Assessing Trade-offs of Regulating and Cultural Ecosystem Services at Muar District
Background of Study and Literature Review

• Background of Study
• Literature review on ES’s trend, scale, and context
• Conceptual Framework Development
• Aim, Objectives, Scope and Significance of Study
1.0 Introduction: A brief definition of ecosystem services (ES)

- Tangible or Intangible goods that derive from ecosystem function and processes that benefit human, directly and/or indirectly.

**Figure 1.0 Type of Ecosystem Services**

Source: https://freshwaterwatch.thewaterhub.org/content/ecosystem-services

- The paddy field of Muar as provision & cultural services
- Foothills that provides regulating, cultural and supporting services
- A flock of pigeons perching on the electrical cable as cultural service
- Supporting service provide natural habitat to living organism as well as maintaining genetic diversity and nutrient cycle.
1.1 Introduction: Systematic review on ES Trend

Reviewed more than 40 literature from 1990s to 2010s: landscape & urban planning, ecological economics, population and environment, urban forestry & urban greening, landscape ecology, biological conservation, and others.

Identify relevant literatures through using the keywords of ecosystem services, biodiversity, land use/land cover (LULC), trade-offs, scales, and urban-rural gradient.

1.1.1 Earlier 1990s
- Classification and concept of ecosystem functions, services and their values (e.g., Costanza et al., 1997; Folke et al., 1997; Bolund and Hunhammar, 1999; Daily, 2000; De Groot et al., 2002; MEA, 2003)

1.1.2 Earlier 2000s
- Valuation of ES by monetization and commodification value - markets and payment mechanisms (e.g., Gómez-Baggethun et al., 2009; Gómez-Baggethun and Barton, 2013; Leimona et al., 2015)
- ES assessment, conceptualization, and pricing (e.g., Tscharntke et al., 2005; Weber, Sloan and Wolf, 2006; Tzoulas et al., 2007; Netusil et al., 2014)

1.1.3 Earlier 2010s
- Restoration and sustainable development in landscape development, design and policy (e.g., De Groot et al., 2010; Adnan, 2011; Frank et al., 2011; Su et. al., 2012; Foo and Hashim, 2014; Blignaut et al., 2014)

1.1.4 Late 2010s
- Trade-offs and Synergies among ES's Assessments (e.g., Raudsepp-Hearne et al., 2010; Larondelle and Hasse, 2013; Haase et al., 2014; Yeo et al., 2016)

Study Concerned: See thesis p. 191 for a comprehensive review

Figure 1.1 A time series review on ES trend
1.2 Introduction: Systematic review on ES Context and Scale

Most nations are not explicitly measured and assessed the values of ES (Seppelt et al. 2011), especially values to be factored into trade-offs consideration (IPBES, 2013). The trade-off consideration is pivotal for making effectual decisions in sustainable planning because attempts to enhance certain ES often lead to neglect of other ES (Bennett, Peterson, and Gordon, 2009; Grêt-Regamey, et al., 2013).

**Figure 1.2:** The number of ES studies across the globe (Source: Seppelt et al. 2011)

**Figure 1.3:** Regulating services (n=141), the second is provisioning services (n=71), then cultural services (n=58) and supporting services (n=30) (Source: Malinga et al. 2014)

ES mapping at spatial village/plot scale are among the lowest.

Among various trade-offs ES assessment, relationship between regulating and cultural ecosystem services is the least considered together.
2.0 Theoretical and Conceptual Framework

Figure 2.1: InVEST Model- Scenario Developments (Source: Nelson et al., 2009). See Thesis p. 32

Figure 2.2: Bundle of ES. Source: Foley et al. (2005). See thesis p. 33

Thee Scenario: to estimate ecological, social-cultural and economic values of ecosystem services provided.

Three hypothetical landscapes and its trade-offs and synergies.

Figure 2.3: A conceptual framework for trade-offs assessment (Yeo et al., 2016)
3.0 Aim, Objectives and Significance of Study

**Aim**: To assess the values of ES and their trade-offs in an urban-rural context within a tropical landscape environment.

<table>
<thead>
<tr>
<th>R. Objectives</th>
<th>To investigate the changes of land use/land cover (LULC) in urban, suburban and rural areas</th>
<th>To evaluate the thermal comfort of people as a regulating service in urban, suburban, and rural areas</th>
<th>To evaluate the recreational provision opportunity as a cultural service in urban, suburban, and rural areas;</th>
<th>To differentiate the trade-offs and synergies of thermal comfort and recreational provision in urban, suburban, and rural areas</th>
</tr>
</thead>
</table>

**Why?** only climate regulation and recreational provision are being examined:

I) Seldom being compared together (see p. 20-22, Section 2.5). ii) Inter-related, e.g., people use public outdoor spaces for various recreational activities and so they are exposed to the external climate (Huang et al., 2015). iii) Development, e.g., urbanization that lead to the deprivation of green space for recreational uses and increase in heat intensity (Peng and Jim, 2013; Shrestha et al., 2012).

<table>
<thead>
<tr>
<th>Significances of Study</th>
<th>Help stakeholders to identify the hotspots; subsequently, treatments can be incorporated to reduce solar radiation and heat intensity.</th>
<th>Help stakeholders to identify the existing resources for various recreational opportunities that may promote public outdoor activities</th>
<th>To mitigate trade-offs and optimise synergies. Eventually, it may promote people’s interest for outdoor engagement, without experiencing heat stress.</th>
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</thead>
</table>

In addition, it also informs the decision and policy makers the potential consequences of an unbalanced treatment of the ES in the process of land-use management (TEEB, 2011; MEA, 2003; De Groot, 2006; Haase et al., 2012).
Research Methods, Analysis and Results

- Site selection
- Data Collection and Data Processing
- Data Analysis (Simulation ENVI-met)
- Data Analysis (Spatial Mapping GIS)
- Data Analysis (Correlational test – Trade-offs analysis)
4.0 Research Method: An Overview

**Table 4.0**: Methodological Design of ES Assessment. Research design: Quantitative, approach utilized is deductive approach. The strategies of inquiry used in this study was quasi-experiment because this study mainly used simulation and spatial analysis to derive the result.
4.1 Study Area, Data Collection and Methods: Data Processing

- Selecting 3 areas to look into detail and compare the change of LULC between 2010-2015

**Figure 4.1:** A) Map of Peninsular Malaysia. B) 12 sub-districts of Muar. C) LULC data set (2010) of Muar

**Figure 4.2:** Level of urbanization was calculated based on physical expansion.

**Figure 4.3:** Three areas were plotted (2.7km x 1.8km) from urban, suburb and rural areas were based on the percentage of urbanization –high, intermediate and low in Fig 4.2

**Figure 4.3:** Updated the map from 2010 to 2015 based on Google Earth and Field Survey
4.2 Study Area, Data Collection and Methods: Field Survey

Urban Landscape: Bandar Maharani

Suburb Landscape: Sungai Terap

Rural Landscape: Ayer Hitam
4.3 Methods and Analysis: RO2- Mapping Thermal Comfort (Regulating Service)

Figure 4.1: Methods of measuring tree height

\[ h = \tan A \times d \]

\[ h = \tan A \times d + \text{eye ht.} \]

h = height, A = angle, d = distance, eye ht. = eye height

Figure 4.2: How ArcGIS data is converted to ENVI-met area input file (see thesis p. 76-78)

```plaintext
% ENVI-met V4 main configuration file
% generated with ProjectWizard

Simulation

Simulation

Urban 15x15.INK

Urban

C:\Working Place Envimet 4\Simulation

29.01.2016

06:00:00

24

2.5

95

0.1

-0.15

7.8

60.8

% end main data
```

Figure 4.3: Configuration of ENVI-met (Data are acquired from MET and mathematical calculation (see p. 79-81). The result of the simulation can refer to slide 17.
Figure 5.1: The maps illustrated the air temperature (a), specific humidity (b), wind speed (c) and mean radiant temperature (d) at 1800.

Figure 5.2: Thermal Comforts Maps (PMV) of Bandar Maharani, Sungai Terap and Ayer Hitam (see p. 130-133 for % distribution).
4.5 Method and Analysis: RO3- Mapping Recreational Provision (Cultural Service)

**Figure 4.4:** Methodological steps to map recreational provision map (see p. 91-92).

**Figure 4.5:** Weighting criteria (based on expert evaluation, p. 218)

**Figure 4.6:** Different layers of criterion map, the first layer is usability criterion followed by naturalness, scenic beauty, distance from the home, distance from the road, and relative relief. The result of the map refer to slide 18.
4.6 Result and Discussion: RO3 - Mapping Recreational Provision (Cultural Service)

<table>
<thead>
<tr>
<th>Raw values (Floating)</th>
<th>Reclassify to integer (representation)</th>
<th>Classification of rank</th>
<th>Physical wellbeing</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1.0</td>
<td>1</td>
<td>Low</td>
<td>Little to no contribution</td>
</tr>
<tr>
<td>&lt; 1.5</td>
<td>2</td>
<td>Slightly Low</td>
<td>Little contribution</td>
</tr>
<tr>
<td>&lt; 2.0</td>
<td>3</td>
<td>Moderate</td>
<td>Fair contribution</td>
</tr>
<tr>
<td>&lt; 2.5</td>
<td>4</td>
<td>Slightly High</td>
<td>Moderate high contribution</td>
</tr>
<tr>
<td>&lt; 3.0</td>
<td>5</td>
<td>High</td>
<td>High Contribution</td>
</tr>
</tbody>
</table>

Figure 5.3: The earlier recreational CES map of Bandar Maharani (A), Sungai Terap (B) and Ayer Hitam (C) and after reclassifying (D, E, and F)

Figure 5.4: Different ranks of recreational provision among urban, suburb and rural areas. The recreation provision of the urban area is slightly better than the suburb and rural areas mainly due to usability of the space and accessibility to the site.

see p. 92 for the operational definition developed based on literature review
4.7 Result and Discussion : RO4- Trade-offs and Synergy Assessments

**Point A**: High RP (rank 5) vs Low HTC (PMV 1.5-3.2) - Recreational Space (Stadium Muar). Both ES is in a **Synergy** relationship.

**Point B**: Low RP (Rank 1) vs Low HTC (PMV 1.5 -2.3)- Mangrove forested areas. Both ES is in a **Trade-off** position.

**Point C**: Low RP (rank 1) vs High HTC ( PMV 3.2-4.0).- Sandy Open Space. Both ES is **worse** than a **Trade-off** position.

**Point A**: Low RP (rank 1) vs High HTC (PMV 3.2-4.0) - Concrete covered industrial areas. Both ES is **worse** than a **Trade-off** position.

**Point B**: Low RP (Rank 2) vs Moderate HTC (PMV 2.5 -3.2)- River edge, open space. Both ES is in a **Trade-off** position.

**Point C**: Low RP (rank 1) vs Low HTC ( PMV 1.5-2.5). Agricultural lands - rubber tree plantation. Both ES is in a **Trade-off** position.

**Point A**: Moderate RP (rank 3) vs Low HTC (PMV 1.5-2.5) - open lawn surrounded by agricultural plantations. Both ES were **closed to a synergistic** relationship.

**Point B**: Low RP (Rank 1) vs High HTC (PMV 3.4 -4.0). Barren land - loamy soil. Both ES is in a **worse** than a **Trade-off** position.

**Point C**: Low RP (rank 1) vs Low HTC ( PMV 1.5-2.0). Reserved Forest. Both ES is in a **Trade-off** position.
Implications, Limitation, Recommendation and Conclusion

- Theoretical and Practical Implications
- Limitation of Study
- Recommendation for Future Study
- Conclusion
5.0 Theoretical and Practical Implications

Practical implication that drawn from the finding of this study is to ensure both regulating and cultural ES can coexist in different types of settings. To do that, this study suggests:

i. Promote the HTC (open spaces): spreading, rounded, open, or vase canopies trees; clear trunk height of 5 m and above; high-density trees (e.g. Acacia confusa; Samanea saman, Peltophorum pterocarpum, Delonix regia, Alstonia scholaris... Artocapus heterophyllus, Filicium decipiens, Mimusops elengi.)

ii. Promote RPS (sensitive area): light facilities, pathway, signage, and resting areas.

iii. Promote HTC: Re-vegetate unused lands with trees, grasses (~0.1 ha to ~2.4 ha), water feature and high albedo surfaces.

iv. Promote RPS and HTS (riverfront): Converting the shrubby areas to recreational spaces (e.g., parks, esplanades, playgrounds). Trees and structures can be incorporated as needed to synergise the evaporating effects.

v. Promote RPS (agriculture): Agricultural lands can be transformed to integrated farming with numerous agritourism activities.

The above-mentioned treatments can serve as guidance for landscape architects, architects, urban planners, and decision and policy makers to understand what type of settings, design composition, and elements can assist in improving the thermal comfort of the people and recreational provision services, and subsequently promote synergies between them.

Figure 6.0: A framework for trade-offs assessment (see p. 162)
6.0 Limitation and Recommendation

The assessment of ES in Malaysia is relatively new. Hence, as a starting point, this study began with climate regulation and recreational provision services within a bundle of ES, as these aspects still have not been widely explored together. In addition, future research can consider other sub-services especially provision and supporting services.

In conclusion, the common trend in assessing single ES should be shifted to the assessment of multiple ES. When assessing a single ecosystem service, the gains and losses are often limited to that service alone. Hence, it is difficult to draw a deliberative decision to achieve sustainable growth of a city or town.

Figure 7.0: An Illustration depicts the limitation and recommendation of this study
The ultimate goal of trade-offs assessment is to improve the synergistic relationship between ES and to minimize the compromise to the other services.

As more ES are being assessed, it helps in facilitating the sustainable growth of towns and cities, in promoting and securing human-wellbeing, and eventually in improving quality of life of the people.
8.0 List of Publication and Conferences attended

**Web of Science (WoS):**

**Scopus:**

**Index Journal:**

**In Proceedings:**
THANK YOU for your ATTENTION!