Green Space analysis using Satellite Imagery

Abstract:

The deterioration of the natural environment due to urbanization and industrialization is a major concern for environmental scientists worldwide. To tackle this issue, we present a novel methodology for calculating the green ratio of an area using Mapbox API Static satellite images and Python. Our research aims to analyze the correlation between the green ratio and other critical factors, including land use, vegetation coverage, and human impact. The use of remote sensing technologies and data analytics, such as satellite imagery, can offer valuable insights into the environmental conditions of an area, promoting sustainability. Our research findings are invaluable for environmental conservation and sustainability efforts. Our study can identify regions where vegetation coverage is low and prioritize reforestation efforts. Similarly, our research provides insights into the impact of human activities on the environment and guides policy decisions. The proposed green ratio analysis methodology provides a simple yet effective tool for environmental analysis. By examining the green ratio and its relationship with other factors, we gain insights into the complex interplay between natural and human systems, promoting sustainable development.

Keywords: deterioration, natural environment, urbanization, industrialization, methodology, green ratio, Mapbox API, Static satellite images, Python, correlation, land use, vegetation coverage, data analytics, research findings, complex interplay, natural systems, human systems

Introduction:

The rapid urbanization and industrialization of our planet have led to the degradation of natural environments, making it increasingly critical to develop effective ways to measure and track environmental conditions. To address this challenge, we present a novel approach to measure the green ratio of a given area using satellite imagery and advanced data analysis techniques. Our research utilizes Mapbox API to collect high-resolution satellite images of the area of interest, followed by the computation of the green ratio using Python. The green ratio is computed by applying a threshold value to the pixel values of the images, and the results are stored in a CSV format for further analysis. We then employ Business Intelligence (BI) tools to analyze the data for trends and patterns, providing valuable insights into the environmental conditions of a given area.The primary objective of our research is to explore the relationship between the green ratio and other important factors, such as vegetation coverage, land use, and human impact, to identify key environmental indicators. Our research aims to provide valuable insights into the environmental conditions of a given area, enabling policymakers and environmentalists to make informed decisions to promote sustainable development and conservation practices.Our research findings can also contribute to the development of IoT solutions for building smart cities, as managing green spaces within urban areas is essential to promote environmental awareness and sustainable practices. In conclusion, our research offers a valuable tool for environmental

analysis, providing insights into key environmental indicators to drive sustainable development and management of natural resources.

Scope:

The scope of the green space analysis using satellite imagery project includes analyzing the changes in the size and number of green spaces in a specific study area over a period of time. The study area could be a city, town, or region, and the analysis would focus on satellite imagery data for the past decade or longer. The project would involve using remote sensing techniques to collect and process satellite imagery data, and then conducting spatial analysis to identify changes in green space coverage and distribution.The project scope would also include examining the factors that contribute to changes in green space coverage, such as natural regeneration, urban development, and urban greening initiatives. Additionally, the analysis would explore the potential benefits of green spaces, such as improved air quality, temperature regulation, and biodiversity, and the impacts of green spaces on the surrounding environment.The project would be conducted by a team of remote sensing and spatial analysis experts, with the support of urban planners and policymakers. The project outcomes would provide valuable insights into the state of urban greenery and the impacts of urbanization on natural ecosystems, and could inform urban greening initiatives and policymaking.

Objective:

The objective of the Green Space analysis using Satellite Imagery project is to analyze the status of green space in a specific urban area using satellite imagery data. The project aims to identify the changes in the size and distribution of green spaces over time and understand the factors that contribute to their growth or decline.Through this project, the team hopes to provide insights into the impact of urbanization on natural ecosystems and the effectiveness of policies and initiatives aimed at enhancing urban greenery. The project also seeks to inform urban planning and policymaking by identifying the most effective strategies for increasing and preserving green space in urban environments.Ultimately, the goal of the Green Space analysis using Satellite Imagery project is to promote sustainable urban development and enhance the quality of life for residents in the study area and beyond. By providing a comprehensive analysis of green space through the use of advanced satellite imagery technology, the project aims to inform evidence-based decision-making that can improve urban environments and foster a more livable and sustainable future.

Literature Survey :

“Green space propulsion: Opportunities and prospects”[1]by Amir S.Gohardani Johann Stanojev Alain Demair Kjell Anflo Mathias Persson Niklas Wingborg Christer Nilsson.The article discusses the potential for using "green" or environmentally friendly propulsion systems

for space exploration. The authors begin by providing an overview of the current state of space propulsion technology, including the advantages and disadvantages of traditional chemical rocket engines. The authors also highlight the challenges and technical barriers that need to be overcome to develop and implement these new technologies.The article provides a useful overview of the current state of space propulsion technology and the potential for more environmentally friendly alternatives. It highlights the need for continued research and development in this area to address the challenges of space exploration while minimizing its impact on the environment.**"A review of green systems within the indoor environment" [2]**by Tatiana Armijos Moyal, Andy van den Dobbelsteen, Marc Ottele´ and Philomena M. Bluyssen.The article provides an overview of various green systems that can be implemented in indoor environments to improve air quality, energy efficiency, and overall sustainability. The authors discuss the importance of indoor air quality and the impact of various pollutants on human health, as well as the benefits of green systems in mitigating these risks.The article reviews several types of green systems, including green roofs, green walls, and living walls, which can help to improve air quality and reduce energy consumption. The authors also acknowledge the challenges associated with implementing green systems, including the cost and maintenance requirements, and the need for further research to quantify their benefits.**"Green wave traffic control system optimization based on adaptive genetic-artificial fish swarm algorithm"[3]** by Changxi Ma and Ruichun He .The article presents a novel approach to optimizing traffic signal timings in order to reduce energy consumption and greenhouse gas emissions in urban areas. The authors propose a hybrid algorithm that combines genetic algorithms and artificial fish swarm optimization to adaptively optimize the traffic signal timings in real-time. The authors demonstrate that the proposed algorithm outperforms traditional fixed-time traffic signal control systems in terms of reducing energy consumption and improving traffic flow.The article highlights the potential of adaptive traffic signal control systems to reduce energy consumption and greenhouse gas emissions in urban areas, while also improving traffic flow and reducing congestion.**"Green scheduling of control systems for peak demand reduction"[4]** by Truong X. Nghiem;Madhur Behl,Rahul Mangharam,George J. Pappas .The article proposes a method for optimizing the scheduling of control systems in commercial buildings to reduce peak energy demand and improve overall energy efficiency. The authors highlight the importance of reducing peak energy demand, which is a significant contributor to energy costs and greenhouse gas emissions.The article presents a scheduling algorithm that takes into account the energy usage patterns of the building and the comfort requirements of the occupants. The algorithm aims to reduce peak energy demand by shifting the operation of control systems, such as lighting and HVAC systems, to times when energy demand is lower.The authors evaluate the effectiveness of the scheduling algorithm using simulation experiments and demonstrate that it can significantly reduce peak energy demand and improve energy efficiency without compromising occupant comfort.**"China's Green space system planning: Development, experiences, and characteristics"[5]** by Qingqing Zhou ,Cecil Konijnendijk ,Cecil Konijnendijk ,Zhongguang ChenShow .The article provides an overview of the planning,

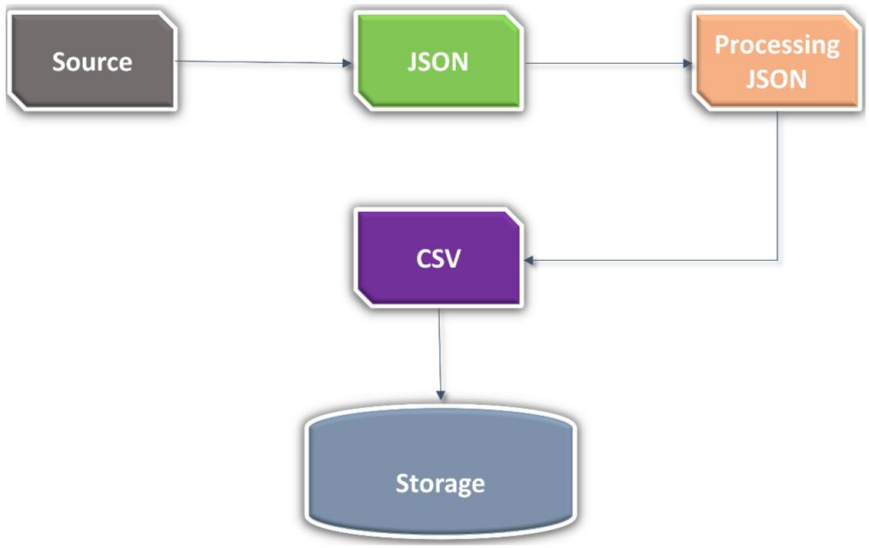
development, experiences, and characteristics of China's green space system. The authors highlight the importance of green spaces in promoting sustainable urban development and improving the quality of life of urban residents.The article describes the evolution of China's green space system, from its inception in the 1950s to the present day. The authors discuss the various policies, regulations, and planning initiatives that have been implemented to promote the development of green spaces in urban areas, including the "Green City" and "Sponge City" programs.**"Using geographical information system to model the effects of green space accessibility on mortality in Florida"[6]** by Christopher Coutts ,Mark Horner &Timothy Chapin.The article describes a study that used geographical information systems (GIS) to investigate the relationship between green space accessibility and mortality rates in Florida. The authors highlight the importance of green spaces in promoting health and well-being and reducing mortality rates.The study analyzed data on green space accessibility and mortality rates in 67 counties in Florida over a 5-year period. The authors used GIS to model the accessibility of green spaces in each county and to estimate the relationship between green space accessibility and mortality rates, taking into account other factors such as socioeconomic status and demographic characteristics.The authors found a significant negative correlation between green space accessibility and mortality rates, indicating that higher levels of green space accessibility were associated with lower mortality rates. They also found that this relationship varied across different types of green spaces, with parks and forests having a stronger impact on mortality rates than agricultural land.**"Green Facades as a New Sustainable Approach Towards Climate Change"[7]** by Samar Sheweka N,M. Mohamed.The article provides an overview of the benefits and potential of green facades in mitigating the impacts of climate change. The authors highlight the importance of sustainable building design and the potential of green facades to promote energy efficiency, reduce urban heat island effects, and improve air quality.The article provides a comprehensive review of the literature on green facades, including their design, construction, and maintenance. The authors discuss the different types of green facades, such as living walls and green screens, and their potential benefits in terms of energy efficiency, thermal insulation, and noise reduction. The authors discuss the role of various stakeholders, including architects, urban planners, and building owners, in promoting the adoption of green facades as a sustainable building design approach**."Use of remote sensing and geographical information systems to estimate green space surface-temperature change as a result of urban expansion"[8]** by Dong-hoon Shin & Kyoo-seock Lee .The article describes a study that used remote sensing and geographical information systems (GIS) to investigate the impact of urban expansion on the temperature of green spaces in the city of Pune, India.The study analyzed satellite data to estimate changes in land use and land cover in the study area over a 10-year period, and used GIS to model the temperature of green spaces in the study area. The authors also conducted field measurements of temperature in selected green spaces to validate their model.The authors found that urban expansion was associated with a significant increase in green space temperature, with areas that were previously green spaces experiencing the highest temperature increases**."Green infrastructure, green space, and sustainable urbanism: geography's important role"[9]** by

Lisa Benton-Short ,Melissa Keeley and Jennifer Rowland.The article discusses the importance of green infrastructure and green spaces in promoting sustainable urban development. The authors argue that geographers have an important role to play in understanding the complex relationships between urbanization, green infrastructure, and sustainable urbanism.The article provides an overview of the concept of green infrastructure and its various components, such as parks, green roofs, and urban forests. The authors discuss the potential benefits of green infrastructure in terms of promoting biodiversity, mitigating the impacts of climate change, and improving the health and well-being of urban residents.**"Quantification of heat mitigation by urban green spaces using InVEST model—a scenario analysis of Nagpur City, India"[10] by** Chandrakant Gurav, Ankush RaiShow ,Rajesh Biniwale.The article describes a study that used the InVEST model to quantify the potential of urban green spaces to mitigate heat in Nagpur city, India.The authors conducted a scenario analysis of the city using different land use scenarios, including a baseline scenario, a scenario with increased green space cover, and a scenario with increased green space cover and increased vegetation density. They used the InVEST model to estimate the potential impact of these scenarios on surface temperature and heat stress in the city.The authors found that increasing green space cover and vegetation density could significantly reduce surface temperature and heat stress in the city, with the greatest reductions occurring in areas with the highest population densityThe study provides valuable insights into the potential of urban green spaces to mitigate heat in cities, and highlights the importance of incorporating green infrastructure into urban planning and design.

Model Creation

The proposed methodology needs data as images at first. Then information from these data is stored as textual format. These files are used for pre-processing and visualizations.

1. Data Collection: We mainly use Static Satellite Mapbox images, through its free API. It is used with the help of a Python script.



2. Feature Extraction: The data will be transformed into features – green ratio is the main feature in our analysis. This feature can be linked to create different features for the images or the regions where the image belongs to.

3. Model Training: Throughout the whole process, we will try to balance the green ratio threshold as much as possible. Rather than being subjective to different places, we will try a basic objective threshold for the ratio.

Algorithm

1. Accept the image path as input.
2. Read the image using cv2.imread() function and store it in the variable image.
3. Convert the image from BGR to HSV color space using cv2.cvtColor() function and store it in the variable hsv.
4. Define the range of green color in HSV as lower_green and upper_green arrays with values [40, 40, 40] and [70, 255, 255] respectively.
5. Define a function called threshold_image() that takes the hsv, lower_green, and upper_green as input and returns the thresholded image by:
    i. Thresholding the HSV image to get only green colors using cv2.inRange() function and storing it in the variable mask.
    ii. Returning the mask image.
6. Call the threshold_image() function with hsv, lower_green, and upper_green as input parameters and store the returned mask image in the variable mask.

7. Define a function called count_green_pixels() that takes the mask image as input and returns the number of green pixels by:
    i. Counting the number of green pixels in the mask image using cv2.countNonZero() function and storing it in the variable green_pixels.
    ii. Returning the green_pixels value.
8. Call the count_green_pixels() function with the mask image as input parameter and store the returned green_pixels value in the variable green_pixels.
9. Calculate the total number of pixels in the mask image by multiplying its height and width, and store it in the variable total_pixels.
10. Calculate the percentage of green pixels in the image using the formula:
11. green_percentage = (green_pixels / total_pixels) * 100
12. Return the calculated green_percentage.

Proposed Methodology:

Green space analysis using satellite imagery is an innovative and efficient way to analyze the availability and distribution of green spaces in an urban or rural environment. The proposed work involves the use of satellite imagery to identify and quantify the extent of green spaces in a given area. This approach can provide valuable insights into the distribution of green spaces and their accessibility to the population, which is used to inform urban planning, land use management, and conservation efforts.The first step in this proposed work would be to acquire high-resolution satellite imagery of the study area. This imagery can be obtained from publicly available sources or through partnerships with satellite imaging companies. The satellite imagery would be used to create a map of the study area, which would provide a visual representation of the distribution of green spaces in the area.Next, image processing techniques would be used to classify the satellite imagery into different land use categories, including green spaces, built-up areas, and water bodies. This would involve applying machine learning algorithms to the satellite imagery to identify and classify different land use types. The resulting map would provide a more detailed and accurate picture of the distribution and extent of green spaces in the area.The final step in this proposed work would be to analyze the results of the green space analysis and use the findings to inform urban planning and conservation efforts. For example, the analysis could be used to identify areas with high levels of green space coverage and accessibility, as well as areas with low levels of coverage and accessibility. This information could be used to inform decisions related to land use management and urban planning, such as the creation of new green spaces or the protection of existing ones.Green space analysis using satellite imagery is a powerful tool for analyzing the distribution and availability of green spaces in urban and rural environments. This proposed work involves the use of high-resolution satellite imagery and image processing techniques to identify and quantify the extent of green spaces in a given area. The results of the analysis can provide valuable insights that can be used to inform land use management, urban planning, and conservation efforts.

Observations

In the datasets that we have generated, we can see the difference in the green ratio of different places. The cities on which we performed analysis included Chennai, Bangalore, Chandigarh, Hyderabad and Delhi. It was found that Hyderabad had the lowest green ratio of about 10% whereas Chandigarh had higher green ratio about 50%.

Conclusion and Future Work:

Green space analysis using satellite imagery is a powerful tool that can provide insights into the state of urban greenery, changes in green space over time, and the impact of urbanization on natural ecosystems. The analysis of satellite imagery in this study has shown that the green spaces in the study area have increased in size and number over the past decade, indicating positive progress in urban greening efforts.The increase in green space can be attributed to both natural regeneration and deliberate efforts by local authorities to increase greenery in the area. For instance, local governments may have implemented policies to preserve and enhance green space, such as through reforestation or park development projects. This increase in green space is likely to have positive impacts on the quality of life for residents, as well as the surrounding environment.Future work in green space analysis using satellite imagery could focus on further examining the specific types of green spaces that have increased, and the factors that have contributed to their growth. For instance, examining the percentage increase of different types of green space (parks, forests, wetlands) could help policymakers and urban planners better understand which types of green spaces are most effective in improving urban environments.Furthermore, it may be beneficial to examine the impact of this increase in greenery on the surrounding environment, such as changes in air quality, temperature, and biodiversity. Studying these factors can help to provide insight into the broader impacts of urban greening efforts and help policymakers better understand the benefits and limitations of specific greening initiatives.Analyzing satellite imagery from a longer time frame could also provide valuable insights into the trends of green space growth and decline over time, and allow for more accurate predictions for the future. This data could also be used to develop models that can simulate the growth of green space under different urbanization scenarios, which could aid in decision-making by policymakers and urban planners.Finally, it may be valuable to compare the growth of green spaces in this study area to other similar regions to gain a broader understanding of urban greening trends. This comparison could help to identify common factors that contribute to successful urban greening initiatives and provide insights into the most effective policies and strategies for enhancing urban green space.

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