MODELLING LIGHT POLLUTION IN SUBURBS USING REMOTE SENSING AND GIS

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Abstract

This study aims to model Tehran's light pollution for three different years using remote sensing and GIS techniques. The study takes advantage of using images provided by DMSP satellite.
The DN value of pixels of the images related to the sources of pollution was categorized into 5 classes according to their quantity. The view-shed maps were produced for each one of these classes separately and the final maps were produced using average mean weight.
Results indicated that due to the expansion of Tehran, northern part of the city has had the most of the light pollution. Studying the pollution temporal changes showed that the western part of the province has had the greatest changes during the studied years.

Key words: light pollution, DMSP Images, Average mean weight

1. INTRODUCTION

Pollution is one of the most important consequences of human civilization. Our environment is treated by different types of pollutions which are produced due to numerous industrial and biological activities. Increasing impositions of mankind on natural resources has made the investigation of the pollution sources and their effects essential.
One of the important pollutions is light pollution which is less known and has rarely been studied.
Nightlight emissions that originate mainly from large urban areas are among the main elements of environmental pollution (Chalkias et al. 2005). Light pollution which is a problem that affects almost any urban areas, is produced by a large number of lighting sources, which spill light into the sky and due to the presence of dust and aerosols in the atmosphere the light is scattered, brightening the sky (Barducci et al. 2006)

A number of people have modeled light pollution in various ways. The first model made by Walker (1970). This model was an important step to start modeling the sky brightness of the cities. Garstang (1986) has done detailed calculations for a number of observatory sites, creating maps showing how the sky glow varies at different altitudes and azimuths from each site (Hosseini et al. 2007).
Further, Burton (2000) has analyzed satellite data from the Defense Meteorological Satellite Program to estimate sky glow in the close vicinity of urban areas (Albers and Duriscoe, 2001). Also Cinzano (2000) produced sky shining maps caused by artificial and human-made lights in vast regions using images of DMSP satellite and different techniques of image processing.
(Chalkias et al. 2005) have modeled light pollution for the outskirts of urban areas by integrating GIS and Remote sensing techniques and produced visibility analysis maps.
Based on the literature mentioned above which certifies the significance of studying this type of pollution and also lack of such studies in Iran, particularly for Tehran, the current research aims to study the modeling of this type of pollution for Tehran, using data provided by DMSP satellite and GIS techniques.

2. DATA

For the nightlight emission study, satellite data were used from the Defense Meteorological Satellite Program (DMSP)/OLS (Operational Linescan System of the USA). The DMSP satellites, with the onboard OLS, have the capability to detect faint sources of visible near-infrared (VNIR) emissions on the Earth's surface, making it possible to detect cities and towns (Chalkias et al. 2005).
In this paper the images provided by DMSP for the years 1992, 1998 and 2003 are used to study the light pollution expansions in Tehran province. The images for the study were retrieved from National Geophysical Data Center website and the required modification * for detecting stable light which exit at nights are conducted on these images.
Digital Elevation Model (DEM) with the pixel size of 90 meters is employed for visibility analysis in the research.

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To determine the threshold value of spectral pixels of DMSP images that define light pollution, ETM+ images for 2002 and the land use map of Tehran province were used.

3. METHODOLOGY

By investigation of the DMSP images, the ETM+ images and the land use maps of Tehran province, the DN Value of 10 were selected as the threshold for light pollution resources. Since different spectral values have different effects on light pollution of their environments, spectral values were categorized under 5 classes, ranging from 10 to 63, assuming that in each class spectral values have similar effect on the environment.
The DN value of pixels of images related to the sources of pollution was categorized into 5 classes according to their quantity and therefore every class's contribution to the pollution was calculated. The view shed maps were produced for each one of these classes separately. Then the final maps were produced using weighted average by assigning weight one for the first class, weight two for the second one, and finally weight five for the last class. Figure 1 presents the flow-chart of the methodology.

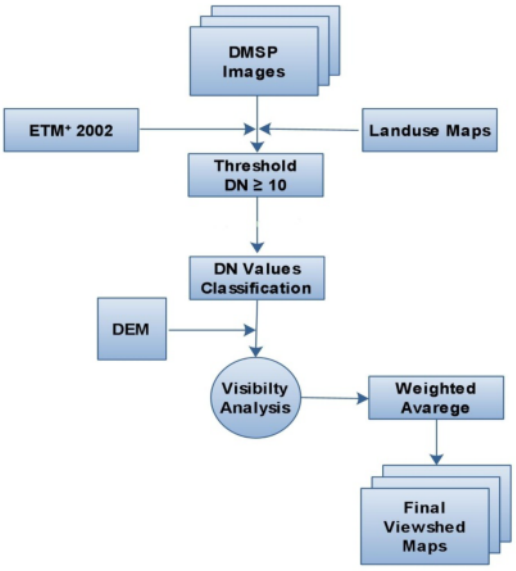

Figure 1. Flow-chart of the methodology

4. RESULTS

In this research, the images for 1992, 1998 and 2003 were used to model and detect the changes in nightlights for province of Tehran. Considering the maps produced for three different years, we observed and modeled the development of light pollution beside the expansion of the urban areas, building highways and building residential and industrial townships (Figure 2). These maps made it possible to recognize areas which were most impacted by this kind of pollution. Due to the expansion of Tehran, northern part of the city has had the most of the light pollution. Studying the temporal changes of the pollution showed that the western part of the province has had the greatest changes during the studied years (Figure 3). The text may include tables and figures. Color figures are available.

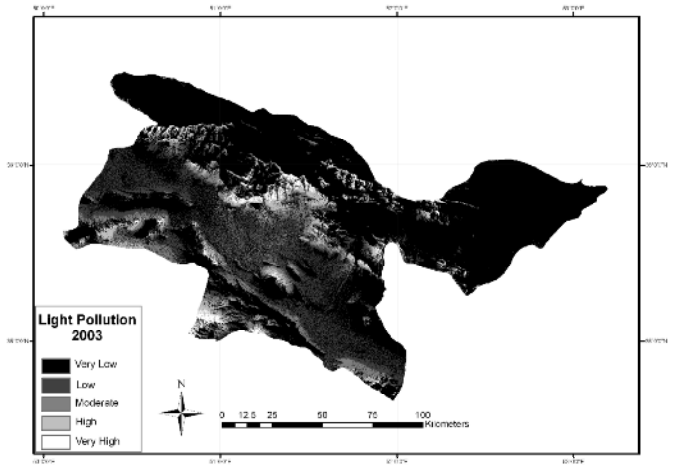

Figure 2. Light Pollution Map (2003)

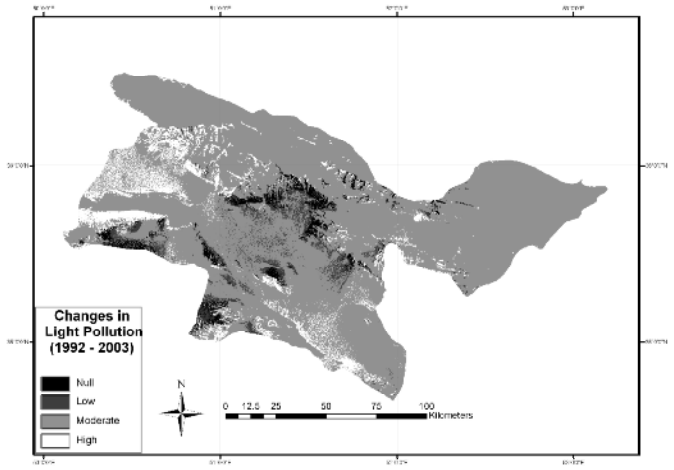

Figure.3. Changes in light pollution for the period (1992-2003)

5. CONCLUSION

Classification of the cities' outskirts by considering the effects of light pollution by means of the light pollution maps is of high importance. These kinds of maps, in fact, show the rate of energy waste. Thus, special attention must be paid to reduce the energy waste by designing the street lamps and lightening. Utilization of satellite images and GIS techniques by using visibility analysis are two powerful tools for modeling this kind of pollution. Assigning different weights to spectral values of the pixels based on their DN values is one of the advantages of the proposed method in this study which attempted to produce the results which are as close as possible to the natural condition of the environment.

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