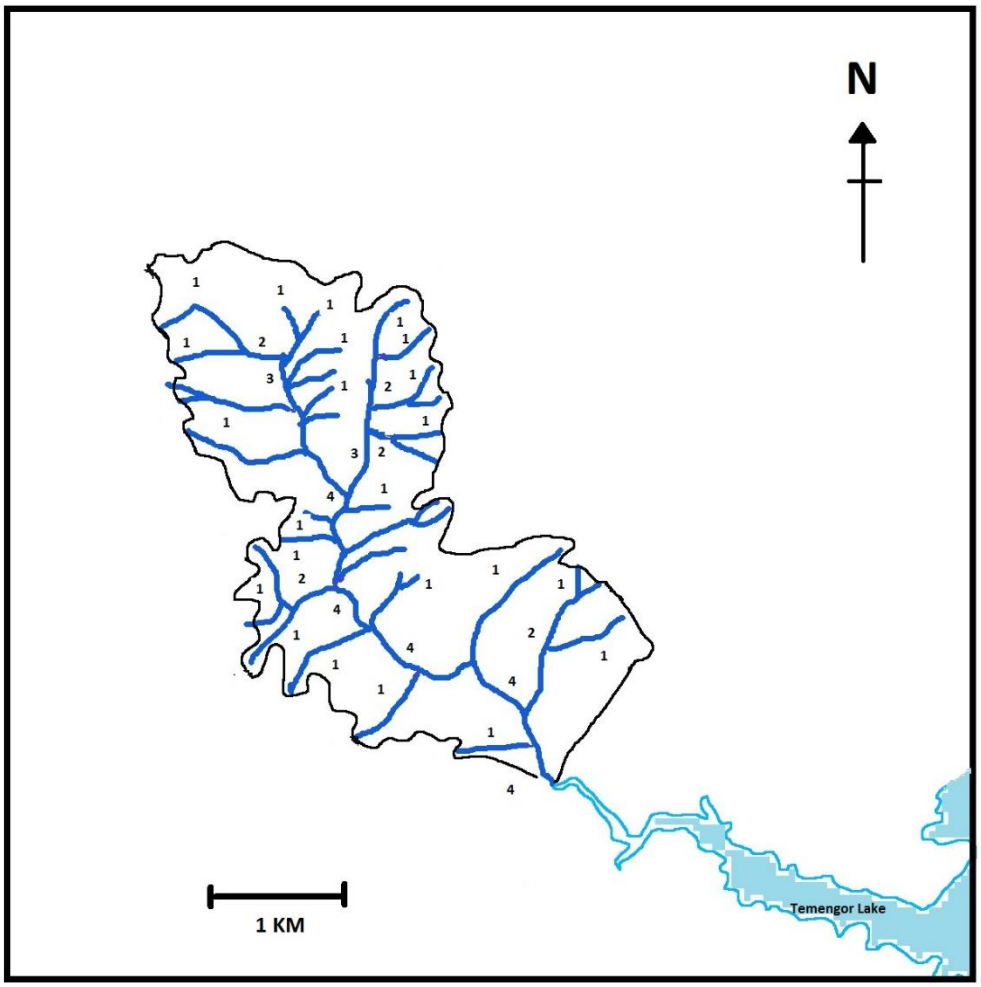

Figure 3.3 Map of Sungai Telang river order and catchment area.

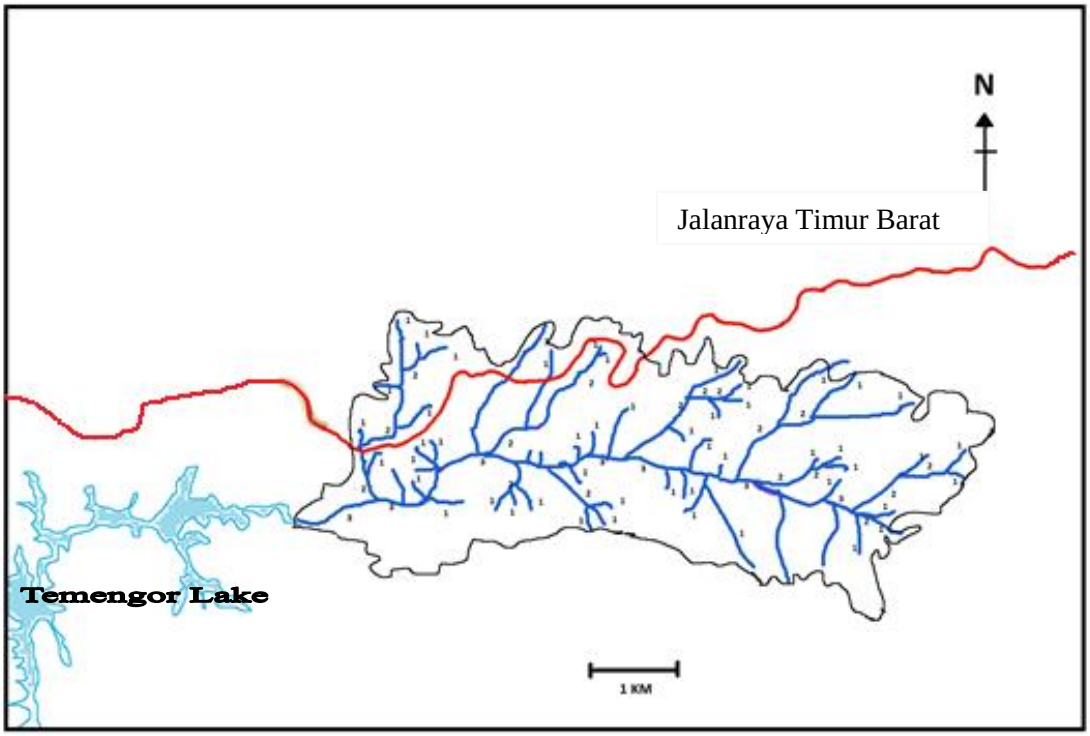

Figure 3.4 Map of Sungai Air Banun river order and catchment area.

3.1.2 Local Seasons of the Study Area

In Malaysia, the air temperature are generally high and there are only two seasonal changes that are wet season and dry season (Muzzalifah, 2012). According to Madhu *et al.*, (2004), Malaysia climate is hot wet equatorial and climate are continuous warm temperatures and the seasonal distribution of rainfall. Mean daily temperatures range from 21°C to 32°C in the lowlands throughout the year and temperatures drop at the higher altitudes. Variation in rainfall distribution is the most significant environmental variable. Seasonal changes in Malaysia were influenced by the Southwest Monsoon from May to August and the Northeast Monsoon from November to February (Tangang *et al.*, 2012). Figure 3.5 shows the rainfall gauge data from the nearest Malaysia Meteorological Department weather station to the study area at Rancangan Pengumpulan Semula (RPS) Air Banun.

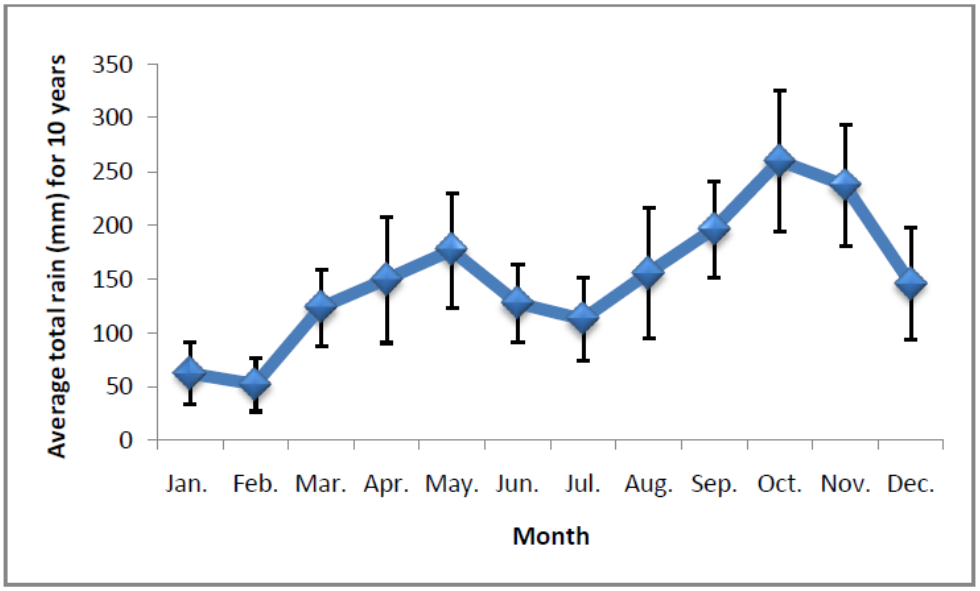

Figure 3.5 Average of rainfall for 10 years (2001 to 2010) from Rancangan Pengumpulan Semula (RPS) Air Banun (± Standard error). (Source: Malaysia Meteorological Department)