International Journal of Engineering & Technology, 7 (4.34) (2018) 14-20

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Water Resources Management of Sedimentation Problems in Terengganu River Basin, Terengganu, Malaysia

Nurul Asma Ezzatee Mohd Razak[1], Mohd Khairul Amri Kamarudin[1,2]*, Noorjima Abd Wahab[2], Ahmad Shakir Mohd Saudi[3], Muhammad Hafiz Md Saad[2,4], Frankie Marcus Ata[2], Nurul Hafizza Mohd Amran[1]

[1]*Faculty of Applied Social Sciences, Universiti Sultan Zainal Abidin, Gong Badak Campus, 21300 Kuala Nerus,Terengganu, Malaysia*
[2]*East Coast Environmental Research Institute (ESERI), Universiti Sultan Zainal Abidin, Gong Badak Campus, 21300 Kuala Nerus, Terengganu, Malaysia*
[3]*Universiti Kuala Lumpur, Malaysian Institute of Industrial Technology, Persiaran Sinaran Ilmu, Malaysia*
[4]*AB Bakti Enterprise, Lot 27215 Kg. Gong Kuin 2, Jalan Tok Jembal, 21300 Kuala Nerus, Terengganu, Malaysia*
**Corresponding author E-mail: mkhairulamri@unisza.edu.my*

Abstract

Water resource management is important for human well-being, ecosystems development and protection of existing water bodies from pollution and exploitation. Water resource management and sedimentation are carried out in Terengganu River Basin, Terengganu. The main objective is to study water resources management on sediment problems in the Terengganu River Basin. The Gravimetric method was used to analysis the TSS measured in mg/L. 250 ml water sample was needed for each study area (each station). Based on the cross section trend and the average downstream and middle section of the Sungai Terengganu system, the average TSS level is higher than the upper section. The minimum width allocation of river reserves to control development near the river is based on the Department of Irrigation and Drainage (DID). Finally, there are a few recommendations of sedimentation management around Terengganu River Basin that will improve the river water quality, especially in Malaysia.

Keywords: *Water Resources Management; Sedimentation Problems; Sedimentations; Terengganu River Basin.*

1. Introduction

The increase in human population densities and the development of industries along the river and coastal areas have increased the pollutant inputs and deteriorated the water quality of the surrounding area [1-3]. Rivers are the major water source for life on the globe and plays an important role in the development of human civilization [4]. Water resource management is the planning, distributing, developing and managing activity the optimum and effective use of water resources which needs to be practiced. Water management not only refer to the absolute amount of water available for ecosystem but to the spatial-temporal distribution of quantity and quality of water flows that are importance to maintain the integrity of riverine ecosystems and preserve their ability to provide services valuable to humans [5-7]. The study of the rivers is to create a discipline of knowledge such as on flood, erosion, sedimentation, water quality, and other studies of streams which are found often being meticulously studied today [8]. However, these studies are much more focused and specific to a sedimentation management such as river sand mining activities, flood control and erosion.

Sedimentation is defined as the process of deposition of particles that have been generated during the process of erosion into rivers, lakes or ponds [9-11]. Sediment is a source of nature, environmental and geomorphological resource. Sediment consists of rocks, mud, minerals and the remains of plants and animals [12-13]. The process of deposition or sedimentation could occur in different places such as on land, sea or river ecosystems. The process of sedimentation also causes rivers to become shallow resulting in the flood in the estuary of a drainage. Loads of sediment load policy is between 0.2 mm to 2 mm diameter, depending on the basic structure of the rocks and soil around the area [14-15]. The sediment is materials generated during the process of weathering and erosion of rock which is usually transported by wind, water, and ice as well as deposited in layered [16]. In general, Sediment has an important role in the nutrient cycle of aquatic environments. In some cases, sediment is responsible for the transport of essential nutrients as well as pollutants. Most surficial sediments in water originate from surface erosion and contain mineral bedrock erosion and organic components during the process of soil formation [17]. The existence of sedimentary material will causing disruption to the process of photosynthesis in the air [18]. Typically, most sedimentation problems stemmed from development unmanaged land use. Besides, land use is considered a man-made land surface adjustment and has an important role in ecosystem function and aquatic life. Therefore, the main objective is to study water resources management on sediment problems in the Terengganu River Basin.

2. Methodology

2.1. Study area of research

Kuala Terengganu is located at the estuary of Terengganu River Basin and across borders other districts to Hulu Terengganu and Hulu Nerus. Terengganu city center is situated at the mouth of the Terengganu River, overseeing the South China City in the east, and also bounded by sandy and gently sloping shoreline [19]. The river is a very important route for transportation and trade. Terengganu River Basin is covered of Kuala Terengganu, Kuala Nerus, and Hulu Terengganu. Therefore, groundwater sources are from the East Coast Ranges [20]. There are several bridges like the Manir Bridge and the Sekati Island Bridge crossing the river. The width of the Terengganu River area is 4,595,996 km^2 which are the largest in the state of Terengganu. The problem of flooding often plagued the residents in Hulu Terengganu [21] and the factors to occur flood stage are river water flow capacity as a result of the deposition of sediment.

Flood control efforts and conduct the deposition of sentiment is done through integrating water resources and flood management projects. Terengganu River Basin indeed in critical and need for a comprehensive study in order to manipulate the water resources management and assess the characteristic for sustainable sedimentation management. Overall, the population density is concentrated at the Kuala Terengganu, Kuala Nerus and Kuala Berang [22]. The water sample were collected from 29 different predetermined sampling stations from downstream to upstream area along Terengganu River Basin. The research location that has been determined using DGPS which covered from downstream to upstream along Sungai Terengganu Catchment representing the length of the Terengganu River Basin (Table 1).

Table 1: Location of Sampling Station at the Terengganu River Basin, Terengganu, Malaysia

Sampling Stations	Latitude	Longitude
Station 1	103° 8'21.92"E	5°20'23.93"N
Station 2	103° 6'20.14"E	5°19'26.55"N
Station 3	103° 5'56.80"E	5°19'40.59"N
Station 4	103° 5'12.22"E	5°18'48.53"N
Station 5	103° 5'12.42"E	5°18'32.74"N
Station 6	103° 5'50.67"E	5°17'7.75"N
Station 7	103° 3'3.64"E	5°16'14.99"N
Station 8	103° 1'32.70"E	5°13'9.00"N
Station 9	103° 1'40.09"E	5°12'42.04"N
Station 10	103° 2'9.46"E	5° 7'37.61"N
Station 11	103° 0'31.30"E	5° 4'8.14"N
Station 12	102°58'43.16"E	5° 3'22.80"N
Station 13	102°57'58.26"E	5° 4'39.67"N
Station 14	102°56'41.24"E	5° 4'37.96"N
Station 15	102°56'10.96"E	5° 3'48.46"N
Station 16	102°55'46.47"E	5° 2'26.86"N
Station 17	102°55'37.24"E	5° 1'55.10"N
Station 18	102°56'28.08"E	5° 3'54.70"N
Station 19	102°57'4.74"E	5° 4'37.88"N
Station 20	102°58'16.48"E	5° 3'43.35"N
Station 21	103° 0'8.50"E	5° 4'8.88"N
Station 22	103° 0'25.47"E	5° 4'31.96"N
Station 23	103° 2'21.33"E	5° 8'2.35"N
Station 24	103° 2'35.85"E	5°11'2.74"N
Station 25	103° 1'50.56"E	5°12'36.82"N
Station 26	103° 2'21.83"E	5°13'26.72"N
Station 27	103° 4'38.05"E	5°16'37.05"N
Station 28	103° 5'29.09"E	5°17'37.90"N
Station 29	103° 5'27.17"E	5°18'57.56"N

2.2. Research methodology

According to [23], the high daily suspended sediment load value is due to the high yield value. Increased water levels occur during the rainy season made the cliffs are soft and easily eroded, thereby contributing to the production of suspended sediments and ultimately to the deposition of sedimentary in the river basin. The water samples were obtained from each station and were kept in the 500 ml bottles to find the Total Suspended Solid (TSS) concentration. Sediment samples were collected using sediment scoops and sediment grab to classify the sediment properties. The samples collected were analyzed in the laboratory. The Gravimetric method was used to analysis the TSS measured in mg/L. 250 ml water sample was needed for each study area (each station) [24]. Firstly, weighing the membrane filters using electronic weighing. Then, a membrane filter was placed onto a filtration apparatus connected to a vacuum pump and clipped in place. The 250 ml water sample lowly poured into the filtration jar. The membrane filter was removed and allowed to dry in the drying jar. Next, the membrane filter was weighing. Readings were taken and calculated using the following formula:

$$TSS = \frac{\{(\text{weight of filter paper + dry residue})\text{-weight of membrane filter}\}(\text{mg}) \times 1000}{\text{volume of filtered water (mL)}}$$

$$= \text{mg/L}/1000/1000/1000$$
$$= \text{tan/L} \quad (1)$$

3. Results and discussion

3.1. Total Suspended Sediment (TSS)

TSS is usually due to the introduction of external factors brought about by rainwater that can help increase the density parameters [25-27]. Contribution from natural phenomenon such as tidal effects [28] and anthropogenic activity such as municipal, industrial, agricultural and aquaculture have also been reported in TSS concentrations [29, 3]. In [30] indicates the higher density recorded by TSS may be due to the disposal of waste from municipal, agricultural and aquaculture activities. The construction activity on the banks of the river caused the river bank to become loose and easily eroded. This is partly due to the impact of discharge from the sea as it is located near the waterfront.

Table 2 shows the value of TSS in mg / L in Sungai Terengganu. The maximum value of the TSS rate was 97.7 mg / L at Station 7 (mid-section) whereas the TSS rate was lowest at 0.4 mg / L Station 19 (upstream section). Based on the cross section trend and the average downstream and middle section of the Sungai Terengganu system, the average TSS level is higher than the upper part (Fig. 1). This is because land use activities and their development are denser in the downstream areas than in the upstream areas. These activities have increased the level of sedimentation and deposition of sediments and also cause sedimentation problems [31-33, 24, 11].

Table 2: The average of Total Suspended Solid (TSS) (mg/L) at Sungai Terengganu, Terengganu

Sampling Stations	Average (mg/L)
Station 1	52.4
Station 2	42.8
Station 3	39.2
Station 4	49.2
Station 5	49.2
Station 6	64.3
Station 7	97.7
Station 8	51.4
Station 9	63.8
Station 10	15.0
Station 11	4.8
Station 12	10.0
Station 13	4.8
Station 14	10.6
Station 15	1.4
Station 16	3.0
Station 17	5.0
Station 18	20.2
Station 19	0.4
Station 20	12.8

Station 21	1.2
Station 22	17.2
Station 23	14.0
Station 24	3.0
Station 25	3.0
Station 26	5.0
Station 27	6.6
Station 28	14.4
Station 29	7.0
Maximum	97.7
Minimum	0.4

Fig. 1 shows the distribution of TSS in the study area at the upstream, middle and downstream of the Terengganu River Basin using interpolation mapping methods. In addition, through observations, most of the land use activities involving development were conducted in the downstream and middle areas of Sungai Terengganu such as Kuala Terengganu, Manir and Telemong areas [34-35].

Theoretically, the production of TSS in a river basin coincides with the previous research conducted by [36], a study on the sedimentation process at Telom River, Cameron Highlands, Pahang. The study states that when the flow of water in a basin increases, the TSS concentration will increase. In addition, according to [37], TSS concentrations are higher in wet seasons than in dry seasons and prove soil erosion that causes suspended solids and long-term investigations to be used to see the change in MS amount. The theory also states that the rapid flow of rainy days has the energy to transport TSS in larger quantities than when the slower flow due to surface runoff during rain has a high corrosion rate and resulting in a strong cliff erosion rate and will contribute to the production of TSS [16, 31, 24, 11, 33].

However, this theory may have an effect on the existence of other external factors such as non-natural factors, local climate change and river plan changes. Based on the study conducted by [11] has proven that not only the exact hydrological theory affects the sedimentation problem that occurs in the river basin but external factors such as anthropogenic factors, climate change and unexpected natural phenomena is also a major factor in the sedimentation problem [38-39, 32]. Climate change, such as the El Nino phenomenon, causes winds blowing westwards through low pressure through the tropics that form high surface water temperatures resulting in lack of rain intensity and loss of moisture from river basin or evaporation, shrinkage of river and dam and river flow abnormal slow [40-41].

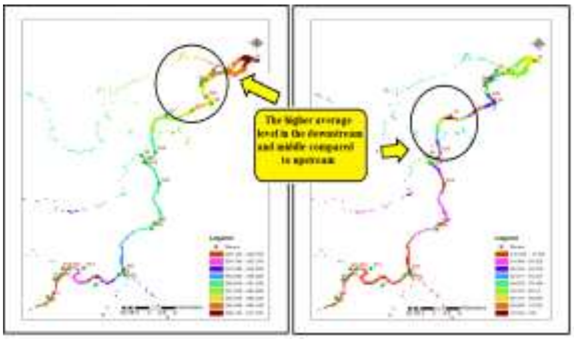

Fig. 1: Distribution of Total Suspended Solid (TSS) along sampling locations at Sungai Terengganu, Terengganu

3.2. Land use

Land use is considered a man-made land surface adjustment and has an important role in ecosystem function and aquatic life [42]. Fig. 2 shows the distribution of land use around the Terengganu River Basin in 2010 and 2016 [43]. In 2010 showed forest areas that did not carry out activities and there was change in the year 2016 showing agricultural activities. The type and factors of land use are to determine the impact of corrosion and sediment transport by the river as it affects vegetative cover from the catchment. Land use activities trigger land erosion rates and increased sediment yields associated with steep hill planting due to the reduction of agricultural land during war or other historical events [44]. In recent years, attention has been paid to how land use changes can affect hydrological responses. Increasing population and urbanization can contribute to development such as residential, agricultural and industrial areas in the floodplain. Hence, a strong need to simulate future floods affected by changing land use and climate change. Water pollution sources in the Terengganu River Basin are waste from development activities such as sand mining activities and will cause disrupted ecosystem and the destruction of aquatic habitats by channel degradation, lower water levels and bed degradation [45, 22].

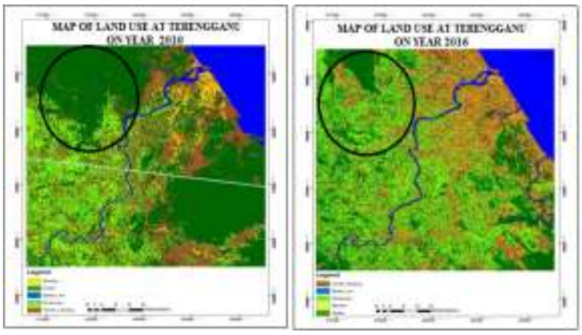

Fig. 2: Map of land use at Terengganu River Basin, Terengganu on 2010 and 2016

Fig. 3 shown, sand mining activities around Terengganu River Basin certainly alters the river regimen, and impacts environment adversely such as river pollution which causes a natural erosion pattern as well that occurs. The processes associated with channel degradation such as large-scale removal of river sediments, digging below the existing riverbed and changing the channel bed form and shape [46]. All of these causes soil erosion and sedimentation problems in the water bodies, which reduce water quality level. Impacts of sand mining can be broadly classified into three categories such as physical, water quality and ecological. The physical aspect gives some effects such as channel and bank channel erosion, channel slope improvement, and channel morphology changes. These impacts can cause the sloping and collapse of the riverbed, loss of land or adjacent structures, upstream erosion due to increased channel slope and flow velocity changes, downstream erosion caused by increased power flow, downstream changes in sedimentation patterns, and changes in channel ducts and habitat types. Besides that, the ecological aspect is the mining which leads to the removal of the channel substrate, resuspension of streambed sediment, clearance of vegetation, and stockpiling on the streambed, will have ecological impacts. Moreover, these impacts may have an effect on the direct loss of stream reserve habitat, disturbances of species attached to streambed deposits, reduced light penetration, reduced primary production and reduced feeding opportunities.

Fig. 3: River sand mining activities along the Terengganu River Basin, Terengganu

3.3. Sedimentation Management

Sediment management approaches are not widely used by dam operators and builders as they may not be aware of the various potential and effective management approaches. Generally, we lose the opportunity to minimize the impact of downstream sediment hungry and maintain reservoir function in the future. Additionally, with a large number of new dams designed for Asia, Africa, and South America is that lessons learned from successful reservoir sediment management have been used to inform the design and design of new dams and establish standards and design standards for shapes sustainable design and reservoir management [47]. In this study, we show the sedimentation management in some countries like Malaysia, Taiwan, and Japan.

Environmental Impact Assessment (EIA) was implemented in Malaysia in 1987 and the objective is to identify, evaluate, estimate and propose environmental control measures in implementing a project [48]. Implementation of the EIA enhancement package in terms of soil erosion control and sedimentation is an appropriate step to control erosion and transmission. This is due to the implementation of Pre-EIA and Post EIA levels which demonstrate high commitment by enforcement agencies to enhance the effectiveness of EIA implementation in Malaysia at every stage project. EIA is the most effective method of predicting sediment and soil erosion, thus reducing the sediment effect to the river [7, 46].

Previous studies showed that the rate of soil erosion due to development projects in Malaysia is very high caused that sediment transported to the air, rivers, lakes, and ponds can affect water quality. The government through the Department of Irrigation and Drainage (DID) had to spend millions of ringgit for river maintenance work in Malaysia. According [50-52], showed that there are weaknesses in the capacity of enforcement authorities, developers and consultants within implement EIA. The weaknesses in EIA implementation in Malaysia have also been discussed by [53] state, that the EIA was less emphasized than with pre-EIA mainly by government agencies. This show that the EIA enhancement package has not been effective yet and needs to be identified and addressed urgently to ensure that the goal of this improvement can be achieved and at the same time enhancing EIA effectiveness in Malaysia.

In Taiwan, Shihmen Dam or "Stone Gate Dam" is a major rockfill dam across the Dahan River. It forms the Shihmen Reservoir, Taiwan's third largest reservoir or artificial lake. Meanwhile, more than three million people in northern Taiwan have been provided the irrigation in Taoyuan, flood control for the Taipei Basin, and hydroelectricity and domestic water supply. Therefore, Reservoir Shihmen in the Dahan River will be renovated to the sedimentary toll road, utilizing a sharp river dam in the reservoir [54-55]. Shihmen was Taiwan's first multi-purpose water project. The advantage is year-round water releases from the dam enabled additional rice harvests and doubled Taoyuan's annual agricultural output. Meanwhile, the reservoir became a major tourist destination due to its scenic beauty and plentiful fisheries. Besides that, the sediment-plagued Shihmen Reservoir on the Dahan River will be retrofit with a sediment bypass, taking advantage of the sharp river bend at the reservoir [54]. Although the cost of the tunnel of sediment bypasses is expensive, but have many advantages in passing sediment without entering the reservoir, and without interfering with reservoir operation. In case of coarse sediment bypassing, an anti-abrasion design for tunnel bottom surface is essential for minimizing long-term operation costs, as described by [56, 10].

In Japan, sediment bypass tunnels of the Nunobiki Dam completed in 1908, while, in 1995 of the Asahi Dam has completed. It has been successfully introduced to realize sustainable reservoir management and after that, there are three operating tunnels and two are under construction. A previous study state, sediment bypasses of the Miwa Dam, Koshibu Dam and Matsukawa Dam on the Tenryu River are expected to be the next leading projects in Japan. In 1995, Proceedings of the Ninth International Symposium has completed and have been successfully introduced to realize sustainable reservoir management. Meanwhile, sediment bypasses at Miwa Dam have been almost completed, and ones at Matsukawa Dam and Koshibu Dam are under construction and planning. For the purpose of designing these bypass systems, hydraulic characteristics of tunnel and diversion weir have been studied [57-59]. In addition, the oldest suction tunnel in Japan was installed in the Nunobiki dam of the municipal water reservoir and proved that the scope of interception had succeeded in diverting abrasive sediments for more than 100 years [10]. At Miwa and Asahi, show that the rivers are steep enough and the straight tunnels have sufficient brightness to carry the bulk of the sediment load downstream of the dam [10, 60]. Miwa Dam (on the Mibu River, Tenryu River) was built in 1959 with a storage capacity of 30 million m^3 (Mm^3). The subsequent deposition of the $20Mm^3$ sediments has resulted in the sediment removal process becoming expensive. In 2005, 4.3 km of sediment and sediment bypass was built to expand the reservoir life. Based on the stated sedimentation management, we can conclude that there are many methods of sedimentation management in the country and abroad. However, we must choose the best and adaptive method to make an effective impact as well as reduce the sedimentation problems experienced.

3.3. Recommendation of Sedimentation Management around Terengganu River Basin

To handle the sediment problem, some recommendation of Sedimentation Management around Terengganu River Basin has been suggested such as; (a) Buffer zone state that river reserves and plants are important for the overall health of the river; (b) River Erosion Cliff can prevent more serious erosion and overcome flood problems; (c) The Integrated River Basin Management Concept (IRBM) is maximizing sustainable socio-economic benefits and maintains and regulates the functioning of natural water.

3.3.1. Buffer zone

Among the proposed was to create a buffer zone (600 meters) around the Bukit Jong quarry area and Kampung Bukit Wan quarry according to District Local Plan Kuala Terengganu (2008-2020) [61] the buffer zone is not allowed any new building construction within the buffer area except those related to quarry activities. The protected zones are a wise step to overcome sedimentation problems, which can reduce the sediment influx from direct surface flows to rivers in the Terengganu River. Table 3 shows the minimum allocation of river reserves to control development near the river. River reserves and plants are important for the overall health of the river such as preventing erosion, maintaining habitat, protecting quality air, and aesthetic and recreational value. The infrastructure development to be built should take into account the concept of river-facing development. Construction of buildings and infrastructure should not protect the landscape of the rivers such as low-rise buildings and high back buildings. In addition, this buffer zone is not only environmental friendly but is capable of reducing sedimentation problems around river basins especially in active land use areas such as Kepong, Manir, Paloh, Kuala Terengganu and Kuala Berang areas comprising Nerus River, Sekati River, Kepong River, Tersat and Berang River and Sala River (downstream).

Table 3: The minimum width allocation of river reserves to control development near the river [62]

The Width of the Waterway Between The Cliffs	The Need for the Width of the Reserves From Both Sides of the Cliff Based on the Existing River Area
More than 40 metres	50 metres
Between 20 and 40 metres	40 metres
Between 10 and 20 metres	20 metres
Between 5 and 10 metres	10 metres
Less than 5 metres	5 metres

3.3.2.River Erosion Cliff

The construction of riverbank control structures is an alternative to minimizing the erosion of the cliffs [63]. Construction Structures like an obstacle in the area can prevent more serious erosion and overcome flood problems. Among the arrangements in addressing erosion problems surrounding the river basin is by erecting the erosion control block. The commonly used wall is 'gabion bank' by using rocks as the barrier. Based on the results, Fig. 4(a) shows the construction of erosion control cliffs using more natural materials 'fiber roll' is more suitable in Terengganu River. In addition, the planting of erosion barrier trees and reserves is also intended to address the erosion problems of the cliffs as well as being a natural sediment filter for the river. Fig. 4(b) shows the method of corrosion control structures and floods of the Rock Revetments hedges that are used to protect the cliffs and the soil. Construction of Rock Revetments in several areas of the Terengganu River Basin can provide direct protection to the erosion of the cliffs and improve the stability of the cliffs. In addition, Fig. 4(c) shows the corrosion and flood control structures of the Flex Slabs ever built in Pengkalan Kubor in Tumpat area in 1996. The function of the Flex-Slab method that is applied in Terengganu River Basin which has high water content. This Flex-Slab method can protect and stabilize the cliffed and it needs to be properly used to keep up with high speed in a long-term.

(a)

(b)

(c)

Fig. 4: (a) Erosion Control Clay Using more natural materials "*fiber roll*" (b) Cliff control method *"rock revetments"* (c) Cliff erosion control method Flex Slab

3.4. The Integrated River Basin Management Concept (IRBM)

Integrated River Basin Management (IRBM) is a process of coordination in the management, conservation, and development of water resources, land and related resources such as river basin or catchment aimed at maximizing sustainable socio-economic benefits for water resources. At the same time, it maintains and regulates the functioning of natural water ecosystems in the long-term. In addition, IRBM seeks to create a coordination framework to administrators and stakeholders involved in river basin planning and management to collaborate in developing a set of policies and strategies agreed with a balanced approach that is acceptable and achievable to manage water resources and nature [64]. Therefore, it is considered a good water resource planning to integrate water quantity and quality management for both groundwater and surface water. Meanwhile, to an understanding of how natural resources and basin populations are affected by various of development, using the new resources such as management and use the land for consideration in water resource planning and management.

4. Conclusion

Balancing development pressures with long-term prosperity for economic, social, environmental and health measures requires integrated technical thinking and multi-party skills. Regeneration, not just sustainability, is a new goal for water resource management and planning in an increasingly uncertain world. Basically, water resources management planning looks at all claims that are competing for water and aim to allocate water fairly to meet all uses and claims. Hence, managing, approaching and controlling the project is done to correct problems such as sedimentation and river sand mining activities. Management of water resources in the Terengganu River Basin cannot be underestimated as it has a direct impact on the treasures we have. In addition, we have proposed water resource management measures in the Terengganu Basin to ensure that the Terengganu River Basin is protected from the pollution of major water resources and can provide clean and quality water to the community.

Acknowledgement

The authors acknowledge to UniSZA for Scholarship under research grants: UniSZA/2017/SRGS/17) – R0019-R017. Special thanks are also dedicated to Faculty of Applied Social Science, *Fakulti Sains Sosial Gunaan* (FSSG) and Department of Statistics Malaysia give permission to use the research facilities, provided the secondary data and supporting in this research.

References

[1] Jindal, R., & Sharma, C., (2011). Studies on water quality of Sutlej River around Ludhiana with reference to physicochemical parameters. Environ. Monit. Assess., 174: 417-425.
[2] Sánchez, E., Colmenarejo, M.F., Vicente, J., Rubio, A., García, M.G., Travieso, L., Borja, R., (2007). Use of the water quality index and dissolved oxygen deficit as simple indicators of watersheds pollution. Ecological Indicators, 7(2): 315-328.
[3] Suratman, S., Awang, M., Loh, A.L., & Mohd Tahir, N., (2009). Water quality index study in Paka River basin, Terengganu (in Malay). Sains Malaysiana, 38: 125-131.
[4] Barry, R. G., & Chorley, R. J. (1984). Introduction to physical hydrology. Methuen.
[5] Scanlon, J. (2003). Flow: The essentials of environmental flows. http://moderncms.ecosystemmarketplace.com/repository/moderncms_documents/iucn_the-essentials-of-environmental-flows.pdf.
[6] Wang, G., Wu, B., & Wang, Z. Y. (2005). Sedimentation Problems and Management Strategies of Sanmenxia Reservoir, Yellow River, China. Water Resources Research, 41(9): 1-17.
[7] Toriman, M. E., Kamarudin, M. K. A., Aziz, N. A. A., Din, H. M., Ata, F. M., Abdullah, N. M., & Abdullah, N. W. (2012). Pengurusan Sedimen Terhadap Sumber Air Bersepadu: Satu Kajian Kes di Sungai Chini, Pekan Pahang. Ebangi. Jurnal Sains Sosial Dan Kemanusiaan, 7(1): 267-283.
[8] Ashmore, P. E., & Rennie, C. D. (2012). Gravel‐bed rivers: From particles to patterns. Earth Surface Processes and Landforms, 38(2): 217-220.
[9] University of Michigan (2004). Soil Erosion and Sedimentation Control Procedures.
[10] Sumi, T., Okano, M., & Takata, Y. (2004). Reservoir Sedimentation Management With Bypass Tunnels In Japan. In Proceedings of the Ninth International Symposium on River Sedimentation, pp. 1036-1043.
[11] Kamarudin, M. K. A., Toriman, M. E., Wahab, N. A., Rosli, H., Ata, F. M., & Faudzi, M. N. M., (2017). Sedimentation Study on Upstream Reach of Selected Rivers in Pahang River Basin, Malaysia. International Journal on Advanced Science, Engineering and Information Technology, 7(1): 35-41.
[12] Kamarudin, M. K., Toriman, M. E., Rosli, M. H., Juahir, H., Aziz, N. A., Azid, A., Zainuddin, S. F., & Sulaiman, W. N. (2014). Analysis of meander evolution studies on effect from land use and climate change at the upstream reach of the Pahang River, Malaysia. Mitigation and Adaptation Strategies for Global Change, 20(8): 1319-1334.
[13] Jackson, C. A., Zakaria, A. A., Johnson, H. D., Tongkul, F., & Crevello, P. D. (2009). Sedimentology, stratigraphic occurrence and origin of linked debrites in the West Crocker Formation (Oligo-Miocene), Sabah, NW Borneo. Marine and petroleum Geology, 26(10): 1957-1973.
[14] Hashim, N. M., Saad, J. M., Othman, N. F., Mei, W. K., & Rani, H.A. (2001). Kajian Angkutan Sedimen Dan Beban Dasar Sungai Di Lembangan Sungai Hijau Bukit Fraser. Pusat Pengurusan Penyelidikan UKM, Malaysia.
[15] Hashim, N.A.N., & Jaaman S.A. (2011). Boat Effects on the Behavior of Indo-Pasific Humpback (Sousa Chinensis) and Irrawady Dolphin (Orcaella Brevirostris) In Cowie Bay, Sabah, Malaysia. Sains Malaysiana, 40(12): 1383-1392.
[16] Tongkul, F. (2000). Sedimentologi. Universiti Kebangsaan Malaysia Press.
[17] Toriman, M. E. (2005). Hydrometeorological conditions and sediment yield in the upstream reach of Sungai Bebar, Pekan forest reserve, Pahang. Biodiversity Expedition Sungai Bebar, Pekan, Pahang. Summary findings. Peat Swamp Forest Project. PSF Technical Series.
[18] Gray, D. M. (1970). Handbook on the principles of hydrology. National Research Council of Canada.
[19] Sultan, K., & Shazili, N. A. (2010). Geochemical baselines of major, minor and trace elements in the tropical sediments of the Terengganu River basin, Malaysia. International Journal of Sediment Research, 25(4): 340-354.
[20] Nalado, A. M., Kamarudin, M. K. A., Wahab, N. A, Rosli, M. H., & Saudi, A. S. M. (2017). Assessment of Individual Water Quality Index Parameter in Terengganu River, Malaysia. Journal Fundamental Appllied Science, 9(2S): 430-442.
[21] Bakar, H. A. (2015). Sungai Terengganu didalamkan bagi atasi banjir. BH Online.
[22] Wahab, N. A., Kamarudin, M. K. A., Toriman, M. E., Juahir, H., Gasim, M. B., Rizman, Z. I., & Damayanti, P. P. (2018). Climate changes impacts towards sedimentation rate at Terengganu River, Terengganu, Malaysia. Journal of Fundamental and Applied Sciences, 10(1S): 33-51.
[23] Idris, M., Hussin, K., & Latiff, A. (2005). Sumber Asli Tasik Chini. Universiti Kebangsaan Malaysia Press.
[24] Wahab, N. A., Kamarudin, M. K., Gasim, M. B., Umar, R., Ata, F. M., & Sulaiman, N. H. (2016). Assessment of Total Suspended Sediment and Bed Sediment Grains in Upstream Areas of Lata Berangin, Terengganu. International Journal on Advanced Science, Engineering and Information Technology, 6(5): 757-763.
[25] Jonnalagada, S.B. & Mhere, G. (2001). Water quality of the Odzi River in the eastern highlands of Zimbabwe. Water Res., 35: 2371-2376.
[26] Rossi, L., Krejci, V., Rauch, W., Kreikenbaum, S., Fankhauser, R. & Gujer, W. (2005). Stochastic modeling of total suspended solids (TSS) in urban areas during rain events. Water Res., 39: 4188-4196.
[27] Suratman, S., Mohd Tahir, N., Lee, C.Y. & Siti Rohayu, A.R. (2006). Monsoon effects on water quality in Besut River basin, Terengganu (in Malay). Malay. J .Anal. Sci., 10: 143-148.
[28] Suratman, S., Hussein, A. N. A. R., Latif, M. T., & Weston, K. (2014). Reassessment of physico-chemical water quality in Setiu Wetland, Malaysia. Sains Malaysiana, 43(8): 1127-1131.
[29] Atkinson, C.L., Golladay, S.W. & First, M.R. (2011). Water quality and planktonic microbial assemblages of isolated wetlands in an agricultural landscape. Wetlands, 31: 885-894.
[30] Sailan, M. I., Hee, Y. Y., Bedurus, E. A., & Latif, M. T. (2015). A Preliminary Study of Water Quality Index in Terengganu River Basin, Malaysia. Sains Malaysiana, 44(1), 67-73.
[31] Toriman, M. E., Kamarudin, M. K. A., Idris, M. H., Gasim, M. B., & Jamil, N. R. (2008). Masalah Sedimentasi dan Penyelesaiannya Melalui Kaedah Pengurusan Persekitaran: Satu Kajian Kes di Sungai Chini, Pahang. E-bangi: Jurnal Sains Sosial dan Kemanusiaan, 3(3): 1-14.
[32] Kamarudin, M. K. A., Toriman, M.E., Idris, M., Juahir, H., Azid, A., Gasim, M. B., Umar, R., Endut, A., Mokhtar, M., Khalit, S. I., Ismail, A., Yaakob, N. H. M., Rwoo, M. A. (2016). Environmental Management on Natural Lake Using Sediment and Hydrology Hydraulic Models. Malaysian Journal of Applied Sciences, 1(2): 9-26.
[33] Wahab, N. A, Kamarudin, M. K. A., Anuar, A., Ata, F. M, Sulaiman, N. H., Baharim, N. B., Harun, N. S., Muhammad, N. A. (2017). Assessments of Lake Profiling on Temperature, Total Suspended Solid (TSS) and Turbidity in the Kenyir Lake, Terengganu, Malaysia. Journal Fundamental Applied of Science, 9(2S): 256-278.
[34] Misnan, N., & Rindam, M. (2012). Morfometri Lembangan Sungai-Sungai Utama di Pulau Pinang. Malaysia Journal of Society and Space, 8(3): 71-81.
[35] Jaafar, M., Zainuddin, M. S., & Abdullah, S. M. S. (2014). Implikasi Pembangunan Bandar Indera Mahkota Kepada Pencemaran Sg. Talam, Kuantan, Pahang. Geografia-Malaysian Journal of Society and Space, 10(3): 201-213.
[36] Abdullah, N. W., & Toriman, M. E. (2011). Ciri Persekitaran Hidrologi dan Sedimentasi Sungai Telom, Cameron Highlands. e-Bangi: Jurnal Sains Sosial dan Kemanusiaan, 5(2): 161-172.
[37] Abdullah, S.M, Al-Toum, S., & Jaafar, O. (2003). Rainsplash Erosion: A Case Study in Telak River Catchment, East Selangor, Malaysia. Geografia, 1(4): 44-59.
[38] Mohamed, A.H. (1993). Manusia dan Geologi. Terjamahan. Dewan Bahasa dan Pusaka.
[39] Sulaiman, N. H., Kamarudin, M. K. A., Mustafa, A. D., Amran, M. A., Azaman, F., Zainal, I. Z. A., Hairoma, N. S. (2015). Trend Analysis of Pahang River Using Non-Parametric Analysis: Mann Kendall's Trend Test. Malaysian Journal of Analytical Sciences, 19 (6): 1327-1334.
[40] Tallaksen, L. M., & Van Lanen, H. A. (2004). Hydrological Drought: Processes and Estimation Methods for Streamflow and Groundwater. Elsevier.

[41] Ahmad, S., & Hashim, N. (2006). Kebakaran Hutan dan Isu Pencemaran Udara di Malaysia: Kes Jerebu Pada Ogos 2005. e-BANGI: Jurnal Sains Sosial dan Kemanusiaan, 1(1): 156-169.

[42] Steffen, W., Crutzen, P. J., & Mcneill, J. R. (2007). The Anthropocene: Are Humans Now Overwhelming the Great Forces of Nature. AMBIO: A Journal of the Human Environment, 36(8), 614-621.

[43] Jabatan Pengairan dan Saliran (JPS) Negeri Terengganu, (2010 & 2016). Guna Tanah Semasa di Lembangan Sungai Terengganu Bagi Tahun 2010 dan 2016.

[44] Sidorchuk, A. Y., & Golosov, V. N. (2003). Erosion and sedimentation on the Russian Plain, II: The history of erosion and sedimentation during the period of intensive agriculture. Hydrological Processes, 17(16): 3347-3358.

[45] Lawal, P. O. (2011). Effects of sand/gravel mining in Minna Emirate area of Nigeria on stakeholders. Journal of Sustainable Development, 4(1), 193.

[46] Environmental Conservation Department (ECD). (2001). State policy on river sand and stone. Sabah: State Environmental Conservation Department.

[47] Kondolf, G. M., Gao, Y., Annandale, G. W., Morris, G. L., Jiang, E., Zhang, J., Yang, C. T. (2014). Sustainable sediment management in reservoirs and regulated rivers: Experiences from five continents. Earth's Future, 2(5): 256-280.

[48] Johnson, E. (2003). A handbook for scooping projects: Environmental Impact Assessment. Environmental Impact Assessment Review, 23(1): 125.

[49] Mahmud, A. R., Sakawi, Z., & Maulud, K. N. A. (2015). Pakej Penambahbaikan EIA di Malaysia:Suatu Ulasan Kritis dalam Aspek Kawalan Hakisan Tanah dan Sedimentasi. Geografia-Malaysian Journal of Society and Space, 11(6): 23-35.

[50] Kirchhoff, D. (2006). Capacity Building For Eia In Brazil: Preliminary Considerations And Problems To Be Overcome. Journal of Environmental Assessment Policy and Management, 8(1): 1-18.

[51] Talime, L. A. (2011). A critical review of the quality of enviromental impact assessment reports in Lesotho. Master thesis, University of the Free State.

[52] Wassserman C. (2011). Enforcement of Environmental Impact Assessment Requrements. Proceedings of the Ninth International Conference on Environmental Compliance and Enforcement, pp. 502-525.

[53] Said, A. M. (2008). Environmental impact assessment: Post-monitoring and audit in Malaysia. Universiti Teknologi MARA Press.

[54] Wang, H. W., & Kondolf, G. M., (2014). Upstream Sediment Control Dams: Five Decades of Experience in the Rapidly Eroding Dahan River Basin, Taiwan. Journal of the American Water Resources Association, 50(3): 735-747.

[55] Hou, H. S., Lee, M., & Hou, P. (2010). Shihmen sediment prevention diversion tunnel planning and design. Proceedings of the IEEE International Conference on Energy and Sustainable Development: Issues and Strategies, pp. 1-8.

[56] Vischer, D., W. H. Hager, C. Casanova, B. Joos, P. Lier, and O. Martini (1997). Bypass tunnels to prevent reservoir sedimentation. Proceedings of the 19th ICOLD Congress.

[57] Ando, N., Terazono, K. and Kitazume, R., (1994). Sediment removal project at Miwa dam. Proceedings of the 18th Congress of ICOLD, pp. 421-441.

[58] Kashiwai, J., Sumi, T. and Honda, T., (1997). Hydraulic study on diversion facilities required for sediment bypass systems. Proceedings of the 19th Congress of ICOLD, pp. 957-976.

[59] Harada, M., Terada, M. and Kokubo, T., (1997). Planning and hydraulic design of bypass tunnel for sluicing sediments past Asahi reservoir. Proceedings of the 19th Congress of ICOLD, pp. 509-539.

[60] Suzuki, M. (2009). Outline and effects of permanent sediment management measures for Miwa dam. Proceedings of the 23rd ICOLD Congress.

[61] Cadangan Guna Tanah Daerah Kuala Terengganu, Terengganu, Malaysia Bagi Tahun 2008-2020,Rancangan Tempatan Daerah (RTD) Kuala Terengganu, Terengganu, Malaysia Bagi Tahun 2008–2020. Enforcement, pp. 502-25.

[62] Akta Perairan (Waters Act 1920). Garis Panduan Konsep Pembangunan Berhadapan Sungai. Jabatan Pengairan dan Saliran Malaysia.

[63] Toriman, M. E., & Che Lah, H. (2007). Ciri Hidrologi dan Hakisan Tebing Sungai di Sungai Lendu, Alor Gajah, Melaka. Journal E-Bangi. 2(2): 1-9.

[64] Millington, Peter; Olson, Douglas; McMillan, Shelley. (2006). An introduction to integrated river basin management (English). Integrated river basin management briefing note; no. 1. World Bank.