

The Value of Services for Water Catchments for Kedah Permanent Forest Reserves

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Abstract. Kedah's forest area for water catchments plays an important role as it serves the demand of water for the state of Kedah, Penang and Perlis intended for domestic, agricultural and industrial used. Forest plays an important role as water catchment not only providing water in term of quantity but also provides the good quality of clean water. This process called purification services. But, how to assess the important of the services based on its value, because most of ecosystem services are not monetized. Therefore, this paper aims to estimate regulating services value of Kedah's Permanent Reserved Forest (PRF) as water catchment especially for domestic used. The information of 36 Water Treatment Plants (WTP) intakes data collected and information of forest land uses from National Forest Inventory (NFI) were used as data input for the analysis. A comparative analysis results the value of services for water purification services for Kedah's PRF is RM49,140,171/year, approximately RM 21.93/hectare/year. Results show a significant impact to protect catchment areas within forest reserves for clean water.

1 Introduction

In kedah, forest areas have important role in supplying water not only for domestic used but also agricultural areas as Kedah is known as 'rice-bowl' of Malaysia. Water from Kedah also been supplying to Perlis and Penang in which important for industrial sector. However, forest areas are now under threat as a result of development projects such as for residential and commercial turns the area of water catchment to be affected. Study by Benavides and Veenstra [1], deforestation will lead to increase of sedimentation, nitrogen and phosphorus which impacts on water quality. Forest acts as "water purifier" where it help filtered contaminants from entering rivers naturally. This services named "water purification".

Water purification services categorized as regulating services under The Economics and Environmental Assessment (TEEB). Forest in water catchments area produce good water quality in which can reduced the cost of treatment. Water that through forests have clean water than water released by other land uses. Therefore, the need for treatment is less compared to polluted water before supply to users.

Millennium Ecosystem Assessment explains the services links to the balance of human well-being as water safety, availability and security. But, how to quantify the benefit to conserve forest in comparison to the cost for water treatment? In assessing water purification

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services and forest conservation for water quality, several methods can be used. One method is called the cost function approach. This approach uses an econometric model that value water catchment service with a relationship between environmental inputs.

Kedah's forest area especially plays an important role for water catchments as it serves the demand of water for the state of Kedah, Penang and Perlis intended for domestic, agricultural and industrial used. Therefore, the objective is to assess the purification services value of Kedah Permanent Reserved Forest (PRF) as water catchment especially for domestic used.

2 Data and methodology

2.2 Data

The crucial part of the study was to obtain several data on catchment including data on treatment plants and forest land uses. Information on treatment plants for Kedah was gathered from Syarikat Air Darul Aman (SADA) Sdn. Bhd. There are 36 WTPs in the state of Kedah which are divided into 6 management regions. The information obtained from SADA are the coordinates of WTPs in Kedah, the amount of treated water production, operational cost including chemicals and electricity consumption for the year 2021. However, the cost data obtained only for the use for the study and restricted for publication, Hence, the data were only used for the analysis and not be highlighted in this paper. Fig.1 show the listed the WTPs intakes.

A Digital Elevation Model (DEM) obtained in the form of contour maps and also USGS Earth Explorer satellite images that provide 30 m x 30 m resolution. This digital elevation model (DEM) is very important for determining the elevation of the ground from MSL and for delineation watershed boundaries.

Other important data was National Forest Inventory, basic data used for forest land uses. This NFI data was published by the Forestry Department of Peninsular Malaysia and is in the fifth series. This data consists of several forest categories known as strata.

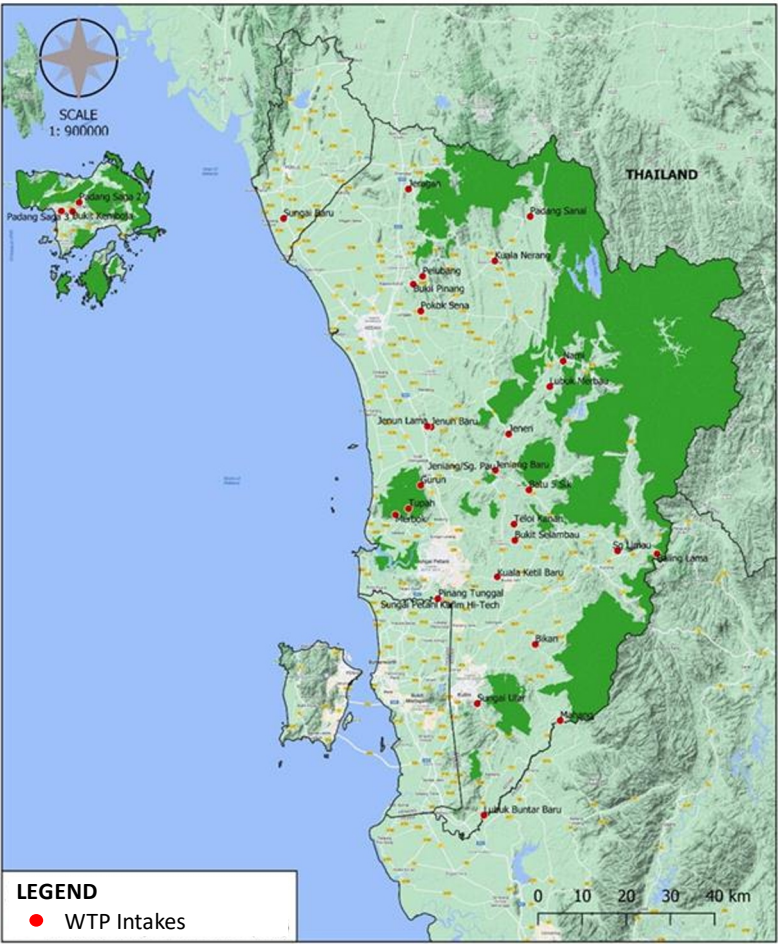


Fig. 1. The distribution of Kedah’s Water Treatment Plant intakes.

2.2 Approach

To identify the catchment of water by treatment plants, each of intake’s coordinate were used as point of watershed delineation. Watershed delineation was generated using module in Soil and Water Assessment Tools (SWAT).

National Forest Inventory was used to assess the percentage of forest land uses comprising the forest land use of virgin and logged forest in a catchment. The impact of different forest land use types gives different impact in the model.

Waterpurification services valuation is constructed by study of economic model in Perak [2] using benefit transfer approach. The assessment from water treatment costs in Perak based on panel data of forest changes. The analysis is guided by the theory of using cost functions for environmental input values [3],[4], and [5], as follows;

$$\ln(C_{it}) = \mathbf{L}_{iy}\boldsymbol{\beta} + \alpha \ln(q_{it}) + c_i + \theta_y + \theta_m + u_{it}$$

(1)

Where;
i WTP,

t Time (years),
y Year,
m Month,
C Operating cost (RM),
L Land use (% of WTP catchments),
q Volume of treated water (m³),
c, θ Fixed effects,
 μ Error term.

3 Results and Discussion

3.1 Catchment Area and water treatments

Table 1 show the descriptive of WTP’s intake catchment delineated from GIS processes. With total of 36 WTP intakes, the minimum catchment area delineated was 385.8 hectares, while the maximum area was 410,080 hectares. Total coverage for WTP catchments areas are 689,649 ha for Kedah, whilst total catchment areas under PRF are 296,085 ha. Table 2 show the descriptive WTP’s catchments data derived from the GIS analysis.

Table 2. Descriptive of WTP’s catchment data

Descriptive of WTP data	
Number of WTP	36
Minimum catchment coverage area	385.79 ha
Maximum catchment coverage area	410,080.17 ha
Total WTP catchment area	689,649.22 ha
Total WTP catchment areas in PFR	296,085.84 ha

The process of water treatments is for removing of pollutants that could affects the quality of water to be supply for domestic use. The treatment is to ensure the water is safe to be consumed. The treatments require several process such as filtration and aeration before several types of chemicals such as lime, liquid chlorine, sodium fluoride and liquid alum were added.

The average monthly operating costs (RM) and average treated water production (m³) were analysed using the cost function approach on algorithm (1).

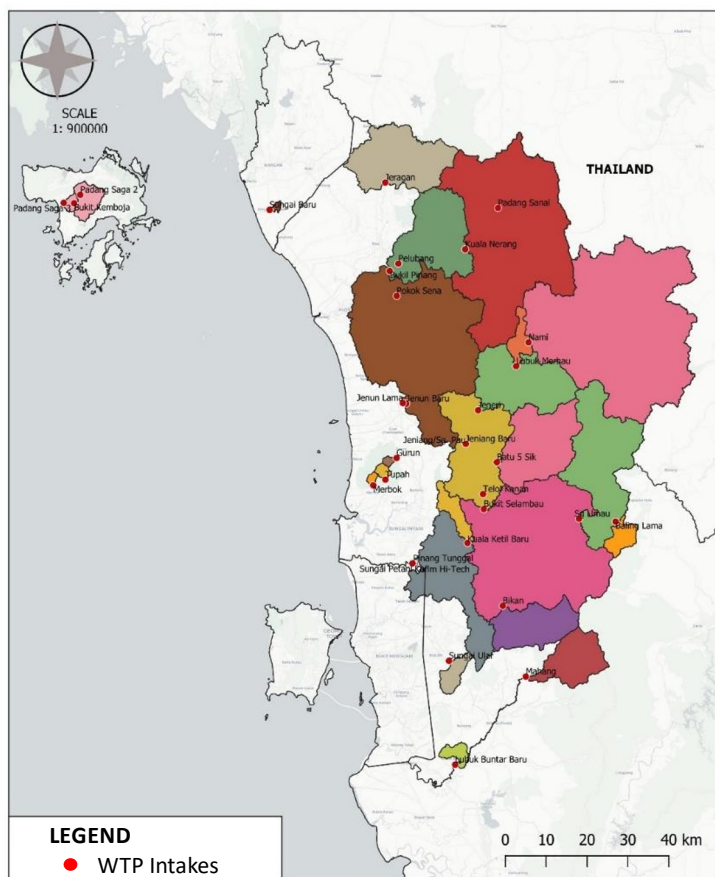


Fig. 1. WTP's catchments delineated area.

3.2 Forest land use

For each catchment, we assess the forest land use types using NFI V data. This is to see the impact of forest land uses to the cost of water treatment in respective treatment plants. The total size of catchments approximately 296,085 ha with percentages of forest land use was more than 70% included in the analysis.

3.3 Value of water purification services

Results indicated the average value for Kedah PRF for water purification services is RM49,140,171/year, approximately RM 21.93/hectare/year. The value can be used to consider for the implementation of sustainable financing of forest. Treatment plants or water operator can pay for the natural water treatment services or purification by forest, just like paying other operational costs.

4 Conclusion

As conclusion, forest is important in providing good water catchments and supply good water quality for users. The value of water purification services of Kedah's PRF is RM49,140,171/year, approximately RM 21.93/hectare/year. The results from this study can help particular agencies in documenting contribution of permanent reserved forest contributions that can lead to the planning and implementation as Payment for forest ecosystem services (PFES) in future.

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References

1. Benavides F & Veenstra JN, Global NEST J. 7 180-187 (2005).
2. Vincent JR, Ismariah A, Norliyana A, Burwell WB, Subrehendu P & Tan Shoo JS Environ Resource Econ. **61** (2015). DOI 10.1007/s10640-015-9934-9
3. McConnell KE & Bockstael NE 2005 Valuing the environment as a factor of production. In: Mäler KG
4. Vincent JR, Valuing the environment as a production input. In: Haque AKE et al (eds) Environmental valuation in South Asia Cambridge University Press, New Delhi, 36–77 (2011).
5. Freeman AM III et al., The measurement of environmental and resource values: theory and methods, 3rd edn. RFF Press, Taylor & Francis, Oxford (2014).