Implementation of Nighttime Radiance Threshold Class for Green Zone Energy Mapping

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Abstract. Bali is the most excellent tourism resort through precious supporting facility. The structure creates with art that inspires from culture and blends with environment. The original concept is not much usable energy for conditioner and light. Modern and comport facilities are more attractive now. Electricity supply becomes issue. It is important to control uses of excessive energy that emitted carbon and cost. This paper presents results of radiance threshold method that can be used as a system to monitor above issue. The variability of light sources aspects that deplete energy had defined. Development of business support tourism privately is a key of this case. For sustainable of energy, a mutual agreement among stakeholder is urgency. Areas that define as class criteria spread widely, mostly at Kuta and Nusadua city. Development of moderate class light is key to understand spatial-temporal of dynamical many aspects that relate to urban cycles. Nocturnal light trend spread up to northern part of island. Notice for stakeholder to attention of diminishes green space. Long-term dynamical trend of nocturnal light requires inter calibration between nighttime satellite mission. The nonlinearity relationship of those data pays attentions to many factors. Possibility of model function approved a power model. Linearity validation results shows agreement. Keyword: radiance, threshold, energy, criteria, nighttime.

1. Introduction
The world becomes globally, thousand people do tours to any place of world and consume huge energy. Destination country set up tens of new hotels, commercial, residential buildings had completed and operated. All are equipped with various mechanical and electrical equipment that draw electricity continuously in 24h a day. Over the past century, continuously increasing population and economic development directly induced a high-rise of CO\textsubscript{2} emissions all over the world, especially in rapidly developing countries in Ozturk and Acaravci\textsuperscript{[1]}. Ou et al.\textsuperscript{[2]} and Bakhtyar et al.\textsuperscript{[3]} stated that the human socio-economic activities known closely related to this emissions cause an enormous threat to the natural environment and human society in the world. This treat initiates global warming and climate change and be the most important environmental problems in the last two decades in Lu and Liu\textsuperscript{[4]} and Wei et al.\textsuperscript{[5]}. The original concept of Bali tourism industry inspires by traditional-art, religion, culture and respectfully to environment. Unfortunately, developments lead to precious modern concepts that draw huge electricity and become supplying issue. Krstinic et al.\textsuperscript{[6]} report that efficiency of energy on tourism and hospitality sector is not just result of investment in sophisticated technology, but also modified by monitoring and active management of energy consumption. Boer et al.\textsuperscript{[7]} point out that, the role of community in reducing carbon emission and saving energy is
essential. Community initiatives can be carried out by increasing efficiency through use of energy-saving technologies and behaviors in the commercial and residential sectors.

To maintain the sustainability of electricity due to rapid development of Bali’s tourism industry, Bali needs regulations by involving the community or stakeholder in energy-saving behaviors roles. Excessive lighting energy overlaps and accumulates into a source of light energy pollution that monitored up to remote sensing satellites [8]. However, research that has been carried still limited, more comprehensive and holistic researches needed. Research and regulations that relate to the role of community or stakeholder in reducing carbon emissions and saving electricity in Indonesia have not regulated well and limited. It is urgent to carry out fundamental research in order to build low-carbon emission societies generally in Indonesia. Especially it must to uses over the top technology to solve fundamental problem, such as satellite remote sensing technology [9] [10]. This paper is one part of publication series with theme light threshold for tourism resort in the role of low-carbon emissions community, and energy savings using nighttime satellite data. This paper aims to present analysis results of light sources aspects from surveys, implementation of index of radiance threshold class and the possibility of creating a long-term dataset of nighttime by inter-calibration of all available of nighttime satellite data.

2. Methods
This paper presents outcome of radiance threshold concept for low carbon emission and energy-saving by applies all available of nighttime satellite data. General views of the methodology of this research had shown on the first and second paper of this research publication series. In this paper, three subjects presented i.e. analysis of features of light sources result from field surveys, implementation of index of radiance threshold class and possibility of inter-calibration of Defense Meteorological Satellite Program Operational Linescan System (DMSP-OLS) to Visible Infrared Imaging Radiometer Suite (VIIRS) data model as stated in Li et al. [11].

2.1. Analysis of features of light sources.
Nocturnal light consists of many sources. On field surveys, features or an aspect that links into the sources also collected. It will provide clarification of sources light distribution. Features will be analyzed using cross-comparison between them.

2.2. Maps of radiance threshold class.
Procedural to implementation of the radiance threshold class shows on figure 1 below. Begin with preparation of global VIIRS scenes data. Daily to annual averages of the VIIRS day-night band available globally. Subject area is Bali island representative of excellent tourism resort. Dataset are subset into Bali area, included background i.e. ocean. Data does not subset with associate coastline, because light can spreads into the seas. Index of radiance threshold class had presented on the second paper of this research publication series. More details about the process and method can be referred to above manuscript. It applied into Bali dataset as density slices. Thus, thematic maps of radiance threshold class obtained with zones i.e. blue as moderate and red as excessive zone. Finally, stakeholder uses these maps for field’s assessment.

![Figure 1. Maps of radiance class procedural flow.](image)

3. Dataset
There are only two operational satellites with NASA’s low-light nighttime imagery mission, namely the DMSP-OLS detail in Letu et al. [12] and the VIIRS detail in Elvidge et al. [13]. Measurement of
light meter aims to enforce stakeholder decision. Location of sampling point initially obtains from threshold criteria map of DPSM-OLS VIIR data. Surveys carried out with GPS and GIS utilities. Measuring instrument used are a high sensitive radiance lux meter (MS6612 model) and meteorology meter i.e. temperature scanner, anemometer, humidity and GPS. Measurement points determined where the light strongest occurs, in a 1 Km square area that same as spatial resolution of DPSM-OLS VIIR data. A high sensitive lux meter provides 0.01 illuminance resolution (lux). Approximately, 1 lux at 1 meter square divides by their luminous efficacy (lumens per watt) give energy in Watt. Typical luminous efficacy of LED lamp is about 80-100 lm/w. Measurements method used as stated in Dominoni et al. [14] and Dharani et al. [15]. The purpose of measurements is to obtain the characteristics of existing lighting sources, such as it is important light (essential or decorative), how much energy is used and others. Surveys data collected and analyzed with description statistics to get their characteristics.

4. Results and Discussion

4.1. Feature of light sources
In field surveys, surveyor also collects of feature or aspects of light sources i.e. light source of ownership, nature of light source etc. Results showed on un-scaled one-single pie-chart figure 2 below. As per-part of aspects, data for instance type of location of light source, brings result for ambient type (about 37%) and dominance Excessive type (about 63%) all united become total 100 percent and so on. From designated area aspect, light mostly from business area (42%), then from tourism area (39%) some percent of public area (14%) few from settlement (4%). Measly of light condition aspect has low-visibility (objects recognition from distance) and low-ability (for reading) mostly (77%) has an adequate amount of light. As light mostly for business area, lights come from many type sources i.e. streetlight, neon advertising, signboard etc denote as composite sources (about 78%). From source of ownership, light sources dominated from private ownership (69%) i.e. mall, outlet store, restaurant, hotel etc. Hence, nature of source dominated for decorative (79%).

![Figure 2. Pie chart of light sources aspects surveys result.](image)

In the chart above, it clear that sources of aspects that cause excessive and redundant of energy (lights). As the most tourism destination, surrounding resort growth up many tourism businesses that are managed privately, such as 24-hour shops, restaurants, art markets and others. To attract the attention of visitors at night, many use decorative lighting, even there are adequate of exiting light. This happens because, no guarantee that services (the government if for public) will sustainably. Mutual agreement among stakeholder to regulates overlapping of lighting urgency to realize.

4.2. Index of radiance threshold class
For clear reviews, again presents the index of radiance threshold class, in which already published on second paper of this research publication series. For generally the index is a radiance range i.e. ambient (≤ 15) excessive (≥ 20) nW/cm2/µm/sr in between, denote as moderate class. By using this index class criterion, maps can be produced as a base for stakeholder to set up regulation. Stakeholder can uses monthly to annual scale maps to assessing blue to red zone that need attention. This index defines which areas or pixels on satellite data that must be monitor in case of energy use. It is interesting to monitor development and growth of economic aspect will imply moderate class of nocturnal light growth wider. Development of moderate class of nocturnal light can be key to
understand spatial-temporal of dynamical many aspects of urban cycles such as urbanization, food distribution etc.

4.3. Maps of radiance threshold

It is necessary to map the distribution of radiance threshold class. Figure 3a and 3b below shows radiance threshold class after applied into the VIIRS dataset of Bali Island for the year 2012-2018. For short term within seven years, expect to reveal transformation class of nocturnal light. Dynamical condition, up-down of sum of classes pixels along years term is nature. That shows many aspects i.e. socio-economic, politic etc. can be linked with nocturnal light as stated in Venter et al. [16] and Tripathy et al. [17]. On figure clearly indicates that potential sources of light as moderate (Blue pixel color) to excessive (Red pixel color) in common denotes as light pollution sources mainly at Kuta, Nusa Dua, and few at Benoa and Denpasar city (figure 3b). Summary of class amount and percent contributions present on table 1. Interesting result shows some points emerge at the North of Bali Island (Buleleng regency) in figure 3b for zoom mode.

Application of index threshold class to the whole of island not urban cities area only aims to encourage of stakeholder so that one island one management become actual. As results, few of area or pixels become object of matters. Remain dominates by nature of nocturnal light and adequate for visibility and ability of lighting.

![Figure 3](image-url)

**Figure 3.** (a) Maps of threshold class results of Bali island in years 2015-2018. (b) Zoom maps of threshold class at southern and northern part of Bali island in year 2012 and 2018.

For both figures, light trend spread up from southern to northern part of island. This is common because the first, Badung regency has territory spreads from south to central-north of island. Settlement expands into the north side of island. Notice for stakeholder to attention of diminishes green space. The next figure same as previous but for years 2015 to 2018. More clear maps shows on figure 3b by zooming at dense of urban cities. If just looks at the radiance data (grey level color), cannot clearly spot the changes that occur. In year 2012, it had of some pixels identified as moderate and excessive, mainly at Kuta, Nusa Dua, Denpasar and Benoa areas. At Denpasar area denser of bright-lit pixels, but lower pixels that match criteria. In year 2018, pixels that identified in class criteria spread wider. At the north side of Island, some pixels identified as class criteria but only in year 2018. That is, a steam power plant locates at celukan bawang, Buleleng regency. Table 1 shows summary of amount of pixel’s class and percent of total 58 520 pixels. It showed progress of numbers of class pixels from 2012 until 2018. Development can be analyzes that on year 2014-2016, moderate and excessive class going up and then down on next period. Its might be correlated with socio-economic or national electric cost [16] [17].

**Table 1.** Progress of number of class pixel points from 2012-2018.

| Years | Class* | n points | Percent | Years | Class* | n points | Percent |
|-------|--------|----------|---------|-------|--------|----------|---------|
| 2012  | M      | 55       | 0.09    | 2016  | M      | 87       | 0.14    |
|       | E      | 50       | 0.08    |       | E      | 91       | 0.15    |
| 2013  | M      | 60       | 0.10    | 2017  | E      | 40       | 0.06    |
|       | E      | 54       | 0.09    |       | E      | 61       | 0.10    |
| 2014  | M      | 87       | 0.14    | 2018  | E      | 74       | 0.12    |
|       | E      | 78       | 0.13    |       | E      | 61       | 0.10    |
| 2015  | M      | 92       | 0.15    |       | M      | 94       | 0.16    |

For clearly data on table 1, again presents on hectare area. With projection changes to UTM zone 50 south, one pixel approximately has 211.646 m² (21 hectares) area. Figure 4 shows detection changes of wide area in hectare.
4.4. Inter calibration of DMSP-OLS and VIIRS dataset
Long-term of DMSP-OLS and VIIRS dataset is useful for analysis of many dynamical processes. Because of their differences in spatial and radiometric properties, both datasets must be intercalibrated [18] [19] to get consistently data. Li et al. [11] and Shao et al. [20] summary of factors that must consider on inter-calibration process. By using two years overlaps operational program of both satellites in year 2012 and 2013. Possibility of inter-calibration result showed in figure 6 a and 6b. A nonlinearity relationship between both dataset, a power function [11] is obtained and shows in figure 6. Linearity validation ($r$) results in about 0.64 shows in figure 6b.

5. Conclusions
This paper had defined variability of light sources aspects that relates with excessive use of energy. Development of business support tourism which owner by privately is key of this case. Public purpose facility should be multiply. For sustainably a mutual agreement among stakeholder to regulates overlapping of lighting urgency to realize. Areas that define as class criteria spread widely. Obviously, class criteria found mostly at Kuta and Nusadua city. Development of moderate class light is key to understand spatial temporal of dynamical many aspect that relate to urban cycles. Nocturnal light trend spread up from southern to northern part of island. Settlement expands into the north side of island. Notice for stakeholder to attention of diminishes green space. Long-term dynamical trend of nocturnal light requires inter-calibration between DMSP-OLS with NPP VIIRS data. The nonlinear relationship of those data pays attention to many factors. Possibility of model function approved a power model. Linearity validation results have an agreement.

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