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A REVIEW ON SURVEY INSTRUMENT TO MEASURE LIGHT POLLUTION

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ABSTRACT: Environmental light pollution, brought on by excessive artificial illumination at night, has grown to be a serious problem that has an impact on both the environment and human health. Scientists and researchers are constantly looking for reasonable remedies to lessen the effects of this issue. An updated survey technology will be used to undertake light pollution surveys in controlled and test situations. These surveys can assist in gathering quantitative information on the level of light pollution in various environments, which can help guide mitigation initiatives. By carrying out these studies, the project can offer insightful information on how artificial lighting affects the environment and assist in identifying practical ways to reduce ecological light pollution.

KEYWORDS: Ecological Light Pollution, Sky Quality Meter, Lux Meter, Artificial Light, Survey Instrument, Biodiversity.

1. INTRODUCTION:-

The development of technology is a double edged sword. Technology makes our life easier but there is always a price to pay when the use of technology is uncontrolled. Light pollution is one such instance where the overuse of artificial lights have caused ecological impacts on the biodiversity of the well lit area during the night time. Ecological light pollution impacts the diurnal cycle of a majority of the biome that do follow the cycle and also is a major factor in the decline of various insect populations and also the oceanic life such as sea turtles.[1] while there is a field of ongoing research on light pollution, a survey method is also a research material. A comparison is done between the existing survey methods in various countries and a tool will be developed to best fit our area of survey of the pollution and a systematic survey will be conducted using our modified device.

2. LITERATURE REVIEW:-

I. The survey done in rural Ireland[6] used satellite measurement of night time light monitoring methods. To overcome some limitations, calibrated data has been used to produce a series of annual average georeferenced cloud free image coverage. Ground based measurements used zenithal light measurement technique. Data was taken using a data logging sky quality metre. The field and species survey was downloaded from the national biodiversity data cortex.

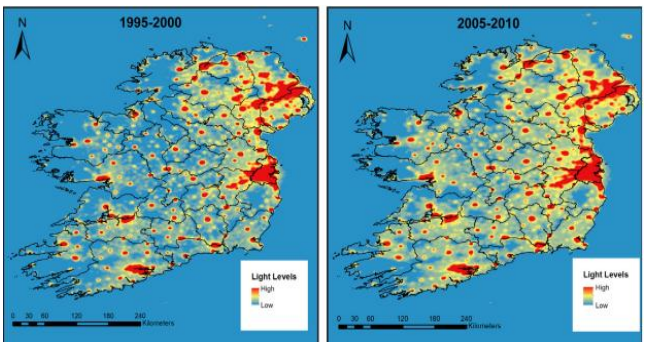

Fig-1. Inter Calibrated DMSP/OLS data for Ireland during the periods 1995-2000 and 2005-2010.

Location	Dates	New Moon (clear sky) mag/arcsec²	New Moon (clear sky) natural dark sky radiance	New Moon (overcast sky) mag/ arcsec²	New Moon (overcast sky) natural dark sky radiance
Ballycroy Visitor Centre	17 – 20 Feb 2015	21.5	1.1	19.6	6.3
NPWS Ranger's Office	17 – 20 Feb 2015	21.6	1.0	23.0	0.3
Altnabrocky	17 – 20 Feb 2015	21.7	0.9	24.1	0.1
Bangor Trail	18 – 21 Mar 2015	21.6	1.0	23.8	0.1

Table-1: Median brightness values from the four light metre sites under clear and overcast conditions.

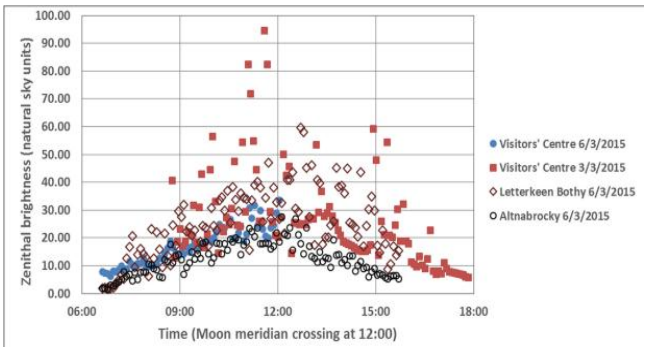

Fig-2. Sky Brightness Variation During Full Moon: Observations and Impact of Clouds

Site	<15 mag/arcsec²	<20-15 mag/arcsec²	20-20.99 mag/arcsec² (Bronze)	21-21.74 mag/arcsec² (Silver)	>21.75 mag/arcsec (Gold)
Mountain Meitheal Hut	14.6	34.0	6.8	13.5	31.2
Brogan Carroll Bothy	14.0	35.9	6.5	14.0	29.6
NPWS Ranger's Office**	13.7	19.7	7.5	26.1	33.1
Ballycroy Visitor Centre	14.4	41.6	11.8	28.2	4.0

Table-2: Light frequency data from the four light metre sites in percentages.

II. The survey done in Berlin[5], Germany used a world atlas of Artificial night sky brightness, a calibrated camera system and night sky brightness process software.

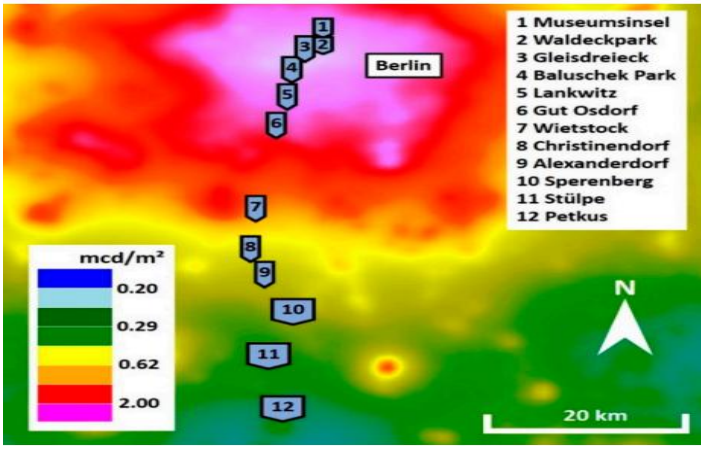

Fig-3. Map of Transect Stops in Berlin, Germany

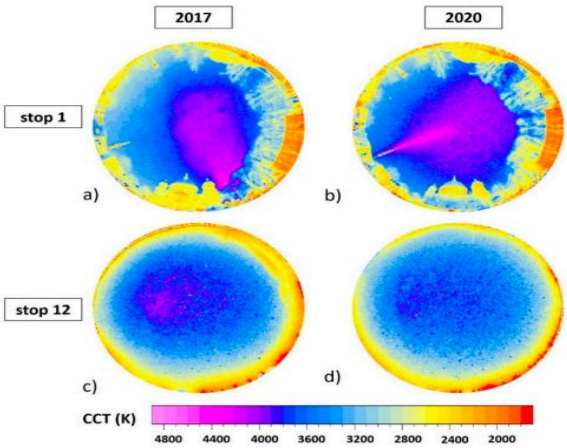

Fig-4. Correlated Colour Temperature (CCT) Maps for Two Transect Stops in Berlin, Germany.

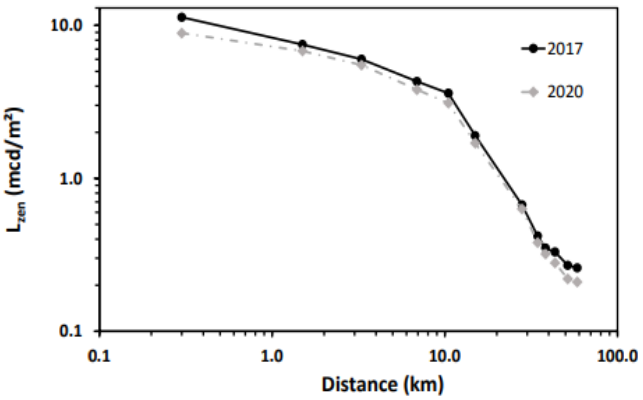

Fig-5. Zenith Luminance at Different Distances from the City Center of Berlin, Germany during Clear Nights in 2017 and the COVID-19 Lockdown in 2020

III. The survey done in Hungarian national parks[3] used a digital camera (24mm) with 180° Gilheyelens and a robotic panorama head. The robot took photos for every 10 minutes from sunset to sunrise and the data was compared and computed.

IV. BAERLIN2014 is a study that gathered information on air quality at a backdrop station in an urban area of Berlin, Germany. The measurements were examined to determine and allocate the sources of air pollution, such as industrial processes, transportation, and burning of biomass. The goal of the study was to increase knowledge of the causes of air pollution in urban settings and to help shape public policy to lessen its negative impacts on the environment and public health. [4]

V. Sky Quality Meters (SQMs), Lux metres, and digital cameras with astronomical filters were among the tools mentioned in the literature review for "The Reality of Light Pollution: A Field Study for the Identification of Lighting Environmental Management Zones in South Korea." Because to its precision and portability, SQMs were discovered to be the instrument that was utilised the most frequently[7]

VI. The use of a DSLR camera and telephoto lens, mounted on a fixed tripod and programmed to take pictures every 30 seconds throughout the night, was noted in the literature review for "Observing the Impact of WWF Earth Hour on Urban Light Pollution: A Case Study in Berlin 2018 Using Differential Photometry." To gauge variations in sky brightness and assess how the Earth Hour event affected light pollution in Berlin, the differential photometry approach was utilised.[8]

VII. High-resolution night aerial lighting maps have been used in conjunction with a number of devices to analyse light pollution. These include ground-based instruments like the Sky Quality Meter (SQM) and the

All-Sky Imager, satellite-based instruments like the Visible Infrared Imaging Radiometer Suite (VIIRS) and Defense Meteorological Satellite Program-Operational Linescan System (DMSP-OLS), and airborne instruments like the Digital Airborne Imaging Radiometer (DAIR). These devices record information on the brightness, spectral properties, and spatial distribution of light pollution.[9]

VIII. The use of several devices such as the Sky Quality Meter (SQM), the Digital Camera, the Radiance Light Sensor, and the All-Sky Imager is included in the literature review on data analysis approaches in light pollution. In order to understand the patterns and trends in light pollution, these sensors collect data on many elements of light pollution, which are then evaluated using various data analysis techniques as geographical analysis, statistical analysis, and machine learning algorithms.[10]

IX. The usage of a smartphone app called Loss of the Night, which enables citizen scientists to gauge the brightness of the night sky and contribute to light pollution studies, is highlighted in the article "Citizen Scientists Demonstrate Light Pollution Erases Stars From the Sky." The software makes use of the phone's camera to take pictures of the night sky, which are then examined to gauge the level of light pollution in the vicinity. For this study, no specialist equipment is needed.[11]

X. The Sky Quality Meter (SQM) was used in the "Artificial Light Survey of Nighttime Pittsburgh" study to calculate how much artificial light is present in the Pittsburgh region. The SQM is a portable instrument that calculates the magnitudes per square arcsecond of the sky's brightness. To fully understand Pittsburgh's light pollution, the sensor was positioned throughout the city at various points. In order to pinpoint regions with high and low light pollution, the data was evaluated, and suggestions for lowering light pollution in the city were made.[12]

XI. The "Device for automatic measurement of light pollution of the night sky" is a custom-made instrument designed specifically for measuring light pollution. The device utilizes a photodiode to measure the brightness of the night sky and a microcontroller to record and process the data. The instrument is equipped with a GPS receiver and a real-time clock to record the location and time of each measurement. The data collected can be used to assess the level of light pollution in a given area and inform efforts to reduce it.

XII. A portable instrument called the Sky Quality Meter (SQM) is used to gauge the brightness of the night sky in magnitudes per square arcsecond. A photodiode sensor, a microcontroller, and a display screen commonly make up the instrument. The sensor calculates how much light it receives, and the microcontroller analyses the information before displaying the outcome on the screen. Several sites can measure sky brightness using the SQM, and the results can be used to determine how much light pollution is present in the area. Many studies on light pollution, including those that identify black skyplaces and assess lighting regulations, have made use of the SQM.

XIII. This paper's literature review examines various technologies used for the analysis of nighttime data to determine light pollution in South Africa's eThekwini Metropolitan Municipality (EMM). The technologies that were examined include data processing algorithms, statistical modelling methods, geographic analytic tools, remote sensing techniques, and satellite imaging. With the help of these technical developments, effective urban planning and environmental management methods may be implemented because it is now possible to fully comprehend the scope and effects of light pollution.[15]

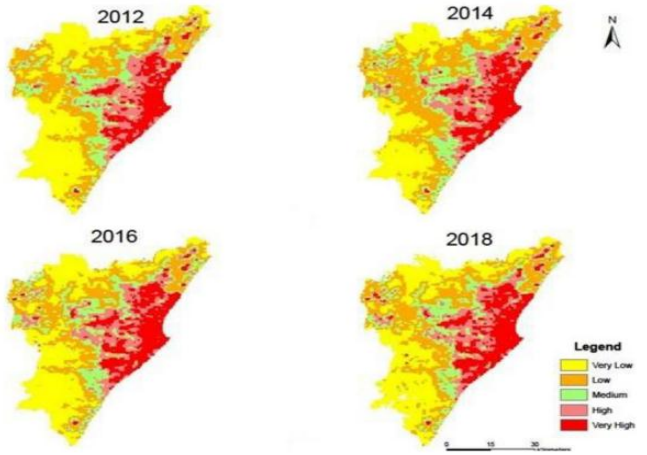

Fig-6. Summer light pollution

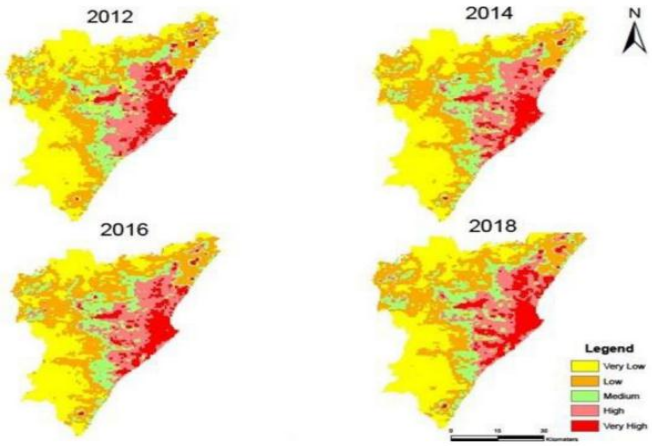

Fig-7. Winter light pollution

	Area 2012	Area 2014	Area 2016	Area 2018
Commercial	24%	25%	30%	30%
Recreational	2%	3%	3%	4%
Built-up	31%	36%	40%	45%
Vegetation	37%	32%	23%	16%
Transportation	5%	4%	4%	6%

Table-3. Area coverage in percentage of LULC

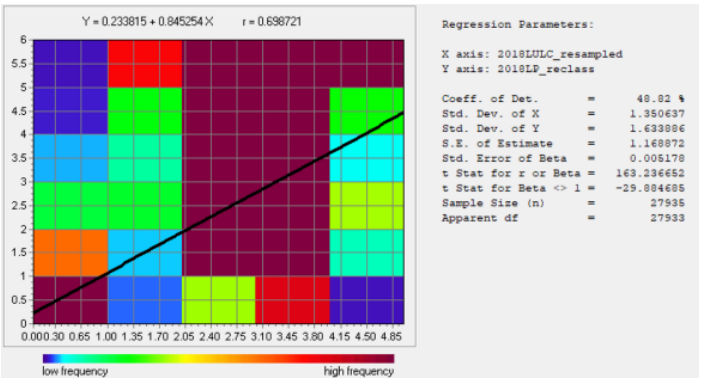

Fig-8. Light pollution and LULC regression analysis results

3. REFERENCE BLOCK DIAGRAM:-

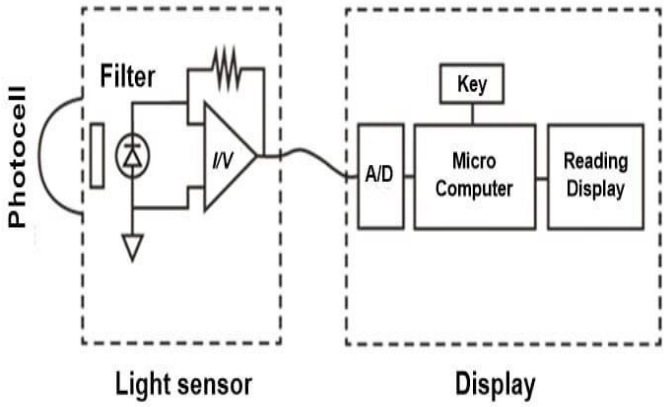

Fig-9. Lux Meter

The illuminometer's light sensor satisfies the criteria for this kind of instrument by including a photodiode, which transforms light into an electrical signal, an optical filter, which assures the same sensitivity as the human eye, and a diffusing globe, which makes cosine correction easier. (Block diagram)[14]

4.SUMMARY:-

The project report talks with the issue of environmental light pollution, which is a result of too much artificial nighttime lighting. The effects of light pollution on the environment and human health are emphasised, as well as the requirement for efficient solutions. The use of modern survey tools to collect precise data on the levels of light pollution in varied environments is highlighted in the paper.Different survey methods employed in various nations are explored in the literature review section. Satellite measurements, calibrated cameras, robotic panorama heads, and various light sensors are some of these techniques. The research that have been cited offer insightful information on how light pollution is measured and analysed. The report suggests creating a customised gadget that can precisely gauge artificial light pollution and offer its intensity and spectrum data. The gadget tries to close the gap in effective light pollution measurement equipment.

Comparison of different methods:-

Survey	Technology Used	Advantages	Disadvantages
Survey I	Satellite measurement of night-time light monitoring methods	- Broad coverage area- Captures information on vast spatial scales.- Coverage of georeferenced images and calibrated data	- Affected by the atmosphere and cloud cover.- Restrictive to some areas
Survey II	World atlas of Artificial night sky brightness	- Provides current data for analysis and comparison.- Software to process night sky brightness	- Reliance on already-available data- Needs knowledge and calibration
Survey III	Digital camera with Gilheyelens and a robotic panorama head	- Images with a high resolution- Accurate and automated image capturing- Repeated images every 10 minutes	- Restrictions to a single camera and lens setup- Dependence on the weather
Survey IV	Air quality measurements at a backdrop station	- Direct measurement of the parameters affecting air quality- Beneficial for environmental management and public policy	- Emphasises air quality rather than directly measuring light pollution.- Strictly defined
Survey V	Sky Quality Metres, Lux metres, digital cameras with filters	Measurements of the sky's brightness that are exact- Measurements of the illumination level- Record particular wavelength ranges	Light pollution may not be fully captured by Lux metres.- Requires skill and camera calibration
Survey VI	DSLR camera and telephoto lens mounted on a fixed tripod	- Images with great definition and quality- Adjustable settings; br- Evaluation of changes in sky brightness	- Manual setup and supervision- A small field of view- Protracted data processing

Survey VII	High-resolution night aerial lighting maps and ground/satellite -based instruments	-A thorough analysis of light pollution- Wide-area data gathering- Note brightness and spectral characteristics	- Fine features may not be present on aerial maps- Cloud cover has an impact on satellite-based sensors.- A restricted supply
Survey VIII	Sky Quality Meter, Digital Camera, Radiance Light Sensor, All-Sky Imager	- A thorough evaluation of light pollution- Information about many aspects of light pollution- Various analysing methods	- Each gadget could have unique restrictions.- Requires proficiency using several instruments
Survey IX	Smartphone app (Loss of the Night)	- Wide accessibility and user-friendliness- A cost-effective strategy- Citizen scientists can add to research	- Relies on the accuracy of smartphone cameras.- Limited ability to influence data quality- Image analysis's possible drawbacks
Survey X	Sky Quality Meter (SQM)	- A portable, user-friendly instrument- Measurables that can be quantified- Analyse the extent of light pollution in various areas	- Restrictions to measuring sky brightness- Affected by regional variables- Necessitates a number of measurements and data analysis
Survey XI	Custom-made instrument (Device for automatic measurement of light pollution of the night sky)	- Created for precise measuring- Extensive brightness and place-specific information	- Limited access and specialised knowledge- Increased costs– Special data formats
Survey XII	Sky Quality Meter (SQM)	- A transportable instrument- Measurements that are consistent.- Comparisons of several websites	- Only concentrates on sky brightness- May not capture other light pollution factors

5. CONCLUSION:-

As a result of excessive artificial nighttime lighting, environmental light pollution has grown to be a serious issue with consequences for both the environment and human health. Researchers and scientists have been investigating various survey techniques and technologies to collect quantitative information on the levels of light pollution in diverse contexts in order to address this issue. The research included in the related works section emphasise the use of numerous tools for measuring and evaluating light pollution, including satellite measurements, calibrated cameras, robotic panorama heads, and various light sensors. The project's main goal is to create a device that can precisely measure and provide light intensity and spectrum values in order to address the problem of the lack of acceptable tools for evaluating artificial light pollution.

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