

Estimation of Light Pollution in Pakistan Using Satellite Remote Sensing and Geographic Information System Techniques

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Light Pollution is becoming an alarming concern for environmentalists, astronomers and remote sensing researchers all around the world. From environmental degradation, migration patterns of the birds to altering the biological life cycle of humans and animals, light pollution has had a negative impact on everyone in the world. It has had the worst implications on astronomers, as it has become difficult to observe the night sky and make observations, especially in the cities (1).

In a research study conducted by Mohsin Jamil Butt, Department of Meteorology, King Abdulaziz University, Saudi Arabia, light pollution is estimated in the urban and suburban regions of Pakistan. He uses techniques such as Satellite Remote Sensing (SRS) and Geographic Information System (GIS) to show that light pollution in the urban environment is mainly due to artificial nightlight sources. Through this study, Mohsin tries to develop a technique to model light pollution along with creating various maps to demonstrate the impact of light pollution on Pakistan's urban and suburban regions. This study will further help in the selection of a location for the Pakistan National Observatory.

Researchers have conducted numerous studies on the impact of light pollution. Cinzano et. al (1) demonstrated a breakthrough by coming up with a method that has been widely adopted: *"The artificial sky brightness present in the chosen direction at a given position on the surface of the Earth is obtained by the integration of the contributions produced by every surface area in the surroundings."* Researchers have created maps to show the variations in skyglow at

different altitudes and azimuths (2, 3, 4, 5). Groups have mapped the brightness of the artificial sky on large states (6, 7). The integration of SRS and GIS has been widely used to study the effects of light pollution on various regions in the world.

In this research, the Defense Meteorological Satellite Program (DMSP) images were used for measurements. DMSP constitutes a scanner that consists of two telescopes and a photo multiplier tube which makes the DMSP capable of detecting even faint sources of visible near-infrared (VNIR) emissions on the Earth's surface. For this study, Cloud-free temporal DMSP nighttime emission images for the period of 2004-2009 were obtained from the National Geophysical Data Center. The GIS spatial database was derived from analog maps and satellite images consisting of road networks, topography, land cover and population data.

Direct and indirect light pollution parameters were studied in the research. Direct methods include direct visual contacts with the nightlights. Indirect methods include visual contact with the sky glow dome over the urban areas. It is important to note that DMSP images have a tendency to overestimate due to the overglow effect. Also, in areas where clouds are present, light might appear dimmer and more spatially diffused. In order to eliminate these issues, time-series analyses were used to study the effects of light pollution on the same parts of the urban and rural areas. This method also helped in distinguishing different light sources such as city lights, shipping fleets, forest fires, which helps in removing ephemeral light sources. Light pollution maps were produced using Natural Breaks methods (8). Figure 1 shows how the Natural Breaks method divides the licensed pilots in the US by State. Figure 2 shows the direct light pollution map for the years 2004 and 2009 (9).

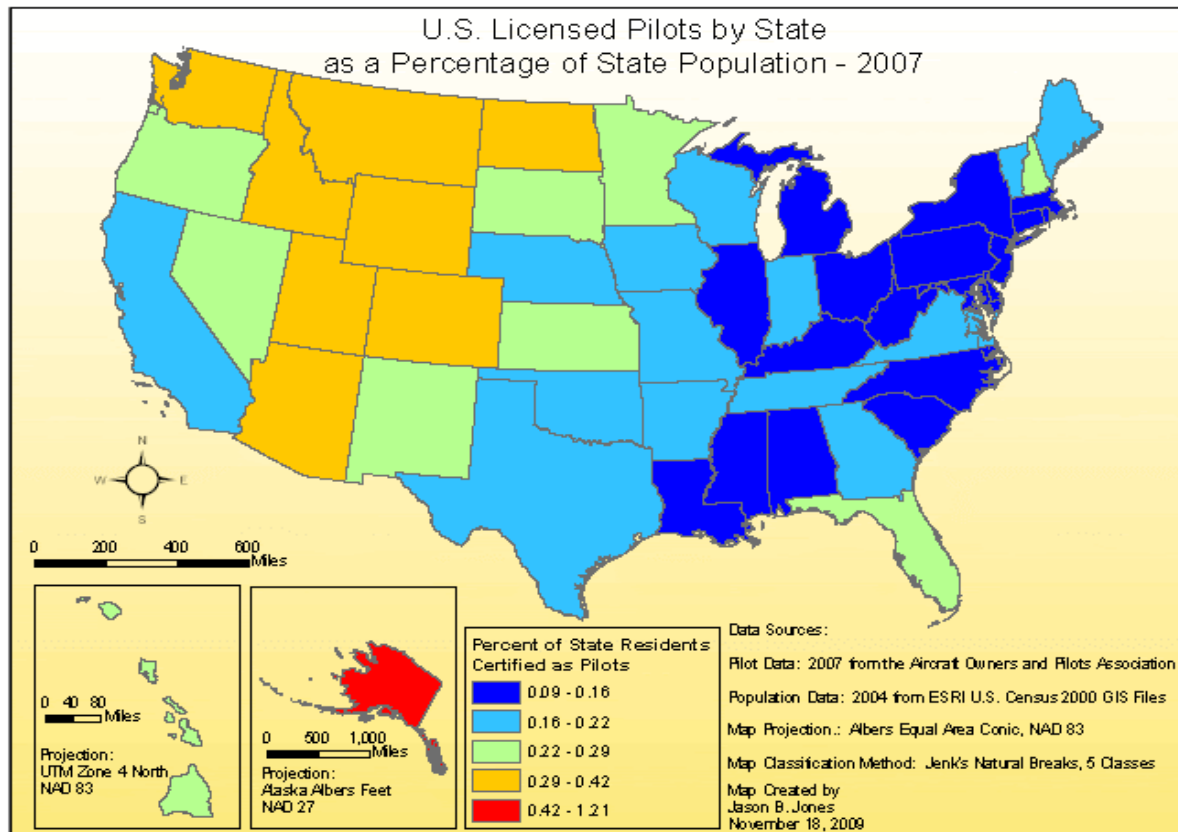


Figure 1: U.S. Licensed Pilots by State divide by the Natural Breaks Method (8)

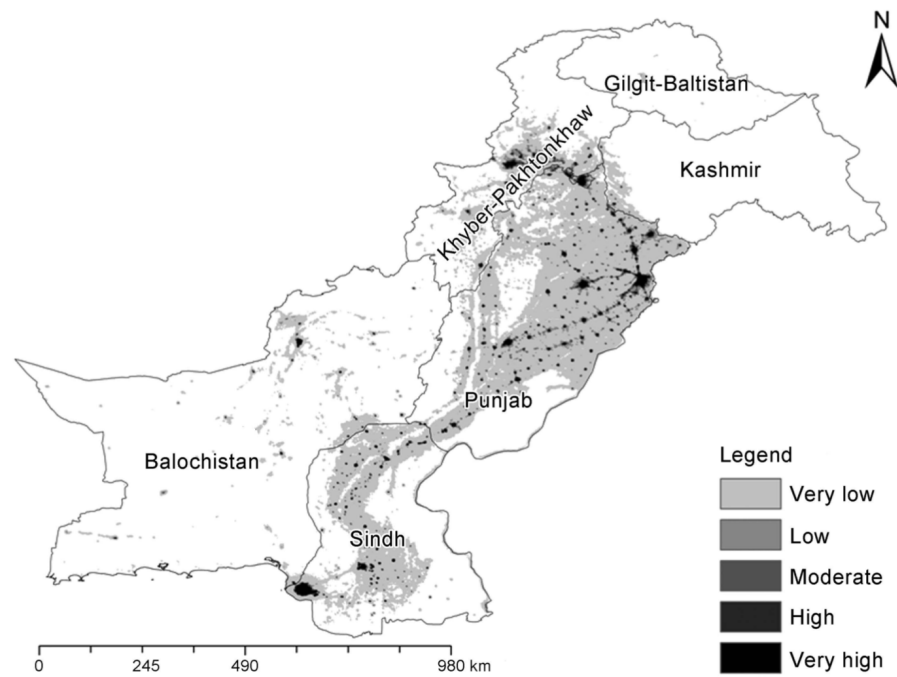
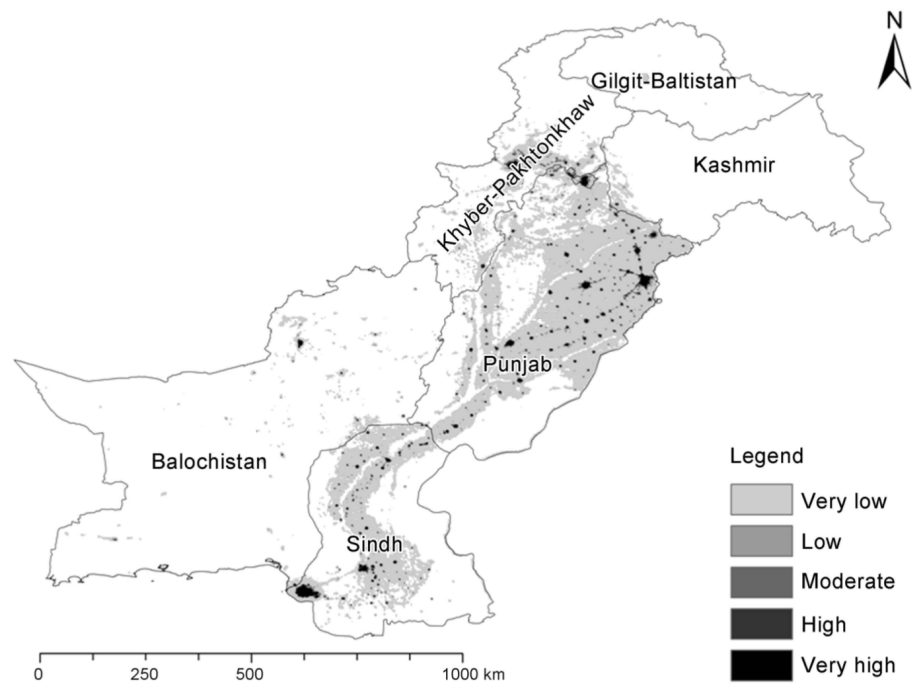


Figure 2: Direct Light Pollution Map – top: the year 2004, bottom: the year 2009.

The results of the study clearly depict a correlation of light pollution with the growing population and human activities in urban areas of Pakistan. From 2004 to 2009, major infrastructure development in urban areas has led to an increase in light pollution. This information is useful to decide the location of the site of the Pakistan National Observatory. The research shows that as humans are developing and creating infrastructures for their betterment, they are not sensitive to the amount of light pollution that is being caused as a side effect of this development. This research was conducted in 2009 and it has been eleven years and we are still continuously contributing to light pollution. It is only a matter of time before we start to see stars and galaxies as objects that used to be visible in the sky.

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