Field Investigation on Anthropogenic Impacted Lowland Riparian Zones

Darrien Y. S. Mah1*, Kelvin K. K. Kuok2

1Department of Civil Engineering, Faculty of Engineering, Universiti Malaysia Sarawak, Kota Samarahan, Malaysia
2Faculty of Engineering, Computing and Science, Swinburne University of Technology, Sarawak, Malaysia

Email: ysmah@feng.unimas.my, kkuok@swinburne.edu.my

Received December 6, 2012; revised January 7, 2013; accepted January 17, 2013

Keywords: Groundwater; Maong River; Measurement; Rapid Assessment; Urban; Vegetation

ABSTRACT

A functioning riparian zone is very beneficial to the environment. However, most of the riparian zones have been disturbed by man-made implications these days. Public awareness about the issues of environmental conservation including riparian zones is needed by providing information on critical areas. Therefore, a novel framework is presented here to reveal how well a riparian zone adapts to changes. This paper highlights the field investigation of an altered riparian system along Maong River in Kuching Sarawak. Investigation of the general riparian health is followed by the studies of its contributing attributes—vegetation cover, human activities and groundwater level, have been carried out. The methods are practicable in harnessing understanding and knowledge of riparian conditions. For a disturbed riparian zone, the findings indicate that 50% - 60% of the study areas are categorized as healthy or functioning riparian systems, at the same time, correlate the influences of the three afore-mentioned attributes.

1. Introduction

Anthropogenic endeavours have long influenced the riparian zones. However, living organisms adapt to disturbance regime over broad spatial-temporal scales [1]. Therefore, an understanding of the mentioned adaptation reflects the pulses of riparian zones and rivers due to changes in anthropogenic activities [2]. This has called for an exploration of an altered riparian system in a Maong River in Kuching, Sarawak.

Maong River is a tributary of and tidally influenced by its main-stem Sarawak River. Naturally, the river was a nipah-fringed river (see Figure 1), where nipah palms (Nypa fruticans) were the dominant vegetation. Nipah is found upstream of mangrove, which strives in freshwater-brackish reaches of a river [4]. However, human settlements were erected along this river over the past 100 years, reducing the nipah system to merely grasses and bushes.

2. Case Study

Nipah system is unique on its own because the plants need both freshwater and salt water to survive. The presence of salt disables other freshwater species to take over its establishment, at the same time, the constant flows of freshwater in the form of high groundwater table maintains its vitality [5-7]. When human removes the nipah for physical development, this process alters the freshwater flows. For the denudation of the water-retaining nipah system reduces the water holding ability of the soil and eventually causes the groundwater level to drop [8,9].

The remnants of riparian zones along Maong River are taking over by secondary growth extending 50 - 100 m from the river banks (see Figure 2(b)). For comparison, the 100-year old painting in Figure 2(a) is showing the
primary growth of tall nipah palms. Apparently, in the late 1880s where human settlement of colonial era was
significant, grasses appeared in the painting after human clearing of lands.

Because of such a drastic change, it is the intention of this paper to explore the current conditions of riparian
zones along Maong River. By understanding and knowing riparian health or function, it allows communities to
identify concerns and to proactively address specific land use issues [10].

3. Methods

Stretches of Maong River beside the Wee and Wee Garden is chosen, for its upper and lower boundaries are
easily identifiable and findable for repeat assessments. Areas of concern are designated into polygons of 100 ×

![Figure 1. Typical Riparian Habitat in Southeast Asia [3].](image1)

100 m in dimension for field investigation and sampling purposes (see Figure 3). There are a total of 27 polygons
selected for representation of its situations in the riparian system under study. All polygons should touch the water
ing as much as possible. The composition in each polygon varies with two distinct characteristics of vegetation
cover and human activities.

Two methods are used here. First, a rapid assessment using Proper Functioning Condition (PFC) method [11, 12]
is carried out. Each polygon is determined of its conditions whether it is functioning or non-functioning. Second,
field measurement of three attributes—vegetation cover, human activities and groundwater level are collected in
each polygon to compare with the corresponding PFC data set.

4. Proper Functioning Condition

There are many ways of assessing the conditions of a riparian system. For an altered system, where the
indigenous plants were fully stripped off, it is fair to take a different approach than the conventional [13,14]. The
Maong River is assessed based on the characteristics of an ecologically healthy river corridor (see Table 1).
Fundamentally, it covers the presence of natural structures like sediments and water, channels and floodplains.
They also include collections of hydrophilic riparian plants and wildlife that rely much upon the natural hydrologic
regimes representative of the landscape [15,16].

Wee and Wee Garden has been established for more than 30 years beside Maong River. The positive aspect is
the river bank remains natural, without any concrete embankment like most of the modern construction does. This
stabilizes the river bank and in turn helps in maintaining its swampy and moist soils favourable for grasses like
napier grass (Pennisetum purpureum), torpedo grass (Panicum repens), wild yam (Colocasia esculenta) and other
local wetland species (see Figure 4). Generally, the grasses signify a functioning riparian system. Although the
richness of the biodiversity is not as high as in pristine state, a variety of wetland communities grow wild in this
narrow strip of land.

![Figure 2. Riparian Zones, (a) view of Sarawak River (1880s) and (b) view of Maong River (2012).](image2)

![Figure 3. Study Area, (a) Western Zone and (b) Eastern Zone (http://www.wikimapia.org).](image3)
5. Field Measurement

The three attributes—vegetation cover, human activities and groundwater level are chosen for they are rather ease to use and convenient to access. It is known that environmental features are continuous by nature and thus making it difficult to assess due to many intermingle factors within a system [17]. We present here a framework while extracting only three parameters may seem fragmented, but in a way, it provides a straight forward means of interpreting complex riparian systems. The first two attributes can be measured using a geographical information system. It is a tool to produce mapping, exploring and analysing data of riparian features [18].

Vegetation cover—this is how much of the ground is covered by any sort of vegetation, of any life form. It is a crucial parameter to judge a riparian [19]. During field visit, it is seen and interpreted more easily to provide an early indication of riparian health and helping to understand the successional trend on a site. The average percentage for vegetation among all polygons is 46%. Superimposing PFC data on the vegetation cover in each polygon, it is found that the riparian renders to nonfunctioning as the vegetation cover is lessening to about 30% coverage (see Figure 5).

Human activities like construction of houses, roads, bridges and other hard structures influence the conditions and functions of the adjacent riparian system. In each polygon, the remaining portions other than vegetation cover are lumped as human activities. The average percentage of human activities is 54%, about 8% higher than vegetation cover. It is found that the riparian degrades to non-functioning when the human activities are approaching 70% of land coverage (see Figure 6).

From the aspect of hydrology, groundwater level is one important factor as riparian vegetation relies much on the groundwater table [20,21]. On-site tests have been carried out. The apparatus involved perforated pipe with adequate diameter, post hole digger, hammer and measuring tape. The pipe is inserted into the soil at a distance 2.5 - 3.0 m away from the water edge allowing the shallow groundwater to flow into the pipe, then lifted up to notice the level of water line from the ground surface (see Figure 7). Average reading for each polygon is plotted (see Figure 8). Comparing to PFC data set, it is observed that when the groundwater level from ground surface is 20 cm or higher, the system in place is no longer functioning. About 60% of the polygons are functioning with groundwater level around 15 cm from the ground surface.

Rearranging all data sets together, it shows the big picture of how much the altered riparian system under study adapted to changes (see Table 2). Riparian

| Table 1. Riparian health assessment. |
|-------------------------------------|
| Note: If no √, non-functioning; If 1 to 2 √, intermediate; If 3 to 4 √, functioning. |

| Table 2. Comparison of data. |
|-------------------------------|
conditions are further divided into three categories—desirable, tolerable and destructive ranges. In reality, human endeavours deem to pressure for more lands due to increasing needs for residential and transportation purposes. We suggest here, the tolerable range provides an opportunity to explore as indicator for tolerable human intervention in riparian zones.

From the findings, it is shown that most of the riparian zones along Maong River are categorized as healthy or functioning riparian systems. This means that the human-riparian interactions have been well managed all this while. Not only the residential around have made the effort, the local council has done their responsibility as well. By observing the conditions along the Maong River, it is still within an acceptable pollution level as there is no bad odour, garbage in the river and the turbidity of the river water is low.

6. Conclusion

Field investigation of an altered riparian zone has been conducted. Factors like vegetation cover, human activities and groundwater level have been taken into consideration. From the analysis of 27 polygons representative of the study site along Maong River, the riparian is generally good and in acceptable level, where 50% - 60% of the areas are classified as functioning systems. This would not have happened if not the river is allowed of its natural banks to continue the cycles of decent hydrological regime and ecosystem. In other words, human-riparian interactions in this area have been well implemented throughout the year.

7. Acknowledgements

The authors express gratitude to opportunity, research, financial supports provided by the Universiti Malaysia Sarawak.

REFERENCES

1. R. J. Naiman, H. Décamps and M. Pollock, “The Role of Riparian Corridors in Maintaining Regional Biodiversity,” The Ecological Society of America, Ecological Application, Vol. 3, No. 2, 1993, pp. 209-212.
2. M. Dubé, N. Nadorozny and A. J. Squires, “Development of the Healthy River Ecosystem Assessment System (Threats) for Integrated Change Assessments of Water Quality in Canadian Watersheds,” In: J. Lundqvist, Ed., On the Water Front Vol. 2, Stockholm Int. Water Institute, Stockholm, 2011, pp. 31-40.
3. Malaysian Ministry of Natural Resources and Environment (NRE), “Managing Biodiversity in the Riparian Zone,” Malaysian Ministry of Natural Resources and Environment, Putrajaya, 2009.
4. E. J. H. Corner, “Wayside Trees of Malaya,” The Malayan Nature Society, Kuala Lumpur, 1988.
5. L. S. Hamilton and D. H. Murphy, “Use and Management of Nipa Palm (Nypa fruticans, Arecaceae): A Review,” Economic Botany, Vol. 42, No. 2, 1988, pp. 206-213. doi:10.1007/BF02858921
6. F. W. Fong, “Perspectives for Sustainable Resource Utilization and Management of Nipa Vegetation,” Economic Botany, Vol. 46, No. 1, 1992, pp. 45-54. doi:10.1007/BF02985253
7. H. T. W. Tan, “A Guide to the Threaten Plants of Singapore,” Singapore Science Centre, Singapore City, 1996.
8. L. H. Liow, “Mangrove Conservation in Singapore: A Physical or Psychological Impossibility?” Biodiversity and Conservation, Vol. 9, No. 3, 2000, pp. 309-332. doi:10.1023/A:1008993417327
9. H. P. Ritzema, “The Role of Drainage in the Wise Use of Tropical Peatlands,” Carbon-Climate-Human Interaction on Tropical Peatland, Proceedings of the International Symposium and Workshop on Tropical Peatland, Yogyakarta, 27-29 August 2007, pp. 27-29.
10. L. Fitch and N. Ambrose, “Riparian Area: A User’s Guide to Health,” Cows and Fish Program,
Riparian zones have been recognized to buffer diffuse nitrate pollution, reducing delivery to aquatic ecosystems, but nutrient removal is not their only function in river systems. In this paper, we propose a new conceptual framework to test the capacity of riparian corridors to retain, remove, and transfer nitrogen along the continuum from land to sea under different climatic conditions. Because anthropogenic inputs of reactive nitrogen to aquatic ecosystems are increasing all over the world, there is an urgent need to evaluate the intrinsic capacity of riparian zones to retain or remove nitrogen. Moreover, the impact of climate change and anthropogenic pressures on the buffering capacity of riparian corridors at local and regional scales remain highly uncertain. We focus on four major phases that witnessed broad anthropogenic alterations to biodiversity—the Late Pleistocene global human expansion, the Neolithic spread of agriculture, the era of island colonization, and the emergence of early urbanized societies and commercial networks. Archaeological evidence documents millennia of anthropogenic transformations that have created novel ecosystems around the world. This record has implications for ecological and evolutionary research, conservation strategies, and the maintenance of ecosystem services, pointing to a significant need for broader cross-d

NOTES

*aFormerly with River Engineering and Urban Drainage Research Centre (REDA), Universiti Sains Malaysia, Penang, Malaysia.

*Painting of Marianne North who travelled the globe between 1871 and 1885 to record the world's flora. The painting is now displayed in the Kew Royal Botanic Garden, UK.