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Analysis of thermal reduction capacity based on green spaces in Maragheh city using the urban cooling model

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Abstract

Background and Objective: Considering the increase in global temperature and the intensification of the urban heat island effect, the expansion of vegetation can reduce the intensity of this phenomenon and provide a healthier and more stable environment for city residents. In general, green areas in cities are an effective approach to reduce the effects of urban heat island and create comfort for residents. The improvement of microclimatic conditions in urban environments is mostly influenced by evaporation and transpiration.

Methodology: In this article, using the urban cooling model, the effects of green spaces on the process of reducing the effects of heat islands in the city of Maragheh were investigated. According to the nature of the subject, the purpose of the research is the application and research method based on the descriptive-analytical method. In this research, Landsat satellite images with 30x30 pixel size have been used to monitor urban land use changes in the period from 1984 to 2022. To check the amount of cooling in Maragheh city, the urban cooling model was used in the Invest software.

Results and Findings: In 1984 in the class 0.83 to 0.90 equal to 19.5%, in 2002 in the class 0.60 to 0.93 equal to 19.87. percent and in class 2022 in class 0.59 to 0.83 equal to 20.65% was able to reduce heat islands. According to the results obtained from the urban cooling model, it was observed that in all three periods, the city of Maragheh did not have a very favorable situation in reducing heat islands. According to the land use maps of three periods, the growth pattern of the city of Maragheh has followed a scattered and horizontal uneven growth pattern with the destruction of garden and fertile agricultural lands and replacing them with the fabric of scattered and incoherent urban and rural neighborhoods. The energy saving due to the reduction of urban heat islands due to urban green infrastructure in Maragheh city in 1984 was 10,626 megawatts for 2002 equal to 19,252 megawatts and finally for 2022 equal to 36,234 megawatts.

Keywords: Thermal islands,Green space,Urban cooling, Maragheh.

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Extended Abstract

Introduction

In recent years, ecological problems and the global environment have become increasingly prominent, the sustainable development of human society (wi et al,2022).seriously threatens The mutual effects of humans and the natural environment always directly and indirectly cause land use changes, which lead to many environmental problems and endanger the life of the planet; Therefore, it is necessary to know the changes and the factors affecting them in order to continue life and reduce the land use changes in order to overcome the problems. . The first factor is at the scale of the whole planet and the other factor is at the scale of the city or region. The effect of greenhouse gases, as the first factor, is a weather phenomenon that traps radiant energy through the presence of greenhouse gases in the earth's atmosphere and causes the earth's atmosphere to warm (Weebles, 2014). In addition to the change in the structure of the earth's atmosphere, human activities and changes in the use of land on an urban and regional scale have helped to increase the temperature, replacing building materials such as concrete and asphalt in urban development instead of trees and other natural resources increases the absorption and storage of thermal energy in cities compared to the surrounding rural areas. It affects many big cities in the world and can increase the air temperature up to 10 degrees Fahrenheit (about 5.5°C) compared to the surrounding environment, the phenomenon of environmental temperature difference of that city (Rizvan, 2017). In the current situation, the urbanization world is the most important cause of climate change and one of the main causes of the heat island phenomenon in an area (Zhang, 2024).Ground level ozone is also closely related to urban heat island (Tan, 2021). Vegetation not only beautifies the environment (Manoli, 2019). It sequesters carbon and releases oxygen, but also plays a central role in lowering the temperature (Han, 2019). The average temperature of UGS is 1-2 degrees Celsius lower than the surrounding temperature. The cooling effect of UGS is mainly due to shading and evaporation .Approximately 80 to 90% of solar radiation can be effectively intercepted (Kutzen, 2018).

Methodology

In this research, in order to monitor urban land use changes in the period from 1984 to2022, Landsat images with pixel size 30x30 are used to check the amount of cooling in Maragheh city, using the urban cooling model in the investment software.

Urban Cooling Model

Urban heat mitigation is a priority for many cities that have undergone heat waves in recent years. Vegetation can help reduce the urban heat island by providing shade, modifying thermal properties of the urban fabric, and increasing cooling through evapotranspiration. This has consequences for health and wellbeing of citizens through reduced mortality and morbidity, increased comfort and productivity, and reduced need for air conditioning (A/C). The InVEST urban cooling model calculates an index of heat mitigation based on shade, evapotranspiration, and albedo, as well as distance from cooling islands.

Results and Findings

The increase in greenhouse gases caused by the change in land use and land cover has led to climate changes and harmful effects on human life on the planet(Asadolahi,2022).Considering that understanding the effects of land use changes on ecosystem services for land management and ecosystem preservation byIt is important for policy makers, studying the relationship

between sustainable use and ecosystem services can be a basis for analysis.environmental changes, formation of regional ecological protection policies, and sustainable use of land resources(Mohammadyari,2023) The aim of the current research is to investigate the land use and its role in increasing the temperature in the urban environment of Maragheh and to identify critical environmental areas. The results indicate that according to the survey of urban land use in Maragheh by satellite images for the years 1984, 2002, and2022, the constructed lands are equal to 436.21, 1080.71, and 1519.33 hectares, respectively, in the discussion of garden lands, 542.76, 398.87, and 291.42 hectares, respectively, and in agricultural lands are equal to 510.42, 122.42 and 115.11 hectares. which shows that in the 38-year period, construction land has increased and garden and agricultural land has decreased, in fact, most of the garden and agricultural areas around the city have been under construction. According to the results, it can be seen that the areas with the highest amount of cooling are the northern and southern areas of the city, which have the highest amount of gardens.

Conclusion

There is a direct relationship between the amount of green spaces and reducing the effects of heat islands on the city. The output of the urban cooling model shows that green spaces and gardens play a valuable role in reducing the heat island phenomenon. . Urban heat island effect is one of the main challenges for urban planning. To achieve sustainable development, using the benefits of ecosystem services in urban planning is very effective. The density of buildings and population has led to a reduction in the cooling capacity of urban areas. In deciding the development of cities or determining the direction of city development, one should pay attention to the factors related to the design and construction of the city and vegetation, land use, transportation and characteristics of surface materials. Ecosystem services are defined as the foundation of sustainable development due to the focus on the interaction between nature and society. Therefore, the quantification of ecosystem services is an important tool for decision makers and country managers in order to manage and monitor the supply level of ecosystem services. Urban cooling capacity is one of the benefits of urban ecosystem services that help reduce urban heat island effects. Recognizing the importance of these factors can show the role and place of urban design, urban planning and architecture in reducing urban heat islands.

Declarations

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Authors' Contribution

Authors contributed equally to the conceptualization and writing of the article. All of the authors approved the content of the manuscript and agreed on all aspects of the work declaration of competing interest none.

Conflict of Interest

The authors declare no conflict of interest.

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References

Abedini, Asghar, Azmoun, Mojtaba, Azarkish, Kiarash and Moshtaghqi, Sina (2010). Reducing the effects of urban heat islands through cool pavement materials. Case study: Region 8 of Tabriz metropolis. Sustainable urban development 105 _128. 10.22034/USD.2024.2008122.1092.(in Persian)

Al-Tamimi, Ayam Shia Ali and Zarkesh, Afsaneh and Yeganeh, Mansour, 1402, Analysis of the effect of green building techniques on reducing energy consumption (green roof technique in an educational building in Wasit city, Iraq). //sanad.iau.ir/Journal/jsde/Article/846529/FullText.(in Persian)

Babraz Karimi , Ahmad Roshani(2018). Analyzing the distribution of public land use from the spatial justice perspective: A case study of 10 districts of Shiraz Metropolitan. Journal of Geography and Spatial Justice2018. doi.org/10.22098/gsd.2024.2983.

Balany, F., Ng, A. W. M., Muttil, N., Muthukumaran, S., & Wong, M. S. (2020). Green infrastructure as an urban heat island mitigation strategy—a review. Water (Switzerland), 12(12), Article 3577. doi.org/10.3390/w12123577

Benz Kotzen (2018).Chapter 4.2 - Green Roofs Social and Aesthetic Aspects.Nature Based Strategies for Urban and Building Sustainability2018, Pages 273-281. doi.org/10.1016/B978-0-12-812150-4.00025-2.

Beverly Parsons, Lovely Dhillon, and Matt Keene (Eds.). (2020). Visionary Evaluation for a Sustainable, Equitable Future . Charlotte, NC: Information Age, 276 pages. (ISBN: 978-1-64113-835-2)

Davide Longato , Chiara Cortinovis , Mario Balzan , Davide Geneletti (2021). A method to prioritize and allocate nature-based solutions in urban areas based on ecosystem service demand. Landscape and Urban Planning Volume 235, July 2023, 10474. DOI:10.1016/j.landurbplan.2023.104743.

Elias Ganivet. Growth in human population and consumption both need to be addressed to reach an ecologically sustainable future. Environment, Development and Sustainability, 2020, 22 (6), pp.4979- 4998. ff10.1007/s10668-019-00446-wff. ffhal-02939187. DOI: 10.1007/s10668-019-00446-w.

Grimm, Karl and Grimm-Pretner, Dagmar (2023) Integrative Design Solutions for Connecting Street Trees to the Urban Water Cycle. LET IT GROW, LET US PLAN, LET IT GROW. Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities. Proceedings of REAL CORP 2023, 28th International Conference on Urban Development, Regional Planning and Information Society. pp. 429-438. ISSN 2521-3938. doi.org/10.48494/REALCORP2023.7091.

Halbian, Amir Hossein Soltani, Zahra. (2010). Analysis of spatial-temporal changes in urban heat islands and land use with an environmental approach in Shiraz. Studies on urban structure and function. //sid.ir/paper/408207/fa.(in Persian)

Han, Wenchao; Li, Zhanqing; Wu, Fang; Zhang, Yuwei; Guo, Jianping; Su, Tianning; Cribb, Maureen; Fan, Jiwen; Chen, Tianmeng; Wei, Jing; Lee, Seoung-Soo (2019). The mechanisms and seasonal differences of the impact of aerosols on daytime surface urban heat island effect Atmospheric Chemistry and Physics Discussions 20:6479-6493. doi.org/10.5194/acp-20-6479-2020, 2020.

Huawei Li, Guifang Wang, Guohang Tian (2020). Mapping and Analyzing the Park Cooling Effect on Urban Heat Island in an Expanding City: A Case Study in Zhengzhou City, China. Land 2020, 9(2), 57; doi.org/10.3390/land9020057.

Huimin Liu a, Bo Huang a b, Qingming Zhan c d, Sihang Gao c, Rongrong Li a, Zhiyu Fan(2021) . The influence of urban form on surface urban heat island and its planning implications: Evidence from 1288 urban clusters in China. Sustainable Cities and Society. DOI:10.1016/j.scs.2021.102987.

Imran, H.M.; Kalab, J.; Nga, A.W.M.; Muthukumaran, S. Effectiveness of vegetated patches as Green Infrastructure in mitigating Urban Heat Island effects during a heatwave event in the city of Melbourne. Weather Clim. Extrem. 2019, 25, 100217. DOI:10.1016/j.wace.2019.100217.

J.K.N. Tan , R.N. Belcher , H.T.W. Tan , S. Menz , T. Schroepfer (2021) . The urban heat island mitigation potential of vegetation depends on local surface type and shade. Urban Forestry & Urban Greening Volume 62, July 2021, 127128.doi.org/10.1016/j.ufug.2021.127128.

José G. Vargas-Hernández, Karina Pallagst ,Justyna Zdunek-Wielgołaska (2023).Urban Green Spaces as a Component of an Ecosystem. Sustainable Development and Environmental Stewardshippp 165–198. DOI: 10.1007/978-3-031-28885-2_8.

Karen Cancino (2009). The urban heat island : causes and effects. Focusing on Urban Forestry as a Key Mitigation Strategy. Faculty of Forestry The University Of BritishColumbiaVancouver, B.C. dx.doi.org/10.14288/1.0075500.

Laouadi, A.; Bartko, M.; Lacasse, M.A. Development of assessment criteria for overheating risk analysis in buildings. In Proceedings of the 2nd International Conference on New Horizons in Green Civil Engineering, Victoria, BC, Canada, 25–27 April 2020. doi.org/10.1016/j.enbuild.2020.110360.

Mahyar Masoudi , Tan Puay Yok (2020). The effects of land use on spatial pattern of urban green spaces and their cooling ability. Urban Climate Volume 35, January 2021, 100743. doi.org/10.1016/j.uclim.2020.100743.

Manoli, G., Fatichi, S., Schläpfer, M., Yu, K., Crowther, T. W., Meili, N., … Bou-Zeid, E. (2019). Magnitude of urban heat islands largely explained by climate and population. Nature, 573(7772), 55–60. doi.org/10.1038/s41586-019-1512-9.

Noredin Rostami , Hassan Fathizad(2022). Spatial and temporal changes of land uses and its relationship with surface temperature in western Iran. Atmósfera vol.35 no.4 Ciudad de México oct. 2022 Epub 25. doi.org/10.20937/atm.52985 .

Nyuk Hien Wong, Chen Yu(2021).Study of green areas and urban heat island in a tropical city. Habitat InternationalVolume 29, Issue 3, September 2005, Pages 547-558. DOI:10.1016/j.habitatint.2004.04.008.

Rahimi, Negin (1400). Study of urban heat islands in relation to land use (Case study of Tehran city). Natural Resources Management, GIS and Remote Sensing Volume 3, Issue 2, November 25-34, 2021. .(in Persian)

Razvan Nita f, Davide Geneletti g, Carlo Calfapietra h i,(2017). A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. Environmental Science & Policy Volume 77, November 2017, Pages 15-24. doi.org/10.1016/j.envsci.2017.07.008.

Rizwan Ahmed Memon, DENNIS Leung Y.C., LIU Chunho (2008). A review on the generation, determination and mitigation of Urban Heat Island. Journal of Environmental SciencesVolume 20, Issue 1. doi.org/10.1016/S1001-0742(08)60019-4.

Roshani, Hossein; Dessouky, Samer; Montoya, Arturo; Papagiannakis, A. T(2016). Energy harvesting from asphalt pavement roadways vehicle-induced stresses: A feasibility study. Applied Energy Volume 182, 15 November 2016, Pages 210-218. doi.org/10.1016/j.apenergy.2016.08.116.

Sitong Luo*, Agnès Patuano(2023).Multiple ecosystem services of informal green spaces: A literature review. Urban Forestry & Urban GreeningVolume 81, March 2023, 127849. DOI:10.1016/j.ufug.2023.127849.

T Croeser, G Garrard, R Sharma, A Ossola, S Bekessy (2021). Choosing the right nature-based solutions to meet diverse urban challenges. Urban Forestry and Urban Greening | ELSEVIER GMBH | Published : 2021 DOI: 10.1016/j.ufug.2021.127337.

Tao Sun , Liding Chen , Ranhao Sun (2024).Cooling effects in urban communities: Parsing green spaces and building shadows. Urban Forestry & Urban GreeningVolume 94, April 2024, 128264. doi.org/10.1016/j.ufug.2024.128264.

Timothy Malcolm Baynes , Josephine Kaviti Musango(2019). Estimating current and future global urban domestic material consumption. Environmental ResearcLetters, Volume13, Number 6. DOI:10.1088/1748-9326/aac391.

Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, 2014: Ch. 2: Our Changing Climate. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 19-67. doi:10.7930/J0KW5CXT.

Wei Zhang , Yuqing Li , Caigui Zheng , Yubi Zhu (2024). Surface urban heat island effect and its driving factors for all the cities in China: Based on a new batch processing method. Ecological IndicatorsVolume 146, February 2023, 109818. DOI:10.1016/j.ecolind.2022.109818.

Yang Xiao, Yi Lo, Yan Guo, Yuan Yuan (2018). Estimating the willingness to pay for green space services in Shanghai: Implications for social equity in urban China. Urban Forestry & Urban Greening Volume 26, August 2017, Pages 95-103. Doi: 10.1016/j.ufug.2017.06.007.

Yin, Zhengtong ; Liu, Zhixin ; Liu, Xuan ; Zheng, Wenfeng ; Yin, Lirong (2023). Urban heat islands and their effects on thermal comfort in the US: New York and New Jersey. Ecological indicators, 2023-10, Vol.154, p.110765-110765, Article 110765. DOI: 10.1016/j.ecolind.2023.110765.

Zhengtong Yin , Zhixin Liu , Xuan Liu , Wenfeng Zheng , Lirong Yin (2021). Urban heat islands and their effects on thermal comfort in the US: New York and New Jersey. Ecological IndicatorsVolume 154, October 2023, 110765. DOI:10.1016/j.ecolind.2023.110765.