ADVANCES IN ARCHITECTURE, PLANNING AND DESIGN

EDITOR

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DOI:10.5281/zenodo.14582391

Advances in Architecture, Planning and Design

EDITOR

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Publisher
Platanus Publishing®

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Cover & Interior Design
Platanus Publishing®

Editorial Coordinator
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The First Edition
December, 2024

Publisher's Certificate No
45813

ISBN
978-625-6982-22-3

Platanus Publishing®
Address: Natoyolu Cad. Fahri Korutürk Mah. 157/B, 06480, Mamak, Ankara, Turkey.
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CHAPTER 1

The Impact of Green Spaces in Mitigating the Urban Heat Island Effect: A Systematic Review of the Literature

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INTRODUCTION

Spatial planning is a multidisciplinary approach that encompasses both the enhancement of existing urban structures and the delineation of new development areas. This approach constitutes a strategic process adopted to regulate cities' environmental, social, physical, and economic development. The process encompasses the development of infrastructure, the planning of transport systems, the design of settlement areas, and the protection and regulation of green spaces. The primary objective of spatial planning is the creation of urban areas that are conducive to human habitation, sustainable, and functional. In this context, the term 'spatial planning' is not restricted to the mere organization of physical spaces. Instead, it encompasses many objectives, including the enhancement of societal well-being, the guarantee of social equality, and the safeguarding of environmental resources. Furthermore, it necessitates implementing strategic decisions to reduce the environmental consequences of urban expansion and address social requirements(Carmona, 2021; Levy, 2015). In essence, spatial planning provides adaptable and viable solutions to address the future requirements of urban areas while concurrently reconciling the imperatives of environmental sustainability, economic development, and social equity (Hall & Tewdwr-Jones, 2019).

"Urban green spaces" describe accessible and publicly accessible areas within urban environments and areas close to urban areas, partially or wholly covered with vegetation (Farahani & Maller, 2018). Urban green areas are fundamental to a country's natural and cultural heritage. They also provide many benefits for human life. At this point, urban green spaces contribute to air and water management in cities and increase the quality and livability of the city (Jim, 2004). Concurrently, urban green spaces enhance the surrounding environment by filtering out pollutants and reducing noise levels. Urban green spaces bolster local biodiversity by safeguarding fauna and flora in urban environments while enhancing climate balance and thermal comfort. Furthermore, the cooling rate is enhanced through shading and evaporation by reducing heat-absorbing surfaces. In addition, it has been demonstrated that implementing green infrastructure can positively impact the psychological well-being of communities, reducing stress and anxiety levels. The presence of green spaces in urban areas has been demonstrated to enhance the attractiveness of such environments, which has positively impacted property values within the city. It is, therefore, essential to consider the benefits of these areas when planning and developing a more sustainable urban environment (Dos Santos & Ribeiro, 2022; Lee & Maheswaran, 2011; QIU et al., 2013; Roy et al., 2012; Semeraro et al., 2021).

Incorporating green spaces into spatial planning processes has been identified as an effective strategy for mitigating urban overheating. Spatial planning has the potential to manage the UHI effect by determining factors such as building density, surface materials, and the amount and layout of green spaces in cities. The UHI effect is caused by the combination of dense urbanization and the intensive use of non-reflective surface materials, which absorb sunlight and lead to heat accumulation. Conversely, the strategic incorporation of green spaces within urban environments, the utilization of highly reflective surface materials, and the implementation of airflow optimization strategies between buildings are of paramount importance in the mitigation of the UHI effect (An et al., 2022; Hurduc et al., 2024; Oke, 1982; Stone, 2012). The implementation of green spaces has the potential to significantly reduce surface temperatures by improving the local microclimate. The presence of vegetation in urban areas has been demonstrated to create a natural cooling effect, which can contribute to the overall climate resilience of cities. Furthermore, green spaces absorb solar radiation through vegetation while simultaneously facilitating evapotranspiration. This process plays a role in mitigating heat in urban environments (Bowler et al., 2010). Green spaces must be integrated into spatial planning decisions and management to reduce the UHI impact effectively.

In this context, this study aims to collate and evaluate the extant knowledge comprehensively to elucidate the impact of green spaces on phenomena such as UHI and surface urban heat islands (SUHI). The role of urban green spaces in the UHI effect is subjected to a systematic analysis to integrate the various elements of this complex subject and identify shortcomings in the existing literature.

1. METHOD

In this study, a comprehensive literature review was conducted to investigate the impact of green spaces on the Urban Heat Island (UHI) effect. The review used databases such as Science Direct, Taylor & Francis, MDPI and SpringerLink, which provide reliable information through peer-reviewed publications in various fields on international platforms. These databases offer user-friendly interfaces and advanced search options, enabling researchers to access the information they need quickly and easily.

Science Direct and SpringerLink are particularly well known for their extensive content in the sciences and engineering, while Taylor & Francis specialises in the social sciences and humanities. MDPI, with its fully open access and rapid publication model, reaches a wide audience and supports multidisciplinary approaches. The selection criteria for these databases were based on the reliability of peer-reviewed publications, the breadth of topics and their alignment with research questions.

The study identified many strategies to mitigate the effects of the UHI. Topics such as "reflective (albedo) and cool roof systems, reflective (cool) pavements, water surfaces and management, natural airflow and urban design strategies, cool urban furniture and shading structures, energy efficient building design, urban regeneration and sustainable planning, and transport and mobility solutions" were initially considered. However, only those directly related to the impact of green spaces on the UHI were included. This filtering process increased the reliability of the data by excluding irrelevant topics.

Keywords such as 'spatial planning', 'urban green spaces', 'UHI', 'urban heat island', 'surface urban heat island' and 'SUHI' were used to identify studies that focused on the role of green spaces in mitigating the UHI. The evaluation process included analysis of full texts, citations and abstracts. A table provides an overview of each study's source, specific UHI-related topic, aims and objectives, methodology, findings and conclusions.

2. FINDINGS

Findings based on analysis

The keywords used in these studies on urban heat island and urban surface heat island effects indicate different aspects of strategies, methods and data that are prominent in addressing the problem of urban warming. In this context, the clustering of keywords reveals the multifaceted and interdisciplinary nature of research on UHI mitigation. In comparison with similar studies in the literature, this analysis reveals important results both in terms of the methods used and the scope of the research.

Table 1. Keyword clusters

Urban Heat Island	Urban Heat Island	Heat	Island	Surface Urban Heat Island	Urban Neighborhood Heat Island	Heat Island		
Green Infrastructure	Green Infrastructure	Infrastructure	Green Roofs	Urban Greening	Nature-Based Solutions	Urban Green Infrastructure	Cooling Effect	
Land and Vegetation	Vegetation	Cover	Vegetation Types	NDVI	Tree Planting	Soil Properties	Soil Nematodes	Ecological Bioindicators
Spatial and Climate Analysis	Simulation Models	Models	CFD Simulations	Regression Models	Meta-analysis	Systematic Review	Cooling Mechanism	
Satellite and Geospatial Data	Landsat	MODIS	Land Surface Temperature	Meteosat	Games-Howell Test			
Urban Planning	Urban	Microclimate	Local Climate Zones	Pocket Parks	Urban Neighborhood	3D Buildings	Spatial Composition	High-density Urban Areas

The Urban Heat Island cluster is directly related to studies focusing on the effects of UHI and SUHI. These studies investigate how urban heat islands are created and how they can be reduced. The UHI effect is caused by factors such as excessive urban development, non-reflective surfaces and lack of green space. Pioneering studies such as Oke (1982) and Stone (2012) have highlighted the impact of dense urbanisation on the UHI, focusing on urban cooling strategies. Bhargava et al. (2017) found that green infrastructure plays an important role in reducing the impacts of UHI. These findings are consistent with the extensive literature highlighting the need for green infrastructure solutions to mitigate the impacts of UHI.

The 'Green Infrastructure' cluster includes studies that highlight the role of green spaces in cities in mitigating the effects of UHI. These strategies include various measures such as green roofs, tree planting and nature-based solutions (NbS). Systematic reviews by Bowler et al. (2010) found that green spaces reduce air temperatures and increase thermal comfort in cities. At the same time, the study conducted in Asia by Ramakreshnan and Aghamohammadi (2024) highlighted that the potential of nature-based solutions to reduce UHI has not yet been sufficiently exploited and that more scientific studies should be conducted on this issue. The role of green infrastructure in sustainable urban development is also widely discussed in the literature (e.g. Lovett, 2023).

The 'Land and vegetation' cluster includes studies that investigate the effects of the density of green areas, vegetation cover and ecosystems on the UHI. In this context, the use of metrics such as NDVI (Normalised Difference Vegetation Index) plays an important role in understanding how the density of green areas and vegetation cover affect temperatures. Park and Jung (1999) showed that high NDVI values reduce surface temperatures and therefore strategic planning of green spaces is a key factor in reducing the UHI effect. The effectiveness of vegetation strategies in combating the UHI is widely recognised in the literature (e.g. Lin et al., 2017).

The Satellite and Geospatial Data cluster includes remote sensing data used to monitor and assess the impact of the UHI. Satellite data such as Landsat, MODIS and Meteosat are critical for analysing temperature changes in cities. The study by Zhang et al. (2024) highlights the importance of satellite data in understanding how green infrastructure can be used to mitigate the effects of the UHI. The use of satellite imagery and remote sensing data in UHI studies increases the precision and accuracy of such studies (e.g. Bowler et al., 2010).

The keywords in the Urban Planning cluster cover how cities are planned and the impact of this planning on the UHI. Urban design elements such as urban microclimate, high-density urban areas and pocket parks are important factors in managing the effects of UHI. Lin et al. (2017) showed how pocket parks mitigate the UHI in high-density areas. These findings suggest that strategic placement of green spaces in urban planning and design is an important step to improve thermal comfort in cities.

The clustering of keywords shows the need for a combination of different strategies to combat UHI and SUHI. Different approaches such as green infrastructure, satellite data, simulation models and microclimate analysis should be combined to mitigate the effects of UHI. As often discussed in the literature (Oke, 1982; Stone, 2012), this interdisciplinary approach is of great importance to make cities sustainable and liveable. In this context, more empirical research and large-scale studies in different climate zones are needed to fill the gaps in the literature. The largest and most frequently used terms in the word cloud clearly indicate the main strategies and topics that have been extensively studied in the literature on UHI mitigation (Fig. 1). Green infrastructure, planting strategies and analysis with satellite data are among the most prominent research topics in UHI mitigation. These findings highlight the strategic steps needed to make cities more sustainable and liveable.

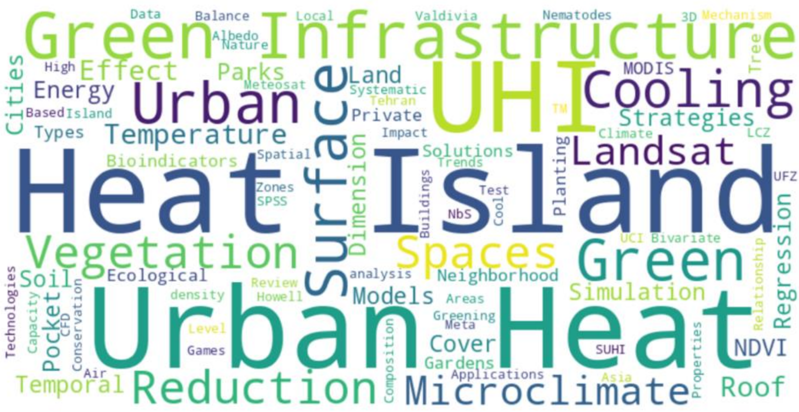

Figure 1. Word cloud of UHI and green infrastructure concepts

The fact that the terms that stand out in the word cloud are the most discussed concepts in UHI research shows the interdisciplinary approach of these studies and the key questions that will guide future studies. These studies use a variety of methods and data sources to investigate the UHI effect (Table 2). The diversity of methods reflects the complexity of the UHI effect and the need for different research approaches. The data used tend to focus on satellite imagery, local climate measurements and biological or environmental indicators. Evaluating studies in terms of methods and data sources is important to understand the scope of these studies and the strength of their findings.

Table 2. Methods and data sources used by UHI studies in the literature reviewed

Analysis Method	Data Used
Simulation Models	Urban surface areas, green infrastructure strategies
Thermodynamic Analysis	Surface energy balance components (radioactive/non-radioactive)
Bivariate Regression Analysis	Climate parameters (solar radiation, air temp, wind speed)
Landsat TM Data (Surface Temp & NDVI Extraction)	Landsat TM satellite data, MODIS, NDVI
Regression, Correlation, and Variance Analysis	Statistical data (SPSS analysis)
Comparative Analysis	Surface temperature data
Meta-Analysis	Existing literature data (observational research)
Computational Fluid Dynamics (CFD) Simulations	Fluid dynamic simulations (microclimatic data)
Clustering and Regression Analyses	Albedo, emission, elevation, NDVI, UTFVI
One-way and Two-way ANOVA, Tukey's HSD, Mauchly's Sphericity	Soil properties, nematode community structure
Forward Stepwise, Random Forest, Partial Least Squares Regression	Predictor variables (LST, SUHI impact)
Games-Howell Test and Welch-ANOVA	LST data, green infrastructure cooling capacities
Boosted Regression Trees (BRT)	Urban functional zones (UFZs), 3D building data
Visual Review & Systematic Literature Review	Systematic literature data
Spatial Neighborhood Analysis	Urban heat/cool island impacts and UFZ data

The analytical techniques employed in research studies encompass a diverse array of methodologies. A variety of analytical techniques have been employed to examine the impact of urban heat island (UHI) phenomena and to develop strategies for their mitigation. These include simulation models, regression analyses, meta-analyses and thermodynamic analyses. This suggests that the UHI impact has been addressed through a multidisciplinary approach, with each study addressing different aspects of UHI using different analytical techniques. To illustrate, simulation models and thermal imaging techniques are instrumental in evaluating present and future surface temperatures in urban areas. The utilisation of these methodologies permits not only the examination of the extant situation, but also the formulation of projections for future planning.

The data sets employed in research are predominantly derived from satellite imaging systems (such as Landsat TM), in situ climate measurements and systematic literature reviews. Satellite data, such as that provided by Landsat TM and NDVI, are of critical importance for the analysis of surface temperatures and vegetation density in urban areas. Moreover, surface temperature data is a fundamental element in the comprehension of the magnitude of the urban heat island and its fluctuations over time. This highlights the significance of remote sensing and geographic information systems (GIS) in the investigation of the impact of the urban heat island (UHI).

Furthermore, more localised data, including climatic parameters (e.g. air temperature, wind speed, humidity) and soil properties (e.g. nematode communities and soil moisture), were employed to conduct microclimatic analyses and evaluate the impact of direct environmental changes. These data are of particular significance for elucidating the response of local ecosystems to UHI and for evaluating the impacts of UHI on environmental health.

The data demonstrate that urban green infrastructure (UGI) is a crucial element in the mitigation of UHI impacts. A substantial body of research has examined the impact of nature-based solutions (NbS), including green roofs, afforestation strategies, and pocket parks. Regression and meta-analysis methods have been employed to evaluate the impact of such strategies, and the temperature-lowering effect of green infrastructure has been demonstrated in a systematic manner. The expansion of green spaces and the increase in vegetation cover represent an effective strategy for the reduction of temperature differences, particularly in large urban areas.

Nevertheless, the sophisticated analytical techniques employed in these studies, including Boosted Regression Trees (BRT) and Random Forest (RFR), facilitate the modelling of the impact of these strategies, thereby identifying the most efficacious factors in mitigating UHI. This enables the optimisation and integration of green infrastructure designs into urban planning processes.

From a methodological standpoint, the scientific rigour and diversity of methods employed in the studies provide a comprehensive approach to understanding the impact of UHI. However, there are gaps in some areas. In particular, systematic literature reviews highlight the necessity for the acquisition of further empirical data and the undertaking of additional field studies. Furthermore, it was observed that economic and social factors should be incorporated into the mitigation strategies for UHI. This emphasises the necessity for integrated urban planning strategies that consider not only environmental but also economic sustainability.

The aforementioned analytical techniques and data sets provide an efficacious framework for research on the urban heat island effect. The utilisation of disparate analytical techniques and data sources facilitates an appreciation of the multifaceted nature of the UHI phenomenon, thereby offering a robust foundation for future planning endeavours. Nevertheless, further empirical research is required in order to facilitate the implementation of nature-based solutions. This could facilitate the achievement of both environmental, social and economic sustainability goals.

The systematic literature review conducted by the researchers provides a comprehensive analysis of the role of green spaces in the impact of UHI and SUHI on spatial planning in a range of cities across the globe. The findings obtained in this context are presented in Table 1.**Table 1.** Summary of the literature on the role of green spaces in UHI impact on spatial planning

References	**Aims and Objectives**	**Methodology**	**Results**
Bhargava, A., Lakmini, S., & Bhargava, S. (2017). Urban heat island effect: It's relevance in urban planning. *J. Biodivers. Endanger.* Species, 5(187), 2020.	This study aims to analyze the impact of urbanization on UHI formation. The objectives of the study are (1) to suggest effective mitigation measures to address UHI impacts in spatial planning and (2) to develop improved planning strategies and green infrastructure to promote sustainable urban development.	Within the study's scope, simulation models were used to optimize urban surface areas and expansion strategies. Surface energy balance, including radioactive and non-radiative components, was assessed with thermodynamic analysis. Green infrastructure strategies such as green roofs and vegetation were developed to reduce UHI impacts.	When the findings of the study were examined, it was determined that there were significant temperature differences between urban and rural areas due to the UHI effect. This situation led to an increase in energy consumption and health risks. It was determined that the suggested mitigation strategies, such as increasing green spaces in cities and using reflective materials, can effectively reduce UHI effects. The need for integrated spatial planning that considers aerodynamic and environmental factors to combat UHI is emphasized.
Lin, P., Lau, S. S. Y., Qin, H., & Gou, Z. (2017). Effects of urban planning indicators on urban heat island: a case study of pocket parks in high-rise high-density environment. *Landscape and urban planning*, 168, 48-60.	The study has three objectives. First, to investigate the ability of pocket parks in high-rise, high-density built-up areas of Hong Kong to improve urban microclimate conditions and reduce UHI intensity. Second, to quantitatively examine the impact of spatial planning indicators such as	This study used HOBO weather stations for in situ climate measurements and field surveys to collect data on climate parameters (solar radiation, air temperature, wind speed and relative humidity). The measurements were carried out in five rounds between 13:00 and 21:00 each day at 195 carefully selected measurement points in pocket parks and surrounding streets. Bivariate regression	The study found that pocket parks offer lower temperatures than the surrounding streets, with UHI intensities of 0.1 °C during the day and 2.39 °C at early night. It was found that there is a positive relationship between parking area and daytime UHI and that buildings around parking lots have a shading effect. Trees

References	Aims and Objectives	Methodology	Results
	parking area, building density, tree cover ratio (TCR), floor area ratio (FAR), and shrub cover ratio (SCR) on the UHI and thermal performance of pocket parks. Third, to provide insights for urban planners and architects in the early stages of spatial planning.	analysis investigated the relationships between spatial planning indicators and climate parameters.	effectively reduce UHI intensity, and TCR should be above 42%. Floor area ratio (FAR) and building density are negatively related to daytime UHI. This is important for design strategies in high-density urban areas.
Park, K. H., & Jung, S. K. (1999). Analysis on urban heat island effects for the metropolitan green space planning. *Journal of the Korean Association of Geographic Information Studies*, *2*(3), 35-45.	This study aims to examine urban heat island effects and assess the potential of green spaces to mitigate these effects.	Within the study's scope, surface temperature and NDVI (Normalized Difference Vegetation Index) were extracted using Landsat TM image data. The land cover classification was performed with ISODATA and supervised classification methods. In addition, statistical techniques such as regression analysis, correlation analysis and analysis of variance were applied with SPSS 7.0 software.	The study's findings showed that the overall land cover classification was 91.2%. High NDVI values were associated with low surface temperatures, proving the potential of green spaces to reduce the heat island effect. The study emphasizes the importance of green spaces in spatial planning and provides a basis for future green space strategies.
Hurduc, A., Ermida, S. L., Trigo, I. F., & DaCamara, C. C. (2024). Importance of temporal dimension and rural land cover when computing surface urban Heat Island intensity. *Urban Climate*, *56*, 102013.	The study has three objectives. First, to understand the temporal dimension of the SUHI effect better across the year and days. Second, to investigate differences in SUHI calculations based on various types of rural land cover used as a reference. Third, to analyze the impact of these factors on urban thermal discomfort and potential mitigation strategies.	Within the study's scope, a comparative analysis was conducted, focusing on three cities (Paris, Milan, Madrid,) selected for their size and representativeness in the existing literature. Meteosat Second Generation (MSG) geostationary satellites providing high temporal coverage were used to obtain surface temperature data. SUHI intensity was defined and calculated as the land surface temperature (LST) difference between urban areas and various rural land cover types, including agricultural and forest references.	The study's findings revealed significant differences in SUHI intensity throughout the day and in different seasons, emphasizing the importance of considering the entire diurnal cycle. Differences in rural land cover types (agricultural and forest) resulted in SUHI differences of up to 5°C, especially in Madrid and Milan. It also highlights limitations related to static land cover assumptions, spatial resolution, and the impact of atmospheric conditions on thermal infrared data accuracy.

References	**Aims and Objectives**	**Methodology**	**Results**
Bowler, D. E., Buyung-Ali, L., Knight, T. M., & Pullin, A. S. (2010). Urban greening to cool towns and cities: A systematic review of the empirical evidence. *Landscape and urban planning*, *97*(3), 147-155.	The study aims to assess the effects of urban planting practices on air temperature. The objectives of this study are: (1) To examine how green spaces affect temperatures in urban areas and their contribution to human health, (2) To highlight the need for further empirical research to guide the design and planning of future urban planting programs.	Within the study's scope, the data in the existing literature were evaluated using the systematic review method. A meta-analysis examined the effects of planting practices on air temperature. The studies are based on observational research measuring air temperatures under parks and trees.	When the study's findings are analyzed, it is found that parks are, on average 0.94 °C cooler during the daytime. Larger parks and wooded areas tended to be more relaxed during the day. However, there is insufficient evidence on the overall cooling effect of green spaces on urban areas. Therefore, further research is needed.
Morales-González, J. I., Verichev, K., & Carpio, M. (2024). Efficiency assessment for the urban heat island mitigation measures in a city with an oceanic climate during the summer period: Case of Valdivia, Chile. *Urban Climate*, 55, 101897.	This study aims to analyze the Urban Heat Island effect in a city in southern Chile during summer using computational fluid dynamics simulations and to propose effective spatial planning strategies to mitigate this effect.	Computational Fluid Dynamics (CFD) software was used to model UHI in this study. Different UHI mitigation strategies were simulated and analyzed using the software. A neighborhood with specific characteristics represented the study area, and microclimatic conditions were simulated using ENVI- met software.	This study compared various UHI mitigation strategies in Valdivia, Chile, including reflective pavements, tree cover, water fountains, and mixed strategies combining them. The results show that mixed strategies effectively reduce UHI impacts, but implementation challenges vary. The study emphasizes the importance of considering economic factors and the local context when choosing mitigation strategies.
Rech, B., Moreira, R. N., Mello, T. A. G., Klouček, T., & Komárek, J. (2024). Assessment of daytime and nighttime surface urban heat islands across local climate zones-A case study in Florianópolis, Brazil. *Urban Climate*, 55, 101954.	The study aims to investigate SUHI differences between different Local Climate Zones (LCZ) using robust statistical methods. In this context, the research focuses on the following objectives: (1) to analyze SUHI variability among different LCZ classes and to study day-night SUHI variations, (2) to	A comprehensive database was used in the study. This database contains information on albedo, emission, elevation, NDVI, and UTFVI (Urban Thermal Field Variance Index). Pixels are treated as individual observations. In statistical analyses, nonparametric, parametric, robust, and data mining methods were used to investigate SUHI dynamics in different LCZs. Additional approaches, such as quantile	The study revealed significant differences in SUHI between various LCZs using robust statistical tests. It was found that daytime and nighttime SUHI variations are substantial, and vegetation cover is a critical factor affecting SUHI behaviour. The study emphasized the need to consider many variables, such as urban structure,

References	Aims and Objectives	Methodology	Results
	assess the influence of factors such as urban structure, vegetation cover, albedo, elevation and land surface emissivity on SUHI dynamics in the Florianópolis metropolitan region in Brazil.	regressions, were used to resolve inconsistencies in the results. Various statistical tests were also performed to compare daytime and nighttime data. The evaluation also combines daytime and nighttime imagery with various statistical tests to comprehensively analyze SUHI events.	albedo, height, and land surface emissivity in urban areas, to understand and mitigate SUHI effects
Hu, J., Chen, G., Wang, F., Hassan, W. M., Cai, M., Fan, W., & Yuan, X. (2024). Nematodes as biological indicators of urban heat island effects in the Chongqing area urban green spaces. *Ecological Indicators*, 158, 111439.	This study aims to investigate the impact of the Urban Heat Island Effect (UHIE) on the composition, ecological function, structure and individual morphology of soil nematode communities in urban green areas. The study also aims to explore the potential of soil nematodes as ecological bioindicators of UHIE and to understand the connection of soil nematodes with other organisms in the food web.	In this study, statistical analysis methods were used to analyze the effects of UHIE on soil properties and nematode community structure. The analyses used were one-way ANOVA, two-way ANOVA, Tukey's HSD test, and Mauchly's sphericity test. Soil samples were collected from urban green spaces (UGS) for the study. It was taken into consideration that these samples were taken from both rainy and dry seasons. Nematodes were extracted using the Baermann Wet Funnel method. The morphology and biomass of nematodes were evaluated. The physicochemical properties of the soil, such as soil temperature, moisture, organic carbon content, nitrogen content, phosphorus content, and potassium content were measured.	In the study, soil physicochemical properties varied significantly among UGS. It revealed that soil temperature varied during wet and dry seasons. The highest soil moisture, pH, nitrogen, organic carbon and potassium levels were observed in UGS, while the lowest levels were recorded in UHI. The UHI significantly affected the community structure and ecological function of soil nematodes. This led to changes in the biomass and morphology of nematodes. The study highlighted the potential of soil nematodes as ecological bioindicators of UHIE.
Zhang, H., Kang, M. Y.,Guan, Z. R., Zhou, R.,Zhao, A. L., Wu, W. J., & Yang, H. R. (2024). Assessing the role of urban green infrastructure in mitigating summertime urban heat island (UHI) effect in Metropolitan Shanghai, China.*Sustainable Cities and Society*, 105605.	This study aims to quantitatively assess the role of urban green infrastructure (UGI) in reducing the impact of summer SUHI in Greater Shanghai. It also aims to provide clarity and insights on reducing the UHI impact, enhancing urban	Within the study's scope, statistical analysis techniques such as normality tests, skewed data transformation, correlation analysis and regression modeling were used to evaluate the complex relationships between predictor variables and response variables.Descriptive statistical procedures were performed to analyze the	The findings of the study revealed that different regression models exhibited contrasting performances in quantitatively assessing the role of UGI in mitigating the SUHI effect. PLSR models showed the highest coefficient of determination (R^2) and offered the best

References	Aims and Objectives	Methodology	Results
	adaptation capacity, and achieving urban sustainability in climate change.	data, and three regression models, i.e., Forward Stepwise Regression [FSWR], Random Forest Regression [RFR], Partial Least Squares Regression [PLSR], were compared to quantify the relative importance of predictors in determining the impact of LSTs and SUHI. The study also used machine learning methods and multi-source satellite data to generate and validate thermally sharpened LST data for analysis.	performance in interpreting the results, while FSWR models are challenging to interpret despite having a high R^2 value. RFR models showed moderate performance in the interpretation of the results. Overall, the findings provided a methodology to assess the role of UGS in mitigating SUHI in complex urban environments.
Lu, L., Guo, H., Weng, Q., Bartesaghi-Koc, C., Osmond, P., & Li, Q. (2024). A transferable approach to assessing green infrastructure types (GITs) and their effects on surface urban heat islands with multi-source geospatial data. *Remote Sensing of Environment*, 306, 114119.	This study has three objectives. First, to develop a transferable method for mapping Green Infrastructure Types (GIT) using high-resolution spatial imagery and open-access GIS data; second, to test the applicability of this method in the large urban core area of Beijing, one of the largest metropolitan areas in the world; and third, to estimate the cooling impacts of Green Infrastructure Types to understand better the influence of morphological, functional, and spatial characteristics on the cooling capacity of these types.	Within the study's scope, GIT is classified by a modified GIT scheme, where ground surfaces, structures and vegetation layers, are logically divided. LST data was obtained using high-resolution Landsat and MODIS data. Cooling Effect Analysis: Mean differences between LST data were analyzed using statistical tests (Games-Howell test and Welch-ANOVA), and the cooling capacities of Green Infrastructure Types were assessed.	The study's findings show that 19 out of 22 GITS were successfully identified in the study area, and green and blue areas were detected with high accuracy using remote sensing. The overall accuracy was 84.7%, the kappa coefficient was 0.815, and the user accuracy ranged from 54.6% to 100%. Cooling Effect: Significant differences were observed between the average LST values of different GIT, and it was determined that GIT with a high proportion of water and trees provided the highest cooling effect. Statistically significant differences were found between the average surface temperatures of GIT, emphasizing the importance of Green Infrastructure in urban heat management.
Jahangir, M. H., Zarfeshani, A., & Arast, M. (2024). Investigation of green roofs effects on reducing of the urban heat islands formation (The case of a municipal district of	This study aims to evaluate the feasibility and effectiveness of green roofs to reduce UHI in Municipal District 6	This study used Landsat 8 satellite data to estimate the earth's surface temperatures in Municipality District 6 (MD-6) in Tehran. The vegetation area was	The study found that the addition of green roofs in Municipal District 6 (MD-6) in Tehran resulted in a significant reduction in UHI area and

References	Aims and Objectives	Methodology	Results
Tehran City, Iran). Nature-Based Solutions, 5, 100100.	(MD-6) in Tehran. Furthermore, the study examines how incorporating vegetation into roof systems reduces the UHI in the region. It also aims to provide insights into how nature-based solutions such as green roofs can reduce the negative impact of urban heat islands on ambient temperatures and environmental quality.	calculated using NDVI, and a relationship was established between the data to determine the reduction rate of urban heat islands by adding vegetation. The study also included mapping the impact of buildings on UHI to measure the area of roofs suitable for green roof development and modeling based on this information to evaluate the effects of green roofs on reducing UHI intensity.	intensity. It was observed that adding vegetation on the roofs of buildings resulted in an average reduction of 38.58% in UHI area and a decrease of 0.68 °C in the UHI intensity in this area. However, the effectiveness of the modeling varied among different regions depending on the existing vegetation and the building areas within the heat islands. Overall, the results showed that green roofs can effectively reduce UHI intensity and contribute to creating more sustainable urban environments.
Na, N., Lou, D., Xu, D., Ni, X., Liu, Y., & Wang, H. (2024). Measuring the cooling effects of green cover on urban heat island effects using Landsat satellite imagery. International Journal of Digital Earth, 17(1), 2358867.	This study aims to analyze the cooling mechanism of UGS on the UHI in Nanjing, China, focusing on vegetation types, cooling intervals, and spatial distribution of UGS.	This study used Landsat images from 2010 to 2021 to analyze the cooling effect of UGS on UHI in Nanjing, China. Methodologically, the study includes analyzing the cooling effect of UHIs with different vegetation types, determining the cooling radiation range of UHIs, and evaluating the spatial distribution pattern of green spaces using NDVI values.	The study found that the cooling effect of UGS on UHI was most evident in summer. It was also observed that different vegetation types exhibited different cooling capacities. The study highlighted the importance of spatial distribution and degree of distribution of UGS in reducing the UHI effect, providing valuable information for spatial planning to improve living comfort and urban thermal environments.
Raj, S., & Yun, G. Y. (2024). Exploring the role of strategic urban planning and greening in decreasing surface urban heat island intensity. Journal of Asian Architecture and Building Engineering, 1-14.	The study aims to examine the monthly patterns and long-term trends of daytime and nighttime SUHII in Seoul and Ulsan, the correlation between vegetation trends and changes in SUHII, and the effectiveness of	The study used MODIS sensors on Terra and Aqua satellites to obtain LST data for Seoul and Ulsan cities. SUHII was calculated by comparing the average LST between urban and rural areas surrounding the cities. The study used vegetation data obtained from MODIS vegetation indices and analyzed the effect of UGS on SUHII.	When the findings of the study were examined, a decrease in daytime SUHII was detected in Seoul during summer days, while an increase was observed in Ulsan. The expansion of green spaces in Seoul contributed to the decrease in daytime SUHII. It was

References	Aims and Objectives	Methodology	Results
	expanding green spaces in cities to mitigate the UHI impact.		revealed that nighttime SUHII in Seoul was higher than in Ulsan due to Seoul's larger and denser urban environment.
Lovett, R. A. (2023). Voting Cities Off the Urban Heat Island How Trees, Paint, and Energy Conservation Can Fight Back Against Urban Heatwaves. Weatherwise, 76(6), 16-23.	This study aims to investigate the UHI and its effects in urban environments. The study's objectives are: (1) to understand the effectiveness of various mitigation strategies such as tree planting, remarkable roof technologies, and energy- saving methods in reducing urban heat, and (2) to also address social and environmental inequalities related to heat exposure in different neighborhoods of cities	The study used methods such as equipping vehicles with inexpensive temperature sensors, using volunteers to collect temperature data across the city, and locating locations via GPS. Temperature measurements were mapped to determine changes in the UHI effect at a fine scale. The study also compared different approaches, such as satellite imagery and mesoscale weather models, to assess urban heat and the impact of mitigation efforts.	The study's findings revealed that tree planting and urban vegetation initiatives significantly reduce the UHI in cities. The study highlighted the importance of trees in providing shade, reflecting sunlight, and cooling the air through transpiration to combat rising temperatures in urban areas.
Qi, L., Hu, Y., Bu, R., Li, B., Gao, Y., & Li, C.(2024). Evaluation of the Thermal Environment Based on the Urban Neighborhood Heat/Cool Island Effect. Land, 13(7), 933.	The aim of this study has three objectives. First, to analyze the distribution of UHI and Urban Cool Island (UCI) impacts in the fourth ring area of Shenyang City; Second, to investigate the relationship between these impacts and 3D buildings and Urban Functional Zones (UFZs); third, to assess the relative importance of UFZs in the UHI/UCI impact.	In the scope of the study, spatial neighborhood analysis was used to examine the distribution of UHI and UCI impacts. 3D building data were combined with UFZs to explore the relationships between these impacts. Boosted Regression Trees (BRT) were used to analyze the relative importance of the factors affecting UHI and UCI impacts.	The study found that the distribution of UHI and UCI impacts in Shenyang City was affected by factors such as building morphology, green space distribution, and UFZs. The research highlighted the importance of these factors in moderating summer thermal conditions and provided valuable information for spatial planning and management to reduce the UHI impact.
Ramakreshnan, L., & Aghamohammadi, N. (2024). The Application of Nature-Based Solutions for Urban Heat Island	This study aims to investigate the effectiveness of Nature-Based Solutions (NbS) in	In this study, a non-systematic literature review was conducted. In this context, a search was conducted using the Web of	The study's findings revealed that the application of NbS for UHI mitigation in Asia is still needs to

References	Aims and Objectives	Methodology	Results
Mitigation in Asia: Progress, Challenges, and Recommendations. *Current environmental health reports*, 11(1), 4-17.	mitigating UHI impacts in the rapidly growing Asian region. A non-systematic literature review aims to explore the challenges, progress, and prospects of implementing urban green and blue infrastructures for UHI mitigation in Asia.	Science database based on peer-reviewed articles published in the Asian region from 2003 to 2023. The literature review focussed on studies that provide quantitative estimates of NbS application for UHI mitigation through urban green and blue infrastructures. To identify relevant studies, a Boolean search strategy was applied using keywords related to UHI , NbS and UGI.	be improved and challenges such as environmental pollution, lack of awareness, and limited scientific studies are hindering its implementation. The study suggests combining urban green and blue infrastructures can provide both a synergistic cooling effect and other ecosystem services to urban areas. The study also recommends more in-depth experimental studies and multidisciplinary research collaborations to explore the application of NbS in Asia.
Silveira, C., Dias, A. T. C., Amaral, F. G., de Gois, G., & Pistón, N. (2024). The importance of private gardens and their spatial composition and configuration to urban heat island mitigation. Sustainable Cities and Society, 105589.	This study aims to assess the importance of UGS in private and public spaces in the suburbs of Rio de Janeiro and the contribution of the composition and configuration of UGS to microclimate regulation.	Within the scope of the study, landscape metrics were used to assess the impact of the spatial distribution of UGS on cooling capacity. Statistical analyses included correlation and Boosted Regression Trees (BRT) methods to determine the relationship between landscape metrics and neighborhood Cooling Capacity (CC). BRT models were built using CC as the response variable and private and public UGI composition and configuration metrics as explanatory variables.	The study's findings show that private UGS have a greater impact on microclimate regulation than public green spaces. Edge density and tree cover were found to be the most critical factors for microclimate regulation in suburban areas. The interaction between spatial configuration and composition was shown to play a synergistic role in microclimate regulation.

A cross-evaluation and interpretation of the studies in question reveals that each of those examining the impact of UHI (Urban Heat Island) focuses on the same theme from different perspectives. The majority of studies have concentrated on the causes, impacts and mitigation strategies of UHI. However, there is considerable variation in the regions, methodologies and strategic perspectives employed in each study.

The majority of studies emphasise the crucial role of green infrastructure and green spaces in mitigating the impact of UHI. For example, Bhargava et al. (2017) and Zhang et al. (2024) demonstrate that green infrastructure practices, such as green roofs and vegetation, can mitigate the impact of UHI. Similarly, Park and Jung (1999) demonstrate that elevated NDVI values are associated with reduced surface temperatures, indicating that green areas can serve as effective mitigators of UHI impacts. Additionally, Hu et al. (2024) proposed the utilisation of green areas as biological indicators through the examination of soil nematodes.

The systematic review conducted by Bowler et al. (2010) revealed that the presence of parks and extensive wooded areas in urban environments can contribute to a reduction in air temperature. However, the study concluded that the overall cooling impact is constrained. This finding is consistent with the conclusions of Na et al. (2024) regarding the potential of UGS (Urban Green Spaces) to mitigate UHI impacts during the summer months. The findings of both studies indicate that the cooling capacity of green spaces should be given due consideration.

Lin et al. (2017) discovered that pocket parks situated in densely populated, high-rise urban areas enhance microclimate conditions and mitigate the intensity of the urban heat island effect. Based on these findings, the authors recommended that green spaces be given greater consideration in urban planning. Morales-Gonzalez et al. (2024) conducted a comparative analysis of various UHI mitigation strategies and concluded that mixed strategies, comprising elements such as tree cover and water fountains, demonstrated the greatest efficacy. This highlights the necessity of selecting strategies that are appropriate to the specific context of each city and climate.

In a related study, Rech et al. (2024) investigated changes in UHI intensity between different LCZs (Local Climate Zones) and found significant differences between LCZs and SUHI (Surface Urban Heat Island). In particular, significant differences were identified between daytime and night-time UHI, with green cover identified as a critical factor influencing UHI behaviour. This is consistent with the findings of Qi et al. (2024) regarding the significance of Urban Functional Zones (UFZs) in influencing UHI/UCI effects.

The studies in question tend to emphasise the necessity for greater consideration of green infrastructures and UGS in urban planning processes. Bhargava et al. (2017) and Lin et al. (2017) propose the formulation of more efficacious planning strategies in this regard. In particular, it is asserted that the proper planning of green spaces in densely built-up areas is of significant importance in the reduction of the UHI impact. These findings are consistent with the results of Zhang et al. (2024), who evaluated the capacity of green infrastructure to mitigate the urban heat island (UHI) effect in urban areas.

The studies conducted by Lin et al. (2017) and Rech et al. (2024) provide clear evidence of the influence of urban structure and green space distribution on microclimate conditions. The cooling effect of green spaces in densely built-up areas is influenced by a number of factors, including building density and the shape of buildings. Furthermore, Hurduc et al. (2024) highlight the necessity of incorporating temporal considerations into such analyses, demonstrating that distinct rural land cover types yield considerable discrepancies in SUHI calculations.

Hu et al. (2024) propose the use of soil nematodes as biological indicators to elucidate the impact of UHI, while underscoring the ramifications of environmental alterations on biodiversity and ecosystem integrity. This is a significant finding that highlights the importance of green spaces in regulating the microclimate and maintaining ecological functions.

A number of studies conducted in diverse geographical locations, including Paris (Hurduc et al., 2024), Milan and Madrid (Morales-Gonzalez et al., 2024), and Chile (Morales-Gonzalez et al., 2024) as well as South Korea (Raj and Yun, 2024), have demonstrated the influence of the urban heat island (UHI) effect in varying climates and urban structures. In particular, Ramakreshnan and Aghamohammadi (2024) highlight that the deployment of NbS (Nature-Based Solutions) in rapidly expanding urban centres in Asia, despite its inherent challenges, offers considerable potential in mitigating the UHI impact.

The principal conclusion to be drawn from these studies is that the UHI impact varies considerably between different urban areas and climatic conditions. However, it can be significantly reduced by appropriate planning and the utilisation of green spaces. It is recommended that green infrastructure be given particular consideration in the urban planning process, with due attention paid to microclimate conditions. Moreover, the use of biological indicators and strategies tailored to the specific context will be instrumental in the long-term management of the UHI impact.

Upon evaluation of the data and methods employed in these studies, it becomes evident that several investigations, including those conducted by Park and Jung (1999), Jahangir et al. (2024), and Na et al. (2024), have delved into the impact of surface temperatures and green areas, utilising satellite imagery and remote sensing techniques. High-resolution satellite data, such as that provided by Landsat TM and MODIS, have been widely employed for the mapping of surface temperatures. These methods are well-suited to the study of the impact of UHI over extensive areas, and are particularly advantageous for comparisons over different time periods.

In their respective studies, Na et al. (2024) and Jahangir et al. (2024) assessed the cooling impact of green spaces through the utilisation of vegetation indices, namely the Normalised Difference Vegetation Index (NDVI). Such analyses are invaluable for elucidating the impact of green infrastructure in mitigating the urban heat island effect. It is important to note that the accuracy of the data in such studies may be affected by the resolution of satellite images and atmospheric conditions.

Bhargava et al. (2017) and Morales-Gonzalez et al. (2024) employed simulation models to analyse the impact of the urban heat island (UHI) phenomenon. Computational Fluid Dynamics (CFD) software and microclimatic modelling software, such as ENVI-met, are employed to elucidate the dynamics of UHI in urban areas. Such methods offer a significant advantage in terms of facilitating comparison between different UHI mitigation strategies.

In their study, Morales-Gonzalez et al. (2024) employed simulation models to analyse and compare various UHI mitigation strategies, including reflective pavements, tree cover, and water features. This approach is beneficial for examining UHI mitigation strategies in the context of a specific city or region.

In their studies, Lin et al. (2017) and Lovett (2023) employed data collection methods that included local climate measurements and field studies. In situ measurements have been conducted using devices such as HOBO weather stations to ascertain parameters including air temperature, solar radiation, wind speed and humidity. Such methods are appropriate for the analysis of microclimate conditions and the evaluation of the impact of small-scale green spaces (such as pocket parks) on UHI.

In a study conducted by Lin et al. (2017), the impact of pocket parks on the surrounding microclimate was investigated through the measurement of temperature differences between these green spaces and the adjacent streets. This approach facilitates a more nuanced understanding of the ways in which green spaces can be utilized more effectively in urban planning.

In a further study, Hu et al. (2024) employed soil nematodes as biological indicators to gain insight into the UHI impact. In this study, the biomass and morphology of nematodes were evaluated through laboratory analyses of soil samples. The extraction of nematodes was conducted using the Baermann wet funnel method. Such biological indicators are useful for understanding the effects of UHI not only on temperature but also on the ecological balance of the urban environment.

In the study conducted by Hu et al. (2024), chemical properties, including soil moisture, organic carbon, and nitrogen, were also assessed, and the impact of UHI on nematode communities was analysed. The aforementioned ecological analyses facilitate a more comprehensive comprehension of the environmental consequences of UHI.

The statistical methods employed in the studies are also highly diverse. In their studies, Zhang et al. (2024), Lu et al. (2024) and Rech et al. (2024) employed regression models and nonparametric tests to analyse UHI-related data. A variety of regression models were employed, including Forward Stepwise Regression (FSWR), Random Forest Regression (RFR) and Partial Least Squares Regression (PLSR), with the objective of quantifying the impact of variables and identifying the most effective strategies for mitigating UHI.

Rech et al. (2024) and Qi et al. (2024) employed boosted regression trees (BRT) and other sophisticated statistical techniques to assess the cooling capabilities of 3D building data and urban ground surfaces (UGS) in urban settings. The utilisation of advanced statistical analyses is crucial for the examination of intricate data sets and the elucidation of the distinctive characteristics of UHI in diverse urban contexts.

As can be discerned from the foregoing, the studies in question exhibit a considerable degree of diversity in terms of the methods and data employed. The utilisation of satellite imagery and remote sensing techniques is a prevalent methodology employed for the examination of UHI at a macro scale. Conversely, local climate measurements and biological indicators assume a pivotal role in micro-scale investigations. Moreover, the utilisation of simulation models and advanced statistical analyses is of paramount importance for a more comprehensive understanding of the intricate nature of the UHI impact and the formulation of efficacious mitigation strategies.

In general, although each method and data source is appropriate for examining different facets of the UHI phenomenon, a common conclusion from these studies is the value of integrating interdisciplinary approaches and both macro- and micro-scale analyses for the effective mitigation of UHI.

3. RESULT

This study provides a comprehensive examination of the role of green spaces in mitigating the effects of the urban heat island (UHI) and surface urban heat island (SUHI) phenomena. The analysis of research conducted in different cities reveals the positive effects of green spaces on urban microclimate and the potential of their strategic planning in reducing urban temperatures. These findings underscore the necessity of incorporating green spaces, vegetation, and other natural solutions into urban planning processes to effectively mitigate the impact of the urban heat island (UHI) effect.

In their 2017 study, Bhargava, Lakmini, and Bhargava investigated the potential of green infrastructure strategies to mitigate UHI impacts in urban areas through the use of simulation models. The findings of the study demonstrate that strategies such as green roofs and planting are effective in reducing urban heat accumulation and reducing energy consumption. It is recommended that, in order to effectively manage the UHI impact, there should be a greater emphasis on integrated spatial planning, and that vegetation strategies should be employed more widely in urban areas.

In 2017, the research team investigated the role of pocket parks in Hong Kong in mitigating the urban heat island (UHI) impact in dense, high-rise urban areas. The results of the bivariate regression analyses indicated that tree cover and pocket parks were effective in mitigating the UHI effect, with daytime temperatures observed to be lower in pocket parks than in the surrounding streets. These findings highlight the significance of strategic placement of green spaces within urban design and planning.

Park and Jung (1999) conducted an investigation into the potential of green areas to mitigate the urban heat island (UHI) effect utilising satellite data from the Landsat TM. The study demonstrated that high vegetation density (NDVI) is associated with low surface temperatures, thereby indicating that green spaces are instrumental in mitigating the UHI effect. It was highlighted that green spaces should be regarded as a fundamental component of urban planning.

Hurduc et al. (2024) investigated the temporal dimension of the SUHI effect and the effect of rural land cover on these calculations. This study demonstrates the extent to which rural areas can influence the intensity of the UHI effect, and reveals that the impact of agricultural and forested areas on UHI varies between cities. These findings underscore the necessity of considering rural and urban land cover in the mitigation of the UHI impact.

Bowler et al. (2010) conducted a comprehensive meta-analysis to investigate the impact of green spaces on air temperature. Their findings indicate that green spaces can effectively reduce daytime temperatures in urban areas. The study demonstrated that parks exhibited an average temperature reduction of 0.94 °C. However, it was emphasised that further research is required to gain a more comprehensive understanding of the cooling effect of green spaces in general.

In a study published in 2024, Morales-González and colleagues examined a range of UHI mitigation strategies in Valdivia, Chile. They compared the effects of different green infrastructure practices on UHI. The study employed computational fluid dynamics (CFD) models to assess the efficacy of reflective pavements, tree cover, and water features, and recommended that strategies be selected based on the specific local context. These findings highlight the necessity of considering economic and geographical conditions when developing UHI impact mitigation strategies for urban areas.

Rech et al. (2024) conducted an investigation into the differences between daytime and night-time SUHI in various local climate zones (LCZ). The study demonstrated that vegetation cover and albedo characteristics are significant factors influencing SUHI dynamics. Moreover, it was emphasised that a range of factors, including urban structures, height and the reflective properties of surfaces, shape the UHI effect. These findings indicate that such factors should be taken into account in the planning of green spaces.

In a further study, Hu et al. (2024) employed soil nematodes as biological indicators to investigate the impact of UHI on the ecosystem. The study demonstrated that UHI had a notable impact on soil properties and the structure of the nematode community. These findings underscore the necessity of studying the impact of the UHI not only in climatic terms but also in biological and ecosystem dimensions.

The study by Zhang et al. (2024) employed a quantitative approach to analyse the role of green infrastructure in mitigating the UHI impact. The findings indicated that strategic placement of green spaces can effectively mitigate UHI, with different regression models demonstrating this. This study serves to reinforce the significance of green infrastructure and planting strategies in bolstering the climatic resilience of urban areas.

In a recent study, Ramakreshnan and Aghamohammadi (2024) explored the potential of nature-based solutions (NbS) and green-blue infrastructures to mitigate the UHI impact in Asia. A review of the literature revealed that NbS solutions remain under-implemented in Asia. The adoption of these solutions is hindered by a number of barriers, including environmental pollution, a lack of awareness, and limited scientific research. These findings underscore the necessity for further research and the implementation of NbS solutions to combat UHI in rapidly developing regions such as Asia.

The aforementioned reviews demonstrate that urban green spaces are instrumental in mitigating the impacts of UHI and SUHI. The strategic planning of green infrastructure can contribute to lowering temperatures, reducing energy consumption and improving the overall quality of life in cities. However, in order to achieve successful results in combating UHI, green spaces must be planned taking into account local climatic conditions, land cover and socio-economic factors. It is therefore of great importance that future research and policy recommendations focus on these factors and develop nature-based solutions.

4. DISCUSSION AND SUGGESTIONS

This study presents a comprehensive analysis of the impact of urban green spaces on phenomena such as UHI and SUHI. It demonstrates the crucial importance of their integration into spatial planning processes. The findings underscore the pivotal role of green spaces in enhancing urban microclimate, augmenting thermal comfort, and curbing urban heating. Nevertheless, adopting a strategic approach to spatial planning and design processes is essential to fully actualizing this potential.

The study's findings confirm the ability of green spaces to reduce surface temperatures in cities. However, they also reveal that the magnitude and extent of this effect depend on several factors, including the size, distribution, plant diversity, and interactions with the overall urban structure of the green spaces in question. The research conducted by Park and Jung (1999) evaluated the potential of green spaces to mitigate the UHI effect. Hurduc et al. (2024) addressed the differences in their study's UHI calculations of various rural land covers. The findings of these two studies demonstrate that green spaces not only serve to mitigate the effects of the UHI phenomenon but also influence the surface temperature differential between rural and urban regions. In this context, the strategic distribution of green spaces can enhance the capacity to mitigate the UHI impact by distributing the environmental impacts of green spaces, which are currently concentrated in specific areas, across a wider geographical area. In particular, utilizing local plant species and encouraging biodiversity will reinforce these areas' positive effects on the urban microclimate, thereby strengthening the ecosystem services provided.

However, the impact of the UHI phenomenon is also influenced by the density of urban construction and the reflectivity of the materials used in such construction. Bhargava et al. (2017) investigated how the UHI impact should be addressed in the context of spatial planning. Lin et al. (2017) examined the impacts of parks on the UHI phenomenon in high-density urban environments, with a particular focus on Hong Kong. The studies mentioned above demonstrate that green infrastructure and urban planning strategies are paramount in mitigating the impact of UHI. The prevalence of surfaces that absorb solar radiation in densely urbanized areas results in an elevation of urban temperatures. Thus, encouraging the use of reflective surface materials in urban design, making structural arrangements to increase airflow, and integrating green spaces with such structural arrangements represent an effective strategy to mitigate the UHI effect.

Climate change projections must be taken into account in the context of spatial planning processes. Given that climate change will intensify the urban heat island effect, it is essential to integrate the potential of green spaces in mitigating these effects into long-term planning strategies. Bowler et al. (2010) conducted a comprehensive analysis of the impact of urban greening initiatives on air temperature. Their findings indicate that green spaces play a significant role in mitigating the UHI. These findings are corroborated by the study conducted by Morales-González et al. (2024) in Chile, which evaluated the efficacy of diverse green infrastructure strategies in mitigating UHI impacts. In this context, it is essential to harmonize green spaces with future climate conditions based on local climate data and projections. It is incumbent upon urban administrations to prioritize the protection of existing green spaces and the creation of new green spaces. It is recommended that local authorities, in collaboration with communities, formulate policies for the sustainable management of green spaces. The safeguarding of existing green spaces is of significant importance, not only in the context of new developments but also in the enhancement of existing urban environments.

It is of the utmost importance to raise public awareness of the advantages urban green spaces offer if these spaces are to be safeguarded and enhanced (Liang et al., 2021). It is recommended that awareness-raising campaigns be organized to disseminate information on the psychological, social, and environmental benefits of green spaces (Pritipadmaja et al., 2023). In addition, social support for the protection of these spaces should be strengthened through the implementation of educational programs (Hayes et al., 2022). Further research is required to gain a more detailed understanding of the impact of green spaces on UHI in a range of climate zones and urban contexts (Teo et al., 2022). Empirical data must be gathered to identify the most effective utilization strategies for these areas and to implement said strategy on a global scale (Peng et al., 2020). In particular, long-term studies examining the effects of green spaces in different urban typologies will contribute to developing spatial planning policies (Turhan et al., 2023).

In the context of spatial planning processes, integrating green infrastructure with other forms of urban infrastructure is of significant importance (Borna et al., 2023). Such integration necessitates the planning of green spaces in a manner that supports environmental sustainability and facilitates economic development and social equity (Xiong et al., 2023). The research conducted by Zhang et al. (2024) investigated the potential of green infrastructure to mitigate the UHI effect in Shanghai. The study demonstrated the capacity of such infrastructure to advance urban sustainability. These findings are consistent with the conclusions of Ramakreshnan and Aghamohammadi (2024), who emphasize the importance of green infrastructure strategies and NbS in reducing the UHI impact. Integrating green infrastructure with transport, water management, and energy systems will enhance the overall sustainability of urban areas.

The study's findings demonstrate that urban green spaces are instrumental in mitigating the impact of UHI (Johnson et al., 2021), thereby underscoring the necessity of integrating these areas into spatial planning processes. The benefits of green spaces for the environment, society, and the economy should be acknowledged as fundamental components for the sustainable development of urban areas (Liu et al., 2023). Accordingly, green spaces must be protected, expanded, and deployed strategically in future urban planning and development initiatives (Techer et al., 2023), as they are indispensable to constructing healthier, liveable, and resilient cities. Furthermore, this study identifies deficiencies in the extant literature and underscores the necessity for additional research in this domain. The planning and management of urban green spaces should be adopted to enhance not only the environmental sustainability of cities but also the overall well-being of society.

Although this study has yielded significant insights into the role of green spaces in mitigating the UHI impact, several research gaps have been identified that necessitate further investigation. It is of the utmost importance to address these gaps to advance the current understanding of how urban planning strategies can effectively incorporate green spaces to enhance urban resilience and sustainability. To address the research gaps identified in this paper and outline strategies for future studies that will build on the current findings and close these gaps, future research should focus on expanding UHI mitigation efforts by creating green spaces in different climate zones and socio-economic conditions. The cooling effects of green spaces exhibit considerable variation between tropical and temperate climates. This variability necessitates a systematic investigation of the underlying factors. Moreover, it is essential to examine the influence of socio-economic factors, including income levels, land use practices, and urban density, on the accessibility and efficacy of green spaces in diverse geographical regions (Kotharkar et al., 2020).

Furthermore, future studies should incorporate longitudinal investigations into the influence of green spaces on UHI effects over extended periods (Mueller et al., 2019). Such studies will facilitate understanding the long-term benefits and potential limitations of green infrastructure, particularly in the context of climate change projections. Understanding the processes by which green spaces develop and their sustainable impact on urban heat over time can inform more effective urban planning and policy-making. It would be beneficial for future research to investigate integrating green spaces with other forms of urban infrastructure, including transport networks, water management systems, and energy-efficient building designs. The combination of green infrastructure and these systems has the potential to enhance the efficacy of UHI mitigation, thereby facilitating the development of more comprehensive urban sustainability strategies. Although green spaces' environmental and social advantages are widely acknowledged, more empirical studies to quantify the precise ecosystem services delivered by these areas need to be conducted. Future research should concentrate on developing methodologies for quantifying services such as carbon sequestration, air purification, and biodiversity conservation, which are directly linked to UHI mitigation.

It is also imperative that future research addresses the role of community participation in the design, implementation, and maintenance of green spaces. It would be beneficial for future studies to examine how participatory approaches can enhance the efficacy of green spaces in mitigating the UHI effect, particularly in marginalized communities.

Declarations

This article has not been submitted for publication to any other journal.

The article is not sponsored or endorsed by any commercial entity.

The authors have familiarised themselves with the journal's policies, as set out in the information provided.

The translations of the article have been verified through the utilisation of artificial intelligence-assisted software.

The references are cited in accordance with the APA 6 style.

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CHAPTER 2

Comparison of Machine Learning-Based and Spectral Index-Supported Image Classification Algorithms Using The Google Earth Engine (GEE) Platform

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1. Introduction

Advancements in remote sensing and satellite imagery have made land use and land cover (LULC) mapping via automated image classification a critical research topic (Balha et al., 2021; Selim et al., 2023). This is because LULC changes are phenomena that impact ecological, economic, social, and cultural parameters, influencing societal well-being, development, the sustainability of global resources, and climate variability (Wang et al., 2022; Cinar et al., 2023; Karakuş et al., 2024). Automated image classification is among the most convenient and widely preferred techniques for generating LULC maps of a given area (Talukdar et al., 2020).

LULC classes are generated by classifying pixels with similar values across multiple image bands through digital image classification techniques. Common approaches include object-based, supervised, and unsupervised methods. Object-based classification primarily uses image segmentation algorithms to group spectrally homogeneous pixels into image objects, which are then classified individually (Liu and Xia, 2010). Supervised classification relies on the concept of a user selecting sample pixels that represent specific classes in an image, allowing image processing software to use these training sites as references to classify all other pixels in the image (Carrizosa and Morales, 2013). Unsupervised classification techniques, which lack a training phase, are generally more efficient and faster to implement. Conventional unsupervised classification methods use user-defined parameters, such as the number of classes, stopping criteria, or algorithm iterations. A primary challenge is determining optimal values for these parameters to achieve satisfactory classification results (Matci and Avdan, 2020). Numerous scientific studies in the literature have aimed to identify the best-performing classification algorithm by comparing different methods (Balha et al., 2021; Chughtai et al., 2021; Naushad et al., 2021; Basheer et al., 2022; Krivoguz et al., 2023). Some of these classification algorithms include Minimum Distance (MD), Maximum Likelihood (ML), Fuzzy Classification (FC), Artificial Neural Network (ANN), Support Vector Machine (SVM), Random Forest (RF), Deep Learning (DL), Deep Transfer Learning (DTL), and Light Gradient Boosting Machine (LightGBM). These studies have utilized various Geographic Information System (GIS)-based software, both proprietary (e.g., ENVI, ERDAS Imagine, and ArcGIS) and open-source (e.g., QGIS, GEE). One such platform, Google Earth Engine (GEE), is a web-based platform that enables access to a vast repository of satellite images, facilitating global analysis and visualization. GEE offers open access to extensive datasets, including satellite image archives, making it a valuable resource for scientists and researchers conducting geospatial and remote sensing analyses (Avcı et al., 2023).

The innovation of this study lies in testing the SVM, RF, and LightGBM algorithms to produce an LULC map of a region using entirely open-source, freely accessible software and data, and comparing the results with the latest Esri LULC map. To improve classification outcomes, the study incorporates the Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and Normalized Difference Built-up Index (NDBI) into the classification process. Additionally, the study area is subject to rapid LULC change due to tourism pressure, rapid urbanization, and frequent wildfire events. Therefore, generating a high-accuracy, practical LULC map for this region holds particular importance.

2. Study area

Located within the borders of the Mediterranean Region in southern Turkey, Antalya is a significant hub for both tourism and agriculture (Olgun et al., 2024). The district of Kemer in Antalya, one of Turkey's most significant tourism destinations, was selected as the study area. Located on a 46 km coastal strip at the foothills of the Western Taurus Mountains, Kemer is positioned at coordinates 36°36'7.23"N and 30°33'28.47"E (Figure 1). The district, bordered by the Mediterranean Sea to the east and forests and mountains to the west, covers an area of 53.483 km², with 45,000 hectares of forest land. The climate is hot and dry in summer, mild and rainy in winter, and the highest elevation in the district center is 15 meters. On average, Kemer enjoys 300 sunny days per year. The district's population was 46,143 in 2019 (Kemer Municipality, 2024), and as of 2024, this figure is approximately 50,000.

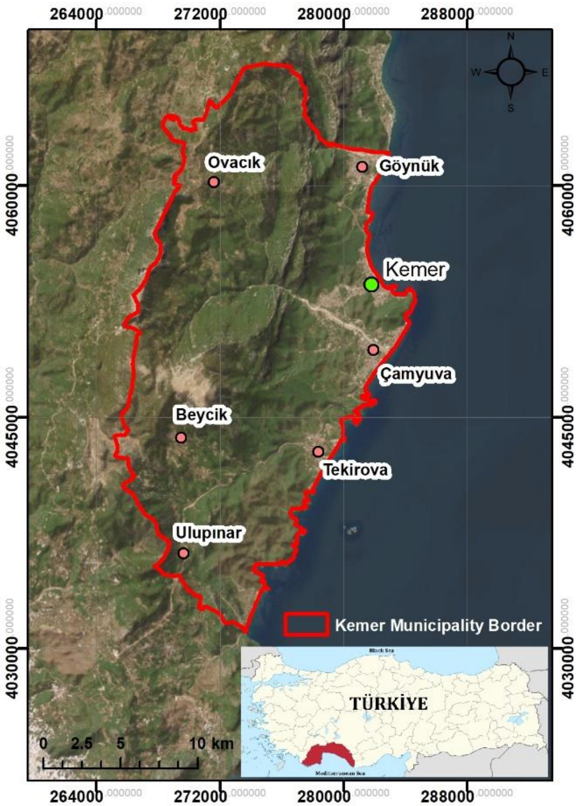

Figure 1. Location of the study area

The district's vegetation consists primarily of maquis formations, typical of the Mediterranean region, along with a belt of Red Pine (*Pinus brutia*) forests. Coastal settlements, such as Göynük, Çamyuva, and Tekirova, host a significant portion of the population, while the interior areas feature village settlements.

3. Data sets

The primary dataset for this study comprises a Sentinel-2 satellite image of the region from June 19, 2024, with a 10-meter spatial resolution and open access, along with a 10-meter annual map of Earth's land surface from 2023 obtained from ArcGIS Living Atlas of the World. The approximate one-year gap between the two images was disregarded. The up-to-date Sentinel-2 satellite image was sourced from https://browser.dataspace.copernicus.eu/, and the Esri LULC map was obtained from https://livingatlas.arcgis.com/landcoverexplorer. This LULC map is reported to be developed with Artificial Intelligence (AI) support using a training dataset of billions of human-labeled image pixels (ESRI, 2024a). The resulting nine-class surface map includes categories such as crops, water, bare surface, vegetation types, and built areas. For the specific study area, five distinct land classes (range land, built area, crops, trees, and water) were defined for both maps.

4. Methods

The study methodology consists of four steps after data preprocessing (including radiometric correction and projection definition): application of classification algorithms, incorporation of spectral indices into the model, accuracy assessment and comparison.

4.1 Supervised Classification algorithms

In supervised classification, the user specifies various pixel values or spectral signatures that should be associated with each class. This is done by selecting representative sample areas of a specific land cover type to create a training dataset. The software algorithm then uses the spectral signatures from these training areas to classify the entire image. Ideally, classes should overlap with each other as little as possible. In this study, commonly preferred and recommended machine learning based algorithms in the literature, such as SVM, RF, and LightGBM, were employed (Talukdar et al., 2020; Ardahanlıoğlu et al., 2020; Bui et al., 2021; Babitha et al., 2023; Li et al., 2024).

4.1.1 Suppor Vector Machine (SVM): One of the machine learning techniques, SVM, aims to not only maximize the margin of separation between different boundaries but also minimize the error. SVM can also be applied in supervised learning techniques for regression models (Vapnik, 1999). Using the SVM classifier offers several advantages (Prasad et al., 2017). The SVM classifier does not require samples to be regularly distributed and needs fewer samples. It is less likely to be affected by noise, correlated bands, or an uneven number or size of training sites within each class (ESRI, 2024b).

4.1.2 Random Forest (RF): The random forest, also known as the random tree's classifier, is a method for classifying images that can handle segmented images and other supplementary raster datasets and is resistant to overfitting (ESRI, 2024b). The Random Forest is composed of several decision trees, each of which will grow fully, does not require processing to be cut, produces more accurate results, and does not overfit. With its automatic feature selection and other benefits, the random forest algorithm will perform the total estimate (Lin et al., 2017). RF has become one of the most popular options for LULC mapping because of its improved accuracy and efficiency, cheap computational cost, and requirement for only a few parameters (Amini et al., 2022).

4.1.3 Light Gradient Boosting Machine (LightGBM): For categorization challenges, a number of potent machine learning algorithms based on decision trees have recently been created. A relatively new method called Light Gradient Boosting Machine (LightGBM) has gained popularity due to its exceptional performance in machine learning competitions. These innovative machine learning algorithms are expansions of traditional ensemble boosting methods from the Classification and Regression Tree family (Abdi, 2020). Despite being a fairly basic algorithm, its exceptional performance and adaptability have made it one of the most popular nonlinear algorithms (Liang et al., 2021). In contrast to the random forest technique, LightGBM is a tree ensemble approach that generates one regression tree at a time by fitting the residuals of the trees that came before it. This process is known as boosting (Candido et al., 2021). LightGBM is relatively fast and has low memory usage, and is designed to provide high speed on large data while providing high accuracy even on small data samples (Ahn et al., 2023).

4.2 Spectral indices

Spectral indices are commonly used to facilitate the LULC mapping process and improve accuracy (Selim et al., 2022). A spectral index can be calculated using two or more bands from remotely sensed satellite images (Eyileten et al., 2022). An index indicates the abundance of a specific class in the image (Santhosh and Shilpa, 2023). To better distinguish land classes and the LULC structure of the region in the study area, spectral indices such as NDVI for green areas, NDBI for built-up areas, and NDWI for water bodies have been incorporated into the model.

4.2.1 Normalized Difference Vegetation Index (NDVI): Because it is less sensitive to soil and atmospheric factors, the NDVI is a useful indicator for regions with medium to high vegetation densities. The index values, which vary from -1 to +1, are determined by how well healthy plants reflect infrared wavelengths and how poorly they reflect in the presence of the electromagnetic spectrum's red band. Consequently, greater NDVI values are typically associated with healthy forest cover (da Silva et al., 2020). Due to the region's dense vegetation, this index has been preferred to better distinguish forested areas from other classes. The NDVI formula is provided in Equation (1) (Piragnolo et al., 2018).

$$NDVI = \frac{NIR-Red}{NIR+Red} \qquad (1)$$

In equation (1), NIR refers to band 8 and Red refers to band 4 for the Sentinel 2 satellite images.

4.2.2 Normalized Difference Built-up Index (NDBI): Buildings, roads, and other infrastructure, such as bridges and pavements, are considered by the widely used NDBI, mainly the impervious cover (Keerthi Naidu and Chundeli, 2023). The built-up area of urban land is extracted using the normalized difference built-up index (NDBI). The range of the NDBI value is-1.0 to +1.0. Built-up area is indicated by a greater NDBI value, water bodies are indicated by a negative value, and vegetation is indicated by a lower value. A larger positive value of the built-up index indicates areas that are built up and areas that are desolate. Both cultivated and uncultivated land are extracted using this index (Pokhariya et al., 2023). NDBI formula is provided in Equation (2) (Duan et al., 2019).

$$NDBI = \frac{SWIR - NIR}{SWIR + NIR} \tag{2}$$

Bands 8 and 11 of the Sentinel-2 data represent NIR and SWIR, respectively.

4.2.3 Normalized Difference Water Index (NDWI): The NDWI highlights the water and glacial cover in a satellite picture by using values from the green and near-infrared (NIR) spectral bands. Water, snow, and ice are represented by positive numbers on the index, which goes from -1 to 1. Soil and terrestrial plants are represented by values smaller than zero (Hamid et al., 2024). Also, the NDWI is used to track variations in aquatic bodies' water content. NDWI highlights water bodies using green and near-infrared bands because water bodies absorb a lot of light in the visible to infrared electromagnetic spectrum (Gao et al., 1996). NDWI formula is provided in Equation (3) (Roy et al., 2024).

$$NDWI = \frac{Green - NIR}{Green + NIR} \tag{3}$$

Bands 3 and 8 of the Sentinel-2 data represent Green and NIR, respectively. The NDWI index has been used in this study to clearly distinguish the boundary between land and water, as well as to identify areas with high water content in terrestrial regions.

4.3 Accuracy Assessment

One important stage in processing data from remote sensing is accuracy assessment. For a user, it determines the information value of the generated data.

Only when the quality of the data is known can geodata be used productively. Each pixel's classification is compared to the specific land cover conditions derived from the associated ground truth data to determine the overall correctness of the categorized image. Errors of omission, a gauge of how accurately real-world land cover categories may be categorized, are measured by producer accuracy. Errors of commission, which indicate the probability that a classified pixel would match the kind of land cover of its corresponding real-world location, are measured by the user's accuracy (Rwanga and Ndambuki, 2017).

To perform accuracy analysis of the classified images, the map was first divided into grids of 1 km x 1 km, and an automatic point was assigned to the center of each grid. The reflectance values of the pixels corresponding to these points were then extracted and compared with current Google Earth satellite images. In this context, kappa coefficient and overall accuracy were generated on the GEE platform. The kappa coefficient and error matrix are now commonly used to evaluate the accuracy of image classification.

4.3 Comparison of classified images with LULC from Earth's land surface

In the final stage of the study, the overall accuracy and kappa coefficients of three different classified satellite images, supported by spectral indices, were compared with the overall accuracy and kappa values of ESRI's AI-assisted LULC map. This comparison was made to test the usability of all classified images and ESRI Land Cover maps, which display global land cover classes, in various planning studies. Based on accuracy values, the classification algorithms were ranked for the specific study area.

5. Results

This study, conducted in the Kemer district, which has a dynamic LULC structure under the pressure of rapid urbanization and population growth, utilized freely available satellite images and user-friendly, open-access software. The aim of the study was to achieve the highest accuracy by supporting different machine learning based classification techniques with spectral indices in a fast and practical manner. The maps produced through supervised classifications were compared with the AI-assisted ESRI Land Cover map, and their accuracies were evaluated.

5.1. Results of spectral index supported classification algorithms

The NDVI, NDBI, and NDWI indices were applied to Sentinel-2 satellite images, with vegetation, artificial surfaces, and areas with high water content being primarily identified (Figure 2). The study area is predominantly covered by dense forest vegetation. From the coastal zone to the higher altitudes, both dense and sparse vegetation cover dominate the area. Artificial surfaces are mainly concentrated along the coast, and small settlements around east-west transportation routes are separated from other land cover classes using the NDBI. The NDWI, on the other hand, effectively delineated the coastline, distinguishing areas with high moisture content from completely dry areas.

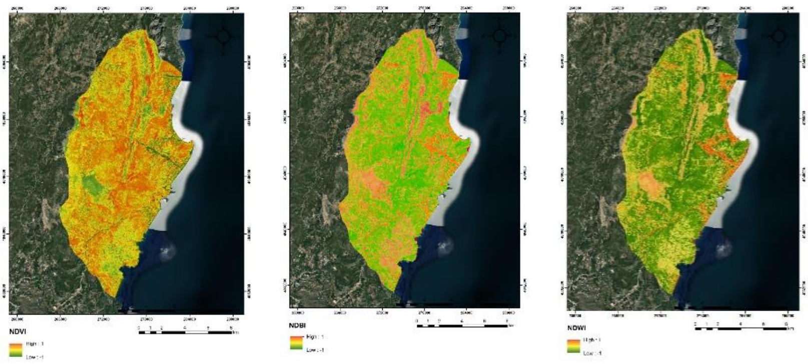

Figure 2. NDVI (left), NDBI (middle), NDWI (right) maps

In the NDVI map, red tones indicate dense vegetation, while green tones represent sparse vegetation with lower NDVI values. In the NDBI map, red tones depict areas of dense urbanization or artificial surfaces, while green tones represent natural areas. In the NDWI map, red colors represent water surfaces and areas with high moisture content, whereas green tones indicate areas with little or no water.

The maps produced using spectral indices were incorporated as input data into the GEE platform for supervised classification, and classification processes were carried out. In the SVM map, data points in the feature space were effectively separated into different classes (Figure 3). In particular, artificial surfaces were effectively distinguished from other classes with the support of spectral index inputs.

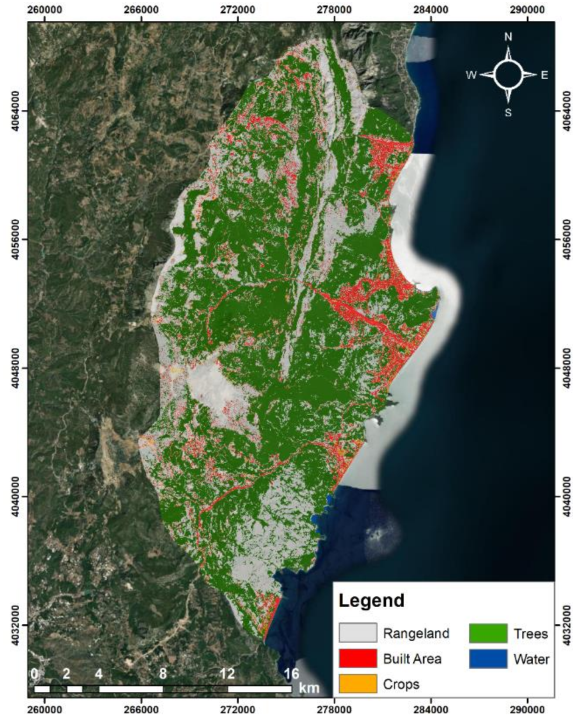

Figure 3. SVM map

In the RF map, the built area has been classified in a more fragmented structure. The tree class and the rangeland class appear to be interwoven in many different areas (Figure 4).

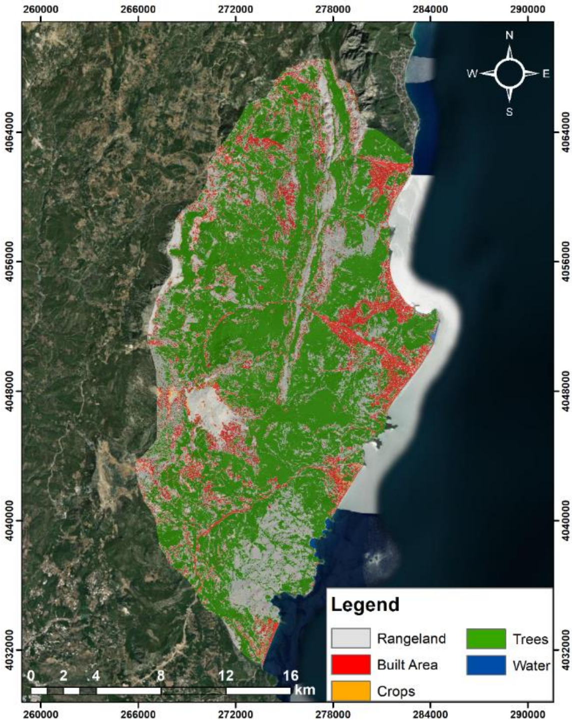

Figure 4. RF map

In the classification created with the LightGBM algorithm, the trees class occupies a larger area compared to the other classes. The built area is more structured compared to the RF classification. The rangeland class is also clearly separated from the other classes (Figure 5).

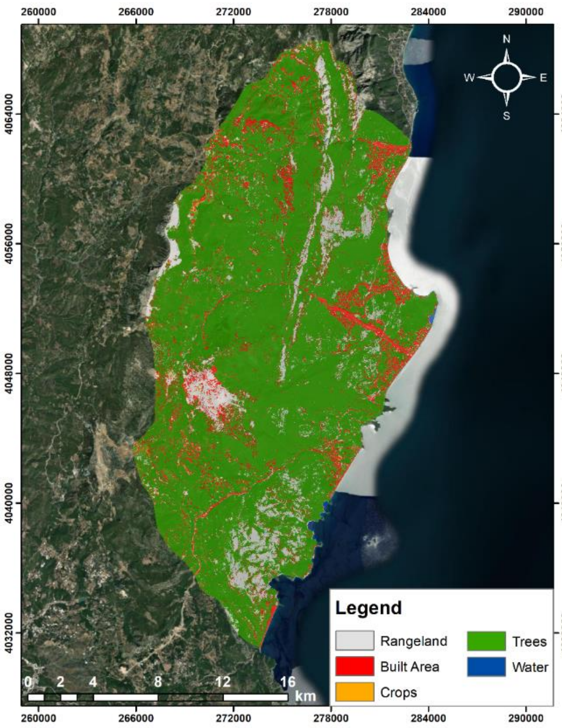

Figure 5. LightGBM map

In the image where three different classification algorithms were applied, it was observed that all classes were systematically separated. Specifically, the built area and rangeland classes were distinctly separated in all classifications. However, when comparing the classification processes of the algorithms, differences were noted, with some algorithms performing better for certain classes while others were less effective.

5.2. Comparison of classification results with ESRI LULC and accuracy assessment

ESRI's AI-assisted classification model generates an LULC map by classifying land surfaces at a 10-meter resolution. This map is created by aggregating a vast number of training datasets from six spectral bands. In the scope of the study, the image, which was subset according to land boundaries, shows a clear distinction between all classes (Figure 6). The settlement areas along the coast and the built-up areas in the interior regions are quite prominent in this map. Furthermore, the boundaries of the rangeland and crops classes are more distinct compared to other classification algorithms. The coastline in this LULC map also clearly separates the land surface from the water surface.

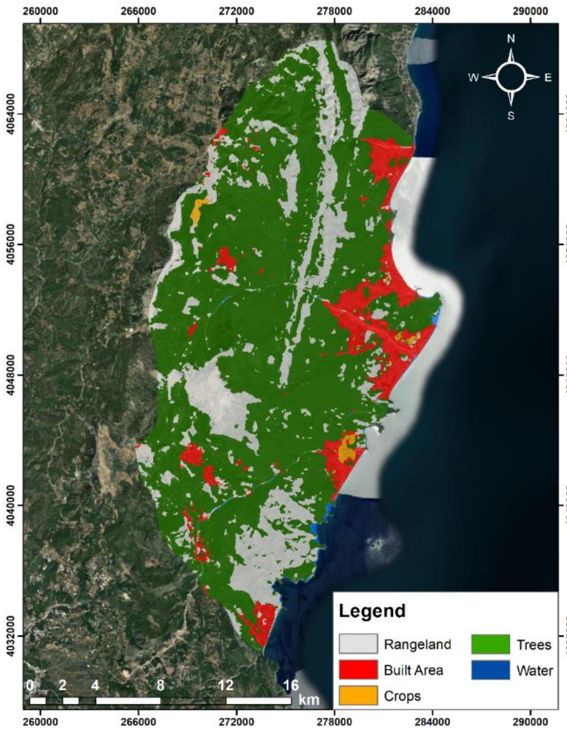

Figure 6. ESRI LULC map

When all the produced maps are evaluated in terms of LULC classes, the results shown in Table 1 are obtained.

Table 1. Class area values of all classification algorithms

Area (km²)	**SVM**	**LightGBM**	**RF**	**ESRI LULC**
Rangeland	150,44	44,86	144,02	92,89
Built area	33,02	45,38	46,22	37,23
Trees	223,87	320,41	216,95	277,30
Water	1,00	0,92	1,01	1,86
Crops	4,83	1,59	4,96	2,53
total	413,18	413,18	413,18	411,83

In all classifications, forest areas cover the largest area. The LightGBM algorithm produces the highest value with 320,41 km², while the RF algorithm gives the lowest value with 216,95 km². The ESRI LULC map provides an intermediate value of 277,30 km² for the same class. For the rangeland class, SVM and RF generate similar results, with areas of 150,44 km² and 144,02 km², respectively. The ESRI data for this class has a value of 92,89 km². In the built area class, both the LightGBM and RF algorithms yield areas of approximately 45-46 km², while SVM produces around 33 km², and the ESRI data provides a value of 37,23 km². For the water class, the ESRI data reports 1,86 km², while all other classification algorithms produce similar results of around 1 km². In the crops class, SVM and RF generate values of 4,83 km² and 4,96 km², respectively, while ESRI reports 2,53 km², with LightGBM producing the closest result at 1,59 km².

The accuracy of the classifications performed for the study area was compared with current Google Earth satellite images. In the area divided into grids, the pixel value at the center of each grid was used to assess whether the classified image overlapped with the actual land cover. The resulting accuracy assessment is shown in Table 2.

Table 2. Accuracy levels of classifications

Classification Algorithms	Overall Accuracy (%)	Kappa Statistic
ESRI LULC	84,52	0,70
LightGBM	75,24	0,47
SVM	71,19	0,48
RF	67,62	0,44

According to Table 2, the highest overall accuracy and Kappa statistics are associated with the ESRI LULC dataset, with an overall accuracy of 84,52% and a Kappa value of 0,70. This dataset has been used as a reference point for classification accuracy and provides highly reliable results for the Kemer district. The algorithms following the ESRI LULC dataset are LightGBM with 75,24% overall accuracy and a Kappa value of 0,47; SVM with 71,19% accuracy and a Kappa value of 0,48; and the RF algorithm with 67,62% accuracy and a Kappa value of 0,44.

The accuracy values for each class in the supervised classification algorithms are shown in Table 3.

Table 3. Accuracy levels of classifications at class level

Classification algorithms	Rangeland (%)	Built area (%)	Crops (%)	Trees (%)	Water (%)
ESRILULC	73,08	88,89	56,25	89,86	100
LightGBM	33,65	66,67	12,5	94,57	100
SVM	50,33	31,03	12,5	91,59	100
RF	64,42	72,22	6,25	71,38	100

According to Table 3, overall, the ESRI LULC dataset provides very high accuracy for all classes. Compared to other classification algorithms, the accuracy level in the trees class is only lower than that of LightGBM and SVM; however, the difference is within an acceptable range. The fragmentation of agricultural areas into small patches across the land and the fact that a large portion of these areas is fragmented around settlements significantly reduced the classification accuracy for this class. Additionally, the crops class has mixed with the tree class in many areas. Despite this, the ESRI LULC dataset provided significant accuracy in this class compared to other algorithms. For the rangeland class, after the ESRI LULC dataset, the highest accuracies were achieved by RF, SVM, and LightGBM, respectively. In the built area class, SVM showed the lowest performance. In the crops and tree classes, both LightGBM and SVM reached very high accuracy, demonstrating excellent performance. For the water class, all classification algorithms achieved very high accuracy.

6. Discussion and Conclusion

Land cover mapping is essential for many applications, including urban planning, environmental management, and natural resource management, as it provides critical information. Specifically, the widespread availability of time-series satellite imagery and the development of digital image processing have made it possible to observe, track, assess, and understand the temporal and spatial fluctuations in land cover (Wang et al., 2018; Candido et al., 2021). In this study, which tested different machine learning based classification algorithms for LULC in the Kemer district, it was found that the AI-supported ESRI LULC dataset achieved higher accuracy compared to SVM, LightGBM, and RF algorithms. Given the rapid changes in land cover due to various anthropogenic factors, the ESRI LULC dataset, with its ease of accessibility, minimal expertise requirements, and high accuracy, can assist central and local governments in decision-making processes. In terms of overall accuracy and kappa statistics, LightGBM, SVM, and RF were ranked after ESRI LULC based on their accuracy levels. While LightGBM outperformed the other implemented classification algorithms, its significant disadvantage is the large number of hyperparameters it requires (Ke et al., 2017). The literature states that LightGBM is preferred over RF because it is newer, faster, and more successful (McCarty et al., 2020). Although the processing time required to apply LightGBM is longer, the results confirmed its superiority over other popular machine learning algorithms such as RF and SVM (McCarty et al., 2020; Liang et al., 2021). In this study, LightGBM showed better performance than RF. However, for the rangeland class, LightGBM performed the worst compared to other classification algorithms. This is likely because rangeland and tree classes have similar spectral reflectance, which the algorithm could not clearly differentiate. The SVM algorithm, on the other hand, showed the lowest performance in the built area class. Also, the literature suggests that RF may perform better than SVM in built-up class for LULC classification (Talukdar et al., 2020; Avcı et al., 2023).

Finally, while nearly all classifications showed maximum performance for the water class, they performed poorly for the crops class. This is likely due to the similar spectral reflectance between the crops and trees classes. Therefore, when performing crops classification, it is recommended to include a greater number of samples in the classification and to divide the crops class into sub-classes (based on agricultural crop patterns) for the algorithms to work more effectively.

The results of this study show that the ESRI LULC classes provided higher accuracy compared to other machine learning classification algorithms for the study area. Therefore, due to its availability, ease of access, minimal expertise requirements, suitability for use over large areas, and high accuracy, it can be preferred as a reference dataset in planning decisions.

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CHAPTER 3

Accommodation of Temporary Residents of Constructıin Sites an Evaluation of Workers' Barracks

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1. Introduction

In Turkey, which is characterized as one of the noteworthy economies among developing countries due to its strategic location, strong banking sector, and trained manpower, and which maintains its investment grade credit rating, investment rates in the construction sector have undoubtedly increased in recent years. These investments are noteworthy in both public and private housing construction [1]. With the growth of construction scales and the strengthening of contractor companies, the accommodation, structural characteristics, and qualifications of workers employed in construction sites have gained importance. Workers trying to live in one room of a 4-5 storey building have been replaced by workers living in large tents or prefabricated sheds. Workers trying to cook with a gas cylinder in the same room of a 4-5 storey building have been replaced by workers who benefit from the collective nutrition facilities provided by the workplace. All these are positive developments. However, not enough attention has been paid to this issue in our country [2].

2. Conceptual Framework

2.1. Workers' Barracks

In addition to occupational health, climatic factors, working conditions and working hours, and living comforts are also important for people working in physical labor-based jobs [3]. Although the beginning of modernization in European standards was with the workers' blocks that came with industrialization, in our country, this issue has not gone further than a few square meters of living space for various reasons.

Figure 1. Example of Worker Barracks [4]

By definition, worker's quarters are closed spatial volumes that can be produced in prefabricated or container types, where workers working on the construction site of the construction company they serve can perform functions such as sheltering, dressing, eating, and resting. Although prefabricated (formed by combining insulated horizontal and vertical parts and joinery) are mostly preferred in our country, in recent years, ready-made containers have started to be preferred due to their ease of transportation, assembly, reusability, and comfort (Figure 1) [4].

2.2. Location of Workers' Barracks and Characteristics of Spatial-Fixture Elements

2.2.1. Location

The barracks, which are generally preferred on the other side of the construction site rather than on the side that is open to view, are located close to the construction site boundary for large plots and closest to it for narrow plots. Material storage and cafeteria sections are also located close to the workers' barracks. This positioning is preferred in order for the worker to have a command of the area during or outside work—to feel at home. Approaching the construction site with a separate entrance from the technical containers and subcontractor work containers in the other part of the construction site close to the site and creating a separate zone can be considered as a result of a class order or an involuntary social necessity. Sometimes, if there is space congestion in construction sites with separate entrances, access is provided with a single entrance. If we take the construction sites of public buildings as a basis, two entrances can be mentioned. From the first entrance, daytime supporters of the construction site, i.e., technical teams, companies, visitors, administrative staff, and sometimes statesmen, approach. From the second entrance, heavy vehicles such as construction machinery, excavation, and trucks are provided access to the construction site and the workers' barracks area, which is the main subject (Figure 2).

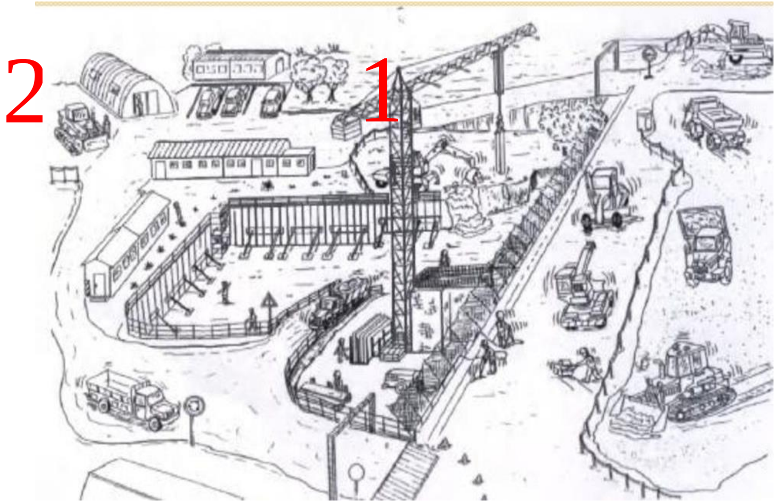


Figure 2. Sample Construction Site Layout [5]

2.2.2. Spatial Function

Worker barracks are formed by arranging areas ranging from 8 m2 to 40 m2 each around a corridor. Sometimes they are solved on a single floor and sometimes on more than one floor. Each sleeping module has a WC and bathroom. These wet areas can accommodate the number of people staying in the barracks. Although rare, some construction sites also use plan types with private showers and WCs for each room. Although the cafeteria section is usually located separately from the worker barracks, it is sometimes considered within the barracks depending on the area and site conditions. The barrack system, which does not have a complex structure in terms of spatial organization, is of two types in terms of construction material: container and prefabricated. In the prefabricated barrack system, the plan scheme can be changed as desired. Horizontal and vertical insulated panels, moving elements, and even lighting are manufactured in the same way as in a new building. However, since the entire space, including the wet areas in containers, comes ready insulated, it does not allow for changes and creates a fast meeting of needs (Figure 3 and Figure 4).

Figure 3. Prefabricated Barracks [6]

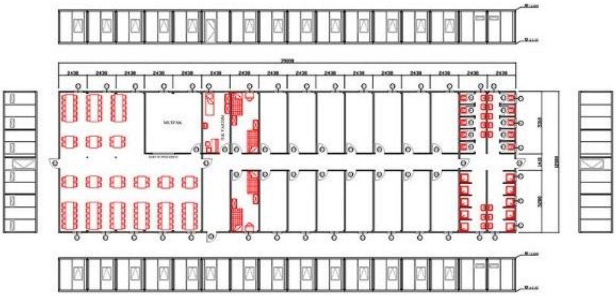


Figure 4. Container-type barracks [7]

2.2.3. Interior Equipment

Worker barracks are not complex functional structures, as mentioned above, nor do they contain complex equipment in terms of interior space. Although the presence of minimum equipment derivatives makes it easier to create interior space fiction, in many construction site worker barracks, minimum equipment is considered an advantage of fitting more people in less space (Figure 5).

Figure 5. Worker Barrack Equipment Analysis [8]

If we categorize the equipment of workers' barracks;

Horizontal and vertical equipment: The horizontal and vertical elements of the prefabricated barrack system are explained through visuals (Figure 6, 7 and 8).

Figure 6. Roof Layers of Worker Barracks [8]

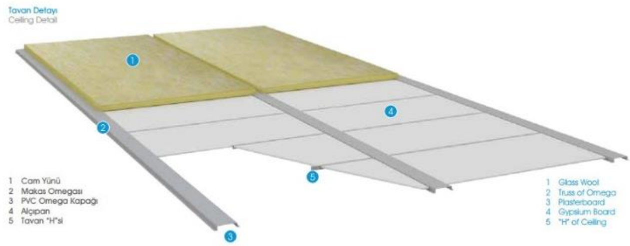


Figure 7. Ceiling layers of workers' barracks [9]

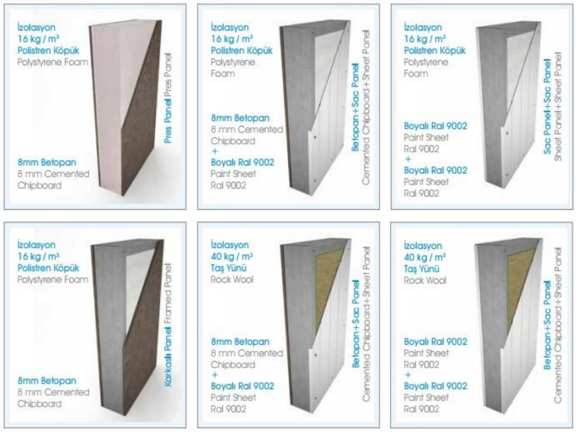


Figure 8. Wall types and layers of workers' barracks [8]

In addition to these visuals, worker barracks must have the necessary installations and fittings for a living space. They are constructed in accordance with health and technical conditions in such a way that they are protected against other external factors and receive natural light and air. Barrack floors should be made in such a way that they can be easily cleaned every day and washed when necessary. In addition, light-colored paint is preferred on the faces of walls and ceilings, which are preferred in narrow temporary spaces [9].

Wet area equipment: In workers' barracks, wet areas, which are usually located inside the barracks, can sometimes be located outside the container. What should be done is to separate the shower section from the WC section with a sharp line. However, in our country, there is always an intertwined example. The number of equipment is proportional to the number of people in the ward and the square meters, and is made in the form of cabins of at least 1 m^2 each so that there is one WC for every 30 people [10]. The wet area detail visual shown below expresses the standards that should be and a functional wet area detail (Figure 9).

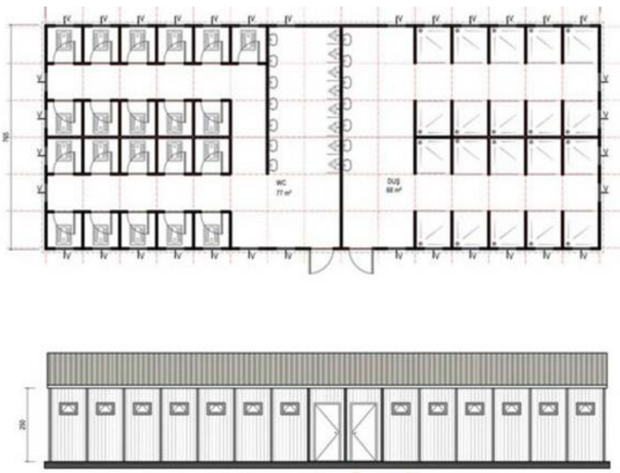


Figure 9. Drawings of the Wet Area Section [9]

Frame Elements: Insulated frames are preferred in workers' barracks. The windows can be opened for ventilation comfort. Wet area windows are arranged with transoms. Doors, especially exterior doors, are insulated. Optionally, it can be preferred as a glazed door or a massive solid panel door. The next figure shows the frame types used in the worker barracks (Figure 10).

Movable Equipment: The number of bunk beds and the number of wardrobes are regulated depending on the square meters of the barracks. A standard barrack is designed with a ceiling height of not less than 2.80 and 10 m3 of air per person. In the sleeping area, there should be a clearance of at least 80 cm between the beds, and in cases where a two-storey bedstead is used, it should be arranged such that the height between the floors and the width of the bedstead is not less than 80 cm [10].

Figure 10. Worker Barracks Frame Details [8]

Bunk beds should be placed so as not to block the window lighting. In the sleeping area, instead of driving nails into the walls to hang clothes or similar materials, locked wardrobes with a height of not less than 170 cm shall be provided for the number of sleeping workers. The schematic plan of the rooms with four bunk beds, bunk bed system cross-section, and barrack cabinets' prototypes and equipment are visually expressed below (Figure 11, Figure 12 and Figure 13).

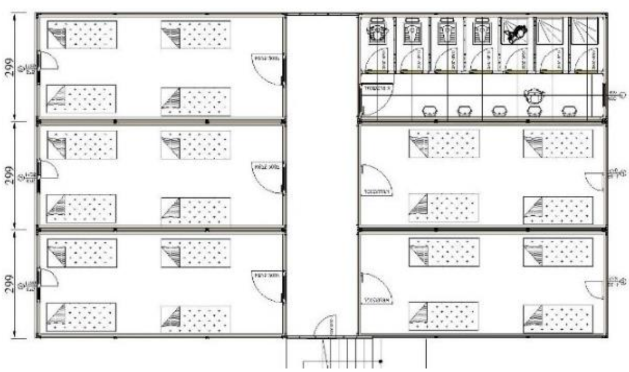


Figure 11. Barrack schematic equipment plan [11]

Lighting Elements: Although the lighting elements in the barracks do not have a specific standard, artificial lighting is preferred over natural lighting. Lighting installations in the sleeping area should be made with 24 or 42 V. Fluorescent white light is predominantly preferred.

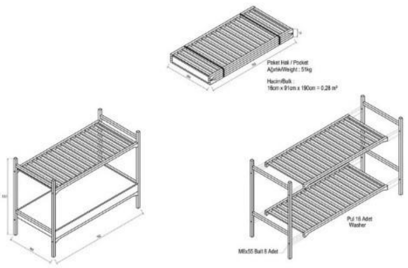


Figure 12. Bunk Bed Detail [12]

Figure 13. Cabinet Image [12]

2.3. Statutes and Regulations

To ensure occupational health, safety, and comfort in workers' barracks, statutes and regulations have been determined considering several standards. These are as follows:

- The air volume in workplaces shall be at least 10 cubic meters per worker, including the volumes occupied by machinery, materials, and similar facilities. In the calculation of the air volume, no more than 4 m above the ceiling height is considered.

- The corridors in the workplaces shall be wide enough to allow workers to come and go easily and to evacuate the workplace quickly in case of danger, and shall be illuminated with natural or artificial light.

- The ceiling height in the barracks shall not be less than 280 cm and the air volume per man shall be calculated as at least 12 cubic meters. The number of workers to be accommodated in each barrack shall be determined accordingly, and a chart showing the air volume of the barrack and the maximum number of workers to be accommodated bearing the signature of the employer or the employer's representative shall be posted in the barracks.

- The beds in the barracks shall be spread on bedsteads and bunk beds in such a way that they are disconnected from the floor, there shall be a clearance of at least 80 cm between them, small nightstands or bedside tables shall be placed at the head-ends for the storage of personal belongings, and in cases where two-storey bedstead bunk beds are used, the height between the floors and the width of the bedstead bunk beds shall not be less than 80 cm.

- Barracks must be heated healthily during the cold season. When stoves are used for heating, necessary precautions should be taken against smoke, gas, and fire hazards. It is forbidden to heat with charcoal or coke, by means such as barbecues or maltz, with open fires, or with pipeless oil stoves or gas stoves. Flammable substances such as benzol and petroleum cannot be used for ignition.

- The railings to be used in workplaces shall be made of solid wooden pipes or metal profiled material, their surfaces shall not be rough, and their corners shall not be sharp. The height of the railings from the base shall be at least 90 cm. The entire railing shall be made to withstand a load of at least 100 kg from any direction.

- In workplaces employing up to 100 workers, a WC cabin and urinal for 30 male workers and at least one cabin for every 25 female workers will be calculated, and for every 50 people after 100, one toilet will be provided.

- The employer is obliged to construct and install shower facilities and make them available for the use of workers in cases where only hand and face cleaning is not sufficient in terms of the nature of the work or after dirty, dusty, and strenuous work or when necessary to ensure that workers wash and clean themselves.

- Sufficient number of wardrobes, desks, chairs, stools, and similar items shall be provided for workers in changing places.

- Construction work is toxic, dangerous, dusty, and dirty. Therefore, workers should not come to the ward with their work clothes. They should have a changing place outside their wards, where they can keep their work clothes and clean clothes, with two doors and wardrobes with the dimensions given in the Regulation

- Two separate barracks should be set aside for resting. Both sleeping and resting in the same barrack can create problems for those who need to rest at different times and in different ways. Moreover, tastes such as television, listening to music, and singing folk songs, etc. do not need to be shared with everyone. Moreover, smoking habits are one of the most important problems in construction sites where there is no separate resting barrack. Smoking is strictly forbidden in barracks used for sleeping. A separate and well-ventilated barrack for smokers should also be set aside for recreational purposes.

- On the other hand, in terms of cleanliness, the issue that should be emphasized as much as the dining hall, bathrooms, and latrines is the necessity of having laundry and ironing facilities where workers can wash their clothes [12].

Apart from these articles, one paragraph of the provisions in the annexes of the "Regulation on Occupational Health and Safety in Construction Works" are as follows:

Rest rooms or shelters shall be of sufficient width and there shall be a sufficient number of tables and chairs with backs for workers.

If such facilities are not available, places for workers to rest between work hours shall be provided.

Fixed accommodation facilities shall include a rest room, a leisure room, adequate showers, toilets, washbasins, and cleaning equipment. Taking into account the number of workers, these places shall be equipped with beds, cupboards, tables and chairs with backs, and these shall be placed taking into account the presence of male and female workers [2].

3. Case Study

3.1. General Information

The Konya Selçuklu Congress Center has been put out to tender by the Selçuklu Municipality administration and is Konya’s largest and most prestigious cultural investment. The project belongs to Melkan and Murat Tabanlıoğlu and has an indoor area of 35,000 m2. The first tender for the center was opened in 2013. Built on 38 acres of land, it is a supply construction that includes independent sections that will serve in different areas under a single roof in the center. In 2015, the construction was put out to tender again and continued after a one-year break. Completed in 2017, the construction site employed approximately 300 people, including technical staff, foremen, manual laborers, security guards, warehousemen, and subcontractor workers, varying between days.

3.2. Investigation of the Interior Space and Equipment

Approximately 200 workers at the construction site are expatriates and are accommodated in field containers. The worker barracks, which have a total capacity of 250 people, accommodate 2-4 or 6 people. The table below shows a comparative analysis of the Selçuklu Congress Center construction site worker barracks against the criteria specified in the conceptual approach (Table 1a, Table 1b and Table 1c).

Table 1a. Analysis table 1

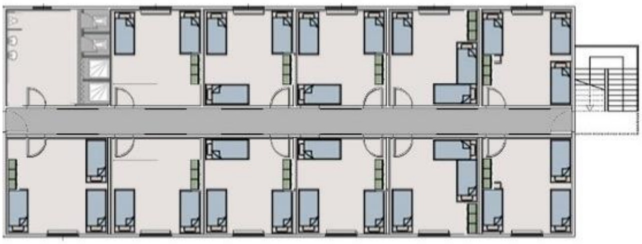
<table>
<tr><td></td><td></td><td>SITUATION AT THE SELUKLU CONGRESS CENTER CONSTRUCTION SITE</td></tr>
<tr><td rowspan="5">APPROACH-LOCATION</td><td rowspan="5">LOCATION INSIDE THE CONSTRUCTION SITE</td><td>
</td></tr>
<tr><td>ERGONOMICS AND WORK SAFETY STANDARDS</td></tr>
<tr><td>• The worker barracks should be located close to the refectory.
• It should be located close to the warehouses.
• The construction site should be positioned to benefit from one of the two entrances allocated for the work site.
• It should not belocated too close to the technical office and administrative container section.</td></tr>
<tr><td>NOTES</td></tr>
<tr><td>• The Selçuklu Congress Center Construction Site worker barracks are close to the refectory.
• They are close to the warehouses
• The construction site benefits from one of the two entrances allocated for the work site.
• It is not very close to the technical office and administrative containers.
• A separate area has been allocated for the workers. The worker can reach every part of the site whenever he wants.</td></tr>
</table>

	VEHICLE APPROACH	
		ERGONOMICS AND WORK SAFETY STANDARDS
		• Worker barracks should be separated from the outside by an alternative vehicle entrance protected by a day and night security system. • If the site is large, vehicle access to the site should be provided. • The vehicle entrance of the barracks should be separated from the vehicle entrance of the guests, technical office, and administrative department. Clear paths should be created to allow ambulance passage in the case of a possible work accident or emergency.
		NOTES
		• The worker barracks are separated from the outside by a separate entrance protected by a day and night security system. • The private vehicles of the people staying in the workers' barracks are not allowed to enter the site through this entrance, but it is only used for the entrance of construction equipment. • The entrance for construction equipment is organized separately. • The wards easily allow ambulance passage in case of a possible work accident or emergency.

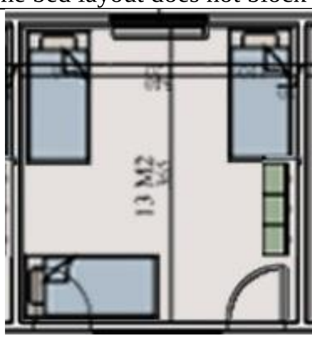
	PEDESTRIAN APPROACH	
		ERGONOMICS AND WORK SAFETY STANDARDS
		• Worker barracks should be within walking distance of the work site. • Pedestrian access to the barracks area should be organized separately from the vehicle entrance of the guests, the technical office, and the administrative department. • Pedestrian access to the barracks from all sides must be safe and clear.
		NOTES
		• Worker barracks are within walking distance of the work site. • Pedestrian access to the barracks area is organized separately from the vehicle entrance of the guests, the technical office, and the administrative department. • There are clear routes for pedestrian access to the barracks from all sides of the site. However, security control becomes difficult as transportation varies depending on the initiative of the worker in the construction area.

<table>
<tr><td rowspan="5"></td><td rowspan="5">LOCATION RELATIVE TO THE WORK EQUIPMENT</td><td>
</td></tr>
<tr><td>ERGONOMICS AND WORK SAFETY STANDARDS</td></tr>
<tr><td>• It should be located close to warehouses for possible material supply.
• The construction site should be close to the work site.
• The technical office should be accessible when required.
• Equipment such as mobile cranes, trucks should be accessible.</td></tr>
<tr><td>NOTES</td></tr>
<tr><td>• Located close to the warehouses.
• The construction site is located close to the work site.
• The technical office can be easily accessed by passing through the site or through the sides when desired.
• Since it is located close to the entrances of construction machinery, equipment such as trucks can be accessed during material download.</td></tr>
</table>

Table 1b. Analysis table 2

<table>
<tr><td></td><td></td><td colspan="2">SITUATION AT THE SELUKLU CONGRESS CENTER CONST-RUCTION SITE</td></tr>
<tr><td rowspan="7">SPATIAL ANALYSIS</td><td rowspan="7">GENERAL PLAN OF BARRACK</td><td colspan="2"></td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">ERGONOMICS AND WORK SAFETY STANDARDS</td></tr>
<tr><td colspan="2">• Worker barracks are formed by arranging areas ranging from 8 m^2 to 40 m^2 each around a corridor.
• Sometimes they are solved on a single floor and sometimes on more than one floor.
• Each sleeping module has a wc and bathroom module.
• The minimum ceiling height in the barracks should be 2.80 m.</td></tr>
<tr><td colspan="2">NOTES</td></tr>
<tr><td colspan="2">• It is a rectangular barrack type measuring 800 2150 cm.
• There are two barrack containers, one with three floors and one with a single floor.
• The floor plan of the two containers is the same.
• Each floor has 11 rooms for 6 people with 3 bunk beds, 2 cabin wc, and 2 cabin showers.
• There are two entrances to the container.
Barrack floor heights are 2.80 m.</td></tr>
</table>

<table>
<tr><td rowspan="8"></td><td rowspan="4">ROOM TYPE A</td><td>
</td><td></td></tr>
<tr><td colspan="2">• The beds in the barracks will be spread on the bedstead in such a way that they are disconnected from the floor, and there will be a gap of at least 80 cm between them.
• There will be enough clothes lockers, chairs, and stools for workers in changing places.
• Workers should not come into the room in their work clothes</td></tr>
<tr><td colspan="2">NOTES</td></tr>
<tr><td colspan="2">• It consists of three bunk beds and a wardrobe.
• The distance between the beds is 1.80 m
• In the hallway, there is a separate hanger for work clothes.
• The bed layout does not block natural light.</td></tr>
<tr><td rowspan="4">ROOM TYPE B</td><td>
</td><td></td></tr>
<tr><td colspan="2">• “The beds in the barracks will be spread on the bedstead in such a way that they are disconnected from the floor, and there will be a gap of at least 80 cm between them.
• There will be enough clothes lockers, chairs, and stools for workers in changing places.
• Workers should not come into the room in their work clothes</td></tr>
<tr><td colspan="2">NOTES</td></tr>
<tr><td colspan="2">• It consists of three bunk beds and a wardrobe.
• The distance between the beds is 1.80 m
• In the hallway, there is a separate hanger for work clothes.
• The bed layout does not block natural light.</td></tr>
</table>

<table>
<tr><td rowspan="8"></td><td rowspan="4">ROOM TYPE C</td><td>
</td><td></td></tr>
<tr><td colspan="2">• The beds in the barracks will be spread on the bedstead in such a way that they are disconnected from the floor, and there will be a gap of at least 80 cm between them.
• There will be enough clothes lockers, chairs, and stools for workers in changing places.
• Workers should not come into the room in their work clothes</td></tr>
<tr><td colspan="2">NOTES</td></tr>
<tr><td colspan="2">• It consists of two bunk beds and a wardrobe.
• The distance between the beds is 1.80 m
• In the hallway, there is a separate hanger for work clothes.
• The bed layout does not block natural light.</td></tr>
<tr><td rowspan="4">ROOM TYPE D</td><td>
</td><td></td></tr>
<tr><td colspan="2">• The beds in the barracks will be spread on the bedstead in such a way that they are disconnected from the floor, and there will be a gap of at least 80 cm between them.
• There will be enough clothes lockers, chairs, and stools for workers in changing places.
• Workers should not come into the room in their work clothes.</td></tr>
<tr><td colspan="2">NOTES</td></tr>
<tr><td colspan="2">• It consists of three bunk beds and a wardrobe.
• The distance between the beds is 1.80 m
• In the hallway, there is a separate hanger for work clothes.
• The bed layout does not block natural light.
• It is the soundest type of plan in a barrack.</td></tr>
</table>

<table>
<tr><td rowspan="4"></td><td rowspan="4">WET AREAS</td><td>
</td><td></td></tr>
<tr><td colspan="2">• For more than 100 workers, there will be one latrine for every 50 people.
• To ensure that workers are washed and cleaned, shower facilities will be made, installed, and made available to workers.
• Each cabin will be at least 1m^2.</td></tr>
<tr><td colspan="2">NOTES</td></tr>
<tr><td colspan="2">• Each floor has a wet area of 17 m^2.
• There is one wc and shower for every 30 people.
• Cabins are 1.10 m^2
• The cabins are arranged at a higher level than the sink in terms of cleanliness.</td></tr>
</table>

Table 1c. Analysis table 3

		SITUATION AT THE SELUKLU CONGRESS CENTER CONSTRUCTION SITE
INTERIOR SPACE EQUIPMENT	**HORIZONTAL AND VERTICAL EQUIPMENT**	
		ERGONOMICS AND WORK SAFETY STANDARDS
		• Although there is no specific standard, insulation material and betoyan, drywall, steel carrier, and glass wool are generally used to ensure the insulation standard. • Light colors should be preferred on the interior facade.
		NOTES
		• It is preferred to use roof covering consisting of roof truss and sheet metal, ceiling covering consisting of glass wool, pvc cover and gypsum board, and wall covering consisting of 8mm betoyan, 80 mm polystyrene foam and construction. • Interior flooring and wall colors are preferred to be light colors. • The wall surfaces are covered with pvc.
	FRAME ELEMEN.	 
		ERGONOMICS AND WORK SAFETY STANDARDS
		• Insulated joinery is preferred in worker barracks. • The windows can be opened for ventilation comfort. • The wet area windows are arranged with transoms. • Doors, especially exterior doors, are manufactured as insulated.
		NOTES
		• Filled betopan (precast concrete) panel was preferred for the doors. • Windows are pvc. • Joinery is supported by steel slats. • Doors are 70 x 210 and windows are 120 x 120.

<table>
<tr><td rowspan="12"></td><td rowspan="4">MOVABLE EQUIPMENT</td><td>
</td><td></td></tr>
<tr><td colspan="2">• In the sleeping area, there must be at least 80-cm space between the beds.
• In cases where two-storey bunk beds are used, they are arranged such that the height between the floors and the width of the bed is not less than 80 cm.
• Bunk beds should be placed so as not to block the window lighting.</td></tr>
<tr><td colspan="2">NOTES</td></tr>
<tr><td colspan="2">• There is a distance of 180 cm between the beds in the sleeping area.
• A two-storey bedstead is used, and the height between the floors and the width of the bedstead is 80 cm.
• The bunk beds are placed in such a way that they do not block the window lighting.</td></tr>
<tr><td rowspan="4">WET AREA</td><td>
</td><td></td></tr>
<tr><td colspan="2">• There is no standard for additional equipment in addition to those mentioned in the spatial function section.</td></tr>
<tr><td colspan="2">NOTES</td></tr>
<tr><td colspan="2">• White and ceramic on the walls were preferred for easy cleaning in wet areas.
• Two cabin ataturk WCs and two cabin curtain showers were built.
• There is one WC and shower for every 30 people.</td></tr>
<tr><td rowspan="4">LIGHTING</td><td colspan="2">ERGONOMICS AND WORK SAFETY STANDARDS</td></tr>
<tr><td colspan="2">• “Although the lighting elements in the barracks do not have a specific standard, artificial lighting is preferred over natural lighting.
• Lighting installations in the sleeping area should be made with 24 or 42 V.</td></tr>
<tr><td colspan="2">NOTES</td></tr>
<tr><td colspan="2">• The windows that allow natural lighting are not blocked by bunk beds.
• Saving white twister lighting between 24 and 42 V is used.</td></tr>
</table>

4. Discussion

As a result of the detailed investigation of the worker barracks of the Konya Selçuklu Congress Center Construction site in the light of ergonomic criteria and a number of standards, no problems that go beyond the standards and threaten occupational health and safety have been identified, except for 4 years of aging due to the fact that the construction is a completion work.

The construction site is on the new Istanbul Street, close to the Konya bus station. Transportation is very easy for workers residing in Konya. It is on tram, minibus, and bus lines.

The entrances to the construction site are not made on the street for ease of control and work safety. After the entrance to the Anadolu industry, the entrance is made from the south side of the construction site.

As seen in the drawing above, there are two entrances. Entrance number 2 is reserved for the entrance to the worker barracks and construction machinery. There is a clear road route that will not cause any trouble in case of an emergency. The barracks are close to the warehouses and refectory.

The interior is in the form of a standard container, and the vertical circulation is made of steel. In the modular rooms connected around the corridor, it was found that the bunk beds and wardrobes were changed according to the workers' preferences.

Because of the study, the barracks were analyzed in detail in the table, and the factors and threats that impair comfort were not identified according to the standards (Figure 14).

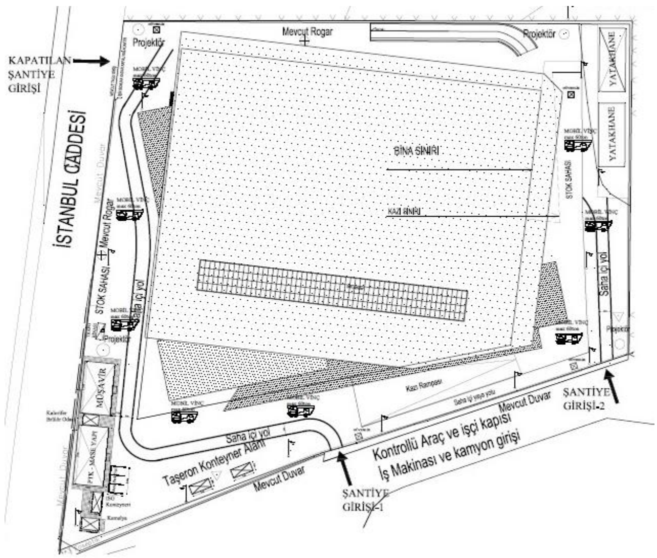


Figure 14. Selçuklu Congress Center Construction Site Mobilization Plan

5. Conclusion

The case study, which aims to qualitatively discuss the housing practices of workers who are temporary residents of construction sites, was determined as the construction site of Konya Selçuklu Congress Center, which has a qualified work intensity and potential in Konya province and is believed to bring innovation to the construction vision of the city. The fact that the qualified project, which has already been completed, has become a landmark for Konya and has become a constant element of the city's art activities is due to its spatial quality and qualified construction. The construction process of this building, which has become a landmark for the city of Konya, was completed and took its place in the city of Konya in a systematic manner based on a series of correct design, implementation, and qualified labor force for its realization. In this context, although the quality of the project designed in this context is qualified, its realization and the realization of the idea dreamed by the architect/designer, even if the envisaged/desired material supply is also provided, the quality of replacing it correctly is due to the appropriate / skilled or qualified workforce. In fact, in such buildings or groups of buildings of public value, even if the supply of materials is as envisaged by the architect, errors occur in the replacement or realization of the project. At this point, the biggest problem encountered in public buildings supplied by tender, which are expected to be completed in a limited number of days, is that the contractors do not work with a proper labor force. The biggest problem encountered in this project was the fact that the first contractor did not do the work in accordance with the project, and the second contractor completed the unfinished construction as a supply. The contractor company Mase Yap completed the construction in accordance with the project and provided the city of Konya with a qualified building.

As a matter of fact, even if qualified labor is provided, the ongoing construction process requires the provision of a very comprehensive need to stay on the construction site. In this study, in which the qualities of worker barracks designed especially for the accommodation of workers coming from outside the city are discussed, a reading has been made by mixing theoretical standards, work safety and health guidelines, and information obtained from the literature with the worker barracks used in practice at the construction site of a medium-sized public building. Therefore, by comparing the spaces used in the construction site (worker barracks) with the data obtained and bringing them into analysis tables, a situation was determined and the ergonomics and quality of the space were discussed. In this context, the barracks, which are very diverse and contain more than one type, have been differentiated in a systematic way based on positioning, spatial function, and interior equipment. This differentiation was analyzed through statutes and regulations, and necessary readings were made on the case study.

Within the scope of ergonomics and work safety standards, the method of transferring worker barracks to analysis tables; under the main title of approach, location within the construction site, vehicle approach, pedestrian approach, location according to work equipment, under the title of spatial function, the general plan of the barrack, room shapes and wet areas according to their types, and interior equipment were analyzed as horizontal and vertical equipment, joinery elements, wet areas, and lighting elements. In this context, the worker wards in the Konya Selçuklu Congress Center Construction Site were analyzed/evaluated and necessary notes were taken.

Because of the sample area analysis, these data were transferred to the analysis tables as mentioned above. In this context, when these data are compared with the data obtained from the literature, no problems that go beyond the standards and threaten occupational health and safety have been identified. As a matter of fact, this study once again reveals the importance of reading the comparative data that emerged in this context through the housing units of the workers, albeit temporary, which enable qualified labor force, and the importance of ensuring the spatial order in accordance with the standards and ergonomics in the construction sites to be built.

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CHAPTER 4

Rethinking Image and Identity of the City: A Review

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INTRODUCTION

One of the sub-goals determined to ensure that cities gain a share of the capital by standing out from other cities in the globalizing space is to create images of the city. It can be said that the concept of image does not exist in reality, but is understood as a phenomenon that is attempted to be concretized by perception. Thus, it can be assumed that image is related to thought, politics or ideology. City image is related to the visual quality of the city and according to the definition above, it can be expressed as the shaping of the city in line with a policy or ideology. Lynch (1995: 8) assumes that the city image consists of identity, structure and meaning components. In order for an image to be processed, it must define an object, separate that object from others and be accepted as an entity, which creates its identity. The spatial or textural relationship of the image with the observers of the object and other objects is established with structure. The object must have a meaning for the observer in terms of application or emotionally (Lynch, 1995: 8-9).

All these components constitute the basic facts of the city image. In short, it can be said that the city image consists of structures that give the city an identity and add meaning to its users. For this reason, based on the concept of image, a new appearance can be given to the city by making changes in the structures so that the desired ideology shapes the city. Efforts to create an image of the city began to develop with the modern period. The social life and organization forms of modernity that started in Europe in the 17th century and later affected almost the entire world (Giddens, 1999: 9) created some negativities in urban space and caused deformations especially in the areas where the working class lived. These deformations are problems that cause the formation of unhealthy urban spaces such as environmental pollution, irregular construction, and low-standard housing. These developments initiated urban renewal interventions aimed at renewing, organizing and solving the problems of the city (Akkar, 2006: 29-38).

Urban renewal movements began with the increase of public spaces. The first example of this was the ‘park movement’. Then came the ‘Haussmann plans’ that provided the opening of wide boulevards. In addition to these developments in Europe, the ‘Beautiful City’ movement began in America at a parallel time. The ‘Garden City Movement’, ‘New Cities Movement’ and ‘Modernist Movement’ that emerged in the first half of the 20th century also pioneered renewal movements in cities. After the Second World War, ‘urban development’, and in the early 1960s and 1970s, ‘urban improvement’ and ‘urban renewal’ strategies were given importance (Özmen, et al., 2021). Projects and plans implemented from the 1980s onwards were made with urban transformation content and were frequently used in the marketing of cities (Gündoğdu and Fidan, 2022). In the 1990s, the legal basis of urban transformation was regulated (Akkar, 2006: 29-38). These strategies, which were effective in the image of the city, were influenced by important periods experienced in the world. Before the 1980s, the city, which had grown by including rural areas, was a place where the 24 hours of the urban individual were planned for the functions of sitting-working-entertaining, and where production and consumption took place, turned into a place of signs and images (Aslanoğlu, 2000: 105) after the 1980s, which coincided with the new breaking point of urban development. Postmodernism, assuming that the belief that external reality can be represented objectively and decisively is a delusion (Tekeli, 2009: 18), stands skeptically against all determining discourses. Although there are discussions that postmodernism is not a transformation that has yet taken place, the effects it has created in the city are clear. Postmodernism views the community not as integrity, homogeneity, continuity and determinations, but as fragmentation, difference, indeterminacy, chaos, transience and discontinuity. This situation has also been reflected in the urban space and has ensured the increase in the importance of urban design that is compatible with postmodern discourses.

The Image of the City

Although the concept of city image has been mentioned in every period, today it does not express its purely literal meaning. While Lynch (2010) argues that the city should be well-shaped and have a silhouette that should serve human purposes, today's image serves the needs of capital groups rather than human services. While it can be assumed that the city image described by Lynch can be protected and created with urban design (Dal Cin, 2002: 53-70), it is seen that creating a city image can sometimes be achieved at the planning and sometimes at the urban design scale in line with capital interests (Tuna-Kayılı, 2024).

In city plans, zoning in space shows where the capital of that city can be transferred. For example, many local governments can decide in which sectors that city will develop as upper decisions in the Zoning Plan studies. For example, many discourses such as 'industrial city', 'tourism city' or 'congress city' originate from the effort to create a city image at the planning scale (Fidan and Önür, 2021). Urban design, on the other hand, is a guide to the division of capital centers into sub-centers within the city. It creates images for the city part with facilities such as closed housing projects, shopping malls, etc. Arrangements that increase the quality of life such as accessibility, mobility or flexibility (Dal Cin, 2002: 53-70) are used in the description and discourse of the city image at both urban design and planning scales.

Because of the unique features of the city, individuals typically build an impression of it in their brains. According to Kenneth Boulding (in Yananda et al., 2014), a place's image is a conglomeration of its attributes that align with the human viewpoint. He then separated the place's image into four primary categories, which are as follows:

-Cognitive, which refers to an individual's knowledge of a place or region.

- Affective, which has to do with how someone feels about a specific place or region

- Evaluative, which has to do with how someone feels about a place or their home.

- Behavioral, which has to do with whether someone is thinking about moving to a particular area to work, visit, invest, or immigrate.

In the meanwhile, Kevin Lynch (1960) proposed the image's literal interpretation, which depicts the form or appearance of a city, and suggested that the map displaying this image should include five components, specifically:

Node: strategic focal points for orientations like squares and intersections; Landmark: a point of external orientation, typically an easily identifiable physical object in an urban landscape; Paths: the route people take across the city; Edges: boundaries and breaks of continuity; third, districts: a region with general characteristics. Lynch claims that the path is the most crucial of these five components since it controls urban mobility.

A brand image, also known as a city image, is an impression that people have of a city based on its features. As stated by Kotler and Keller (2016). The opinion and trust that customers have of a city or brand is mirrored in the associations that they have stored in their memory. According to the circumstances, Kotler categorizes a location's image (place image) into favorable, weak, negative, mixed, paradoxical, and overly attractive representations (Yananda and Salamah, 2014).

As opposed to Kotler, Kenneth Boulding contends in Yananda and Salamah (2014) that a place's image is a collection of attributes that are part of the human viewpoint. In terms of a city's image from the standpoint of city branding, it is rather typical for many cities to market themselves by utilizing their potential these days. Generally speaking, image, originality, and authenticity are the three primary pillars upon which city branding is built. In an effort to restore its reputation, practically every city has city branding (Michalis Kavaratzis, 2004).

Cities are increasingly being marketed and promoted using branding as a marketing approach, much like a commodity.

Among other things, Ashworth claims that city or place branding seeks to identify or produce distinctiveness that sets this city apart from others (Ashworth, 2009). In order to create a marketable identity that everyone can embrace, city branding needs to take into account a variety of factors, including history and culture, social and economic development, infrastructure and architecture, landscapes and the environment, and more (Özeren and Tuna-Kayılı, 2020). Using a comprehensive strategy, city branding is a marketing tactic that helps to establish a distinctive perception of a place. Therefore, a city's image can be regarded as one of the most crucial factors affecting both city branding and city identity.

The Identity of the City

The Latin words *identitas,* which means sameness, and idem, which also means same, are the linguistic roots of identity. "Is it possible for something or an individual to be considered the same at different times?" is one of the identity-related issues in philosophy. and "When some of its components change, is it a different object or individual?" Martin and Barresi (2006) utilized this term in their personal identity theory to explain why some people are the same as others at one point in time and distinct from others at another (Tuna-Kayılı et al.,, 2016). Additionally, the term "same" implies that an entity is both unique and shares characteristics with other entities. Identity is the quality of the self that sets people apart from one another.

Webster's Ninth New Collegiate Dictionary defines identity as "the distinguishing character or condition of a person or a thing". Identity is also described by Lynch (2015) as "the degree to which an individual can identify or remember a location as being different from other locations." Cities should have personality and uniqueness, just like people do. This flavor is composed of many traits, or distinguishable components. In his groundbreaking book Place and Placelessness, Relph (1976, p. 147) emphasized the importance of place identity in the following ways:

“A deep human need exists for associations with significant places. If we choose to ignore that need, and follow the forces of placelessness to continue unchallenged, then the future can only hold an environment in which places simply do not matter. If, on the other hand, we choose to respond to that need and transcend placelessness, then the potential exists for the development of an environment in which places are for man, reflecting and enhancing the variety of human experience.”

Together with the realization that cities are not becoming more homogenizing in the wake of industrialization and globalization, studies have increasingly focused on urban identity in planning literature. In the planning literature, this idea is still not entirely obvious, but (Bernardo et al., 2016; Cheshmehzangi, 2020; Nientied, 2018). The idea of urban identity is somewhat ambiguous and frequently needs more explanation (Fidan and Gündoğdu, 2023). Architecture and urban design interpret this idea as the urban/city or architectural identity, whereas environmental psychology literature and the social sciences define it as human or social identity. In light of this, Lalli (1992) clarified four theoretical traditions pertaining to location and urban identity. He begins by offering a cognitive viewpoint that can be divided into two representations: meaning and environmental orientation.

Lynch's environmental orientation, "The Image of the City," looked at how people use cognitive maps to identify the urban environment. Meanwhile, Boulding's (1961) study, which assessed the city's environmental features, can be used to track the representation of meaning. The second discusses the phenomenological viewpoint, which emphasizes how people experience a location (Relph, 1976; Tuan, 1980). The third is the self-concept theory, which links identity to gender and ethnic identities and views it as a component of the self-concept (Proshansky et al., 2014). The fourth is sociological influence, which looks at how people's social identities relate to where they live.

Three identity theories—place identity, social identity, and identity process—were discussed by Hauge (2007) in relation to environmental behavior studies and architecture. Regarding the environment, the first is comparable to Lalli's (1992) self-concept theory. Place identification is a substructure of self-identity, claim Proshansky et al. (2014). A self-concept connected to people's presence in groups is described by social identity theory. Tajfel (1982) was primarily responsible for popularizing this concept, which was distinct from the location's real surroundings. Additionally, continuity, distinctiveness, self-efficacy, and self-esteem—the formation principles of Breakwell (1986) that Twigger-Ross and Uzzell (1996) later developed—are the main ties between identity process theory and these concepts. This notion claims that human identity is derived from one's location. Furthermore, there is still a problem with the widely recognized definition of urban identity in planning theory. Lalli and Hauge's explanations are not enough to situate the idea of urban identity within planning theory and practice.

These concepts merely outline theoretical traditions; they don't clarify how planners might influence urban identity. Different viewpoints among academics and urbanists were noted in the recent study by Mansour et al. (2023), which acknowledged the lack of agreement on the notion of urban identity. By analyzing viewpoints from many fields, they aimed to provide a thorough, interdisciplinary explanation and description of urban identity, with an emphasis on temporal dimensions, spatial size, and spectator views.

In order to develop the word in planning, it is important to differentiate between the three conceptions of urban identity, even though this method helps to understand the dynamic, temporal features of this idea. This differentiation allows planners to pinpoint particular facets of a city for focused intervention to strengthen its identity. A number of concerns are brought up by the use of the phrase "urban identity" in planning literature, including whether a city's identity issue stems from its physical characteristics or from its human nature. Many advantages can be gained by discovering and reinforcing a city's own identity. Small differences may be magnified, special events may be commemorated, designers may seek to set their stamps on projects, and many other motives may encourage efforts to undertake the quest for urban identity. A particular density determines a settlement's identity in relation to its surroundings. Density was undoubtedly a defining feature of towns and villages in every era and region of the world. Thus, this attribute appears to meet a fundamental human need. One could make reference to the necessity of defense in this context, which undoubtedly played a significant impact. But as Norberg-Schulz (1971, p. 30) noted, density also shows up in situations where defense was not required. Therefore, the incentive is more profound. The Egyptian hieroglyph for "city" was understood to also indicate "mother."

The city was perceived as being intimate, cozy, and welcoming. It generally correlates with what is commonly referred to as "human scale."

However, unless a suitable contextual layout is taken into consideration as an entity inside the city's evolving context, the density of a settlement is meaningless. Every aspect of the natural and physical world, especially the way the urban environment is developed over many generations, contributes to the local context. Cities are constantly changing due to a variety of circumstances; they are never static; they are constantly evolving, and while they do so, they may also replace and destroy some of their components (Dawelbait and Tuna-Kayılı, 2022). Therefore, the urban environment has to be considered from a historical perspective, not merely understanding historically significant buildings, but rather understanding the evolution of the local urban context, with respect to human activity, built form, and nature. This is also significant in creation of “a sense of place”, an important factor in achieving identity in urban settlements as stated by many theorists, such as Relph (1976) and Punter (1991).

In order to compete with other cities for resources, investment, or tourists, Ashworth (Hazime, 2011) asserts that a city must establish a distinctive identity that appeals to different stakeholders. A brand's identity is composed of six components, according to Kapferer (2008): physical components, personality, culture, relationships, reflection, and self-image. The Prism of Brand Identity is the name given to this feature. A brand uses the Prism of Brand Identity to determine and convey the most appropriate image and unique communication style to its target market. The following explanation applies to these aspects:

- Physical: an assortment of terms and outward traits connected to the brand. It evokes the brand's physical character and is its fundamental component.

- Personality: A brand's personality is a collection of human traits connected to it.

- Culture is a set of values and fundamental ideas that guide the actions of a brand. A brand might evoke a certain nation of ori-gin or technology, and it celebrates a particular culture.

- Relationships are the kinds of interpersonal connections that brands conduct. Brands frequently create explicit relationships amongst people by offering chances for intangible interactions.

CONCLUSION

Lynch identifies legibility, imageability, image, and identity as the four components that make up a city's visual quality. Lynch also defines five image elements for the physical examination of metropolitan settings. However, there is still room for research into how locals interpret different aspects of urban images. Therefore, when developing urban imaging, it is important to take into account a space's historic and sociocultural structure to avoid false urban aspects that could detract from its distinctive urban qualities. Establishing new landmarks and viewpoints can enhance and maintain urban imaging. Visually connecting landmarks can improve legibility, which is undoubtedly a practical strategy. The perception of the locals might be influenced by city tours, photography classes, and initiatives that allow visitors to view the city from various angles.

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CHAPTER 5

Repurposing of Industrial Buıldıngs: An Assessment in the Context of Sustainability

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1. INTRODUCTION

The repurposing of industrial buildings has increasingly become a widely adopted approach for sustainable development in modern urban areas. This process not only provides an opportunity to preserve historical value but also promotes efficient use of environmental and economic resources (Fidan and Önür, 2021; Gündoğdu and Fidan, 2022). Repurposing unused or obsolete structures with new functions contributes to urban resilience against growing populations and aids in the conservation of natural resources (Bullen & Love, 2011; Fidan ve Gündoğdu, 2023). Additionally, this process offers the potential to reduce environmental impact through the reuse of building materials, thereby supporting sustainable urbanization goals (Langston et al., 2018). In this context, repurposing industrial buildings for sustainability results in lower energy consumption and reduced waste generation in urban transformation processes. This leads to a reduction in structural carbon footprint and provides a lower environmental impact compared to new construction (Thomsen & Van der Flier, 2011). Therefore, the adaptive reuse of industrial structures is viewed as a sustainable option from both economic and environmental perspectives and is supported by many countries (Shipley et al., 2006).

This section aims to evaluate the importance of repurposing industrial buildings from a sustainability perspective. The study will elaborate on the environmental, economic, and social benefits that can be achieved through the reuse of these buildings. Additionally, the ways in which adaptive reuse processes can be integrated into sustainable development goals will be examined. In this context, examples from both Turkey and international literature will be provided, and the impacts of such projects on sustainability will be discussed.

2. THE CONCEPT OF SUSTAINABILITY AND REPURPOSING

2.1 Principles of Sustainability

Sustainability involves the use of resources to meet present needs without compromising the ability of future generations to meet theirs, by maintaining environmental, economic, and social balance (Brundtland, 1987; Tuna-Kayılı and Onur, 2019). The principles of sustainability are structured around three main elements:

Environmental Sustainability: This principle emphasizes the conservation of natural resources, energy and resource efficiency, biodiversity preservation, and waste management. Repurposing industrial buildings promotes lower resource consumption by reusing existing structures instead of constructing new ones (Pinder & Tweed, 2007).

Economic Sustainability: Economic sustainability includes practices that support the local economy, cost-effective solutions, and long-term gains. Repurposing projects are often less costly than new constructions and can contribute to the economy by creating employment opportunities (Shipley et al., 2006).

Social Sustainability: Social sustainability aims to improve the health, education, culture, and well-being of communities. Repurposing industrial buildings supports cultural heritage preservation and fosters a sense of belonging in the community (Bullen & Love, 2011; Onur and Tuna-Kayılı, 2021).

2.2 The Relationship Between Repurposing and Sustainability

Repurposing industrial buildings serves as an effective tool for achieving sustainability goals. It allows for the modernization of older structures to improve energy efficiency, thereby reducing construction waste and optimizing resource use (Langston et al., 2018). This process not only maintains the building's original character but also supports social and cultural sustainability, increasing community support for such projects (Thomsen & Van der Flier, 2011).

Additionally, the reuse of industrial buildings offers an eco-friendly solution in urban transformation projects. Equipping these buildings with modern energy systems and environmentally friendly materials reduces energy consumption and positively contributes to environmental sustainability (Langston et al., 2018). Furthermore, repurposing provides an opportunity to utilize existing building stock instead of increasing urban density, reducing the need for new land use (Pinder & Tweed, 2007).

Repurposing industrial buildings contributes to sustainable urbanization and environmental conservation efforts by enabling more efficient use of existing building stocks (Onur, 2020). This practice can be evaluated under four main categories in terms of sustainability: environmental benefits, economic advantages, social impacts, and cultural preservation

Environmental Benefits

Repurposing projects generally consume less energy and resources compared to new constructions. Reusing existing buildings significantly reduces the materials, energy, and water needed for new construction (Thomsen & Van der Flier, 2011). These projects also help reduce construction waste and prevent greenhouse gas emissions that could occur during demolition, thereby lowering the carbon footprint (Langston et al., 2018). By reducing energy consumption and environmental degradation, repurposing provides an effective solution for combating climate change. For example, integrating energy-efficient systems in buildings can significantly reduce carbon emissions (Bullen & Love, 2011).

Economic Advantages

From an economic perspective, repurposing projects are often more cost-effective than new construction. Reusing existing structures reduces material and labor costs while also shortening the project timeline (Shipley et al., 2006). When implemented in urban areas with developed infrastructure, repurposing projects support regional economic development and create employment opportunities for the local workforce (Pinder & Tweed, 2007). Additionally, repurposed industrial buildings adapted for commercial or residential use often experience high demand, contributing to an increase in property values. Research indicates that these projects can provide a higher return on investment compared to new constructions and offer long-term operational savings (Bullen & Love, 2011).

Social Impacts

Repurposing projects contribute to social sustainability by generating community benefits. Abandoned or obsolete industrial areas can be revitalized with new functions, improving community access to livable spaces (Thomsen & Van der Flier, 2011). This transformation strengthens a sense of belonging and encourages social cohesion. Moreover, these projects enhance local interest in cultural heritage and promote environmental awareness (Shipley et al., 2006). For instance, transforming an industrial structure into an arts center, museum, or social venue meets the cultural and social needs of the community, enhancing social sustainability while improving residents' quality of life (Bullen & Love, 2011).

Cultural Preservation and Heritage Continuity

While each architectural type retains its fundamental characteristics at its roots, it displays unique differences in details influenced by cultural and geographical factors (Eraslan & Mutlu, 2024). The repurposing of industrial buildings contributes to the preservation of cultural heritage (Bölükbaşı Ertürk, 2020). When industrial buildings with historical value are adapted for new functions, they maintain their original character, thereby preserving collective memory (Onur, 2020; Yağcı & Değirmenciler, 2024). These structures are preserved as part of both cultural and architectural heritage, passing on to future generations (Langston et al., 2018). Industrial architecture, in particular, is considered a reflection of past economic and social structures; when such buildings are lost, cities lose part of their historical identity. Repurposing projects preserve the architectural value of these buildings while adapting them for modern use, thereby strengthening the connection between past and future (Thomsen & Van der Flier, 2011).

Contribution to Sustainable Urbanization

Repurposing industrial buildings plays a significant role in sustainable urbanization. Utilizing existing building stock instead of expanding urban areas helps to prevent urban sprawl and reduce environmental degradation (Pinder & Tweed, 2007). Repurposing projects also enable more efficient use of urban spaces, reduce infrastructure demands, and help conserve the natural environment. For example, repurposing an industrial building reduces the need for new land use, allowing for the preservation of green spaces within cities. This contributes to sustainable urban planning policies, paving the way for creating more livable cities in the future (Shipley et al., 2006).

In this context, the repurposing of industrial buildings should be viewed not only as individual projects but also as a strategic application that contributes to the broader sustainability goals of cities. In summary, repurposing industrial buildings offers significant environmental and social benefits and plays a critical role in urban planning and sustainable development strategies.

3. REPURPOSING OF INDUSTRIAL BUILDINGS: METHODS AND STRATEGIES

3.1 Repurposing Process

The process of repurposing industrial buildings involves several distinct stages. Initially, a thorough assessment of the building's current condition is conducted, taking into account factors such as structural integrity, environmental impact, historical significance, and cultural value (Conejos et al., 2016). These evaluations are essential for determining the building's suitability for new functions and for selecting the methods that will meet environmental, economic, and social sustainability goals (Plevoets & Van Cleempoel, 2011).

Another crucial factor in the repurposing process is compliance with legal and technical regulations. Local building codes, energy efficiency standards, and environmental protection laws play a significant role in shaping repurposing strategies (Douglas, 2006). Additionally, identifying user needs and securing community support are essential for the project's success. Projects that enhance social sustainability are more likely to be embraced by the community, ensuring their long-term success (Bullen & Love, 2011).

3.2 Material and Energy Efficiency

Repurposing industrial buildings presents significant opportunities in terms of material and energy efficiency. Preserving and reusing existing building materials, such as steel, concrete, and brick, not only saves energy but also reduces environmental impact by minimizing waste and material consumption (Thormark, 2006; Kara and Tuna-Kayılı, 2021).

In terms of energy efficiency, renewable energy sources can be integrated into repurposed industrial buildings. Technologies like solar panels, wind turbines, and energy-efficient HVAC (heating, ventilation, and air conditioning) systems help reduce the energy consumption of these buildings, lowering their carbon footprint (Yung & Chan, 2012). Such energy efficiency strategies contribute to the building's sustainability goals while also lowering its life cycle costs (Dixit et al., 2012).

3.3 Environmental Impact Reduction

Repurposing industrial buildings offers considerable potential for reducing environmental impact. During the repurposing process, aspects such as material transportation, waste management, and energy use are carefully managed to minimize the building's carbon footprint (Thomsen & Van der Flier, 2011). Proper waste management and recycling practices in repurposing projects are critical steps toward environmental sustainability (Gorgolewski, 2008).

Another strategy to reduce environmental impact in repurposing is the use of green roofs and green walls. These systems improve thermal performance, enhance air quality, and aid in water management by retaining rainwater (Wilkinson & Reed, 2008). Furthermore, equipping existing buildings with energy-efficient systems helps reduce greenhouse gas emissions, enhancing the overall sustainability of the structure. These repurposing strategies not only reduce the carbon footprint but also provide long-term energy savings (Langston et al., 2018).

4. EXAMPLES OF REPURPOSED INDUSTRIAL BUILDINGS

4.1 Silahtarağa Power Plant – Istanbul, Turkey

Original Function: Power Plant

New Function: Cultural and Arts Center

Silahtarağa Power Plant stands as a successful example of industrial repurposing in Turkey. Built in the early 20th century, this was Turkey's first power plant, and in 2004 it was repurposed by Istanbul Bilgi University as "Santral Istanbul." Today, Santral Istanbul serves as both an educational hub and a cultural and arts complex, exemplifying how historic industrial structures can be adapted to serve cultural functions (Bademli, 2010). In this project, the industrial aesthetic of the power plant has been preserved, while the space has been transformed to create environments conducive to education and social interaction.

- **Preservation and Aesthetic Balance**: In the Silahtarağa Power Plant and Tate Modern projects, the industrial character of the structures has been preserved while adapting them for modern uses. This approach maintains the historical identity and aesthetic value of the buildings while also providing functional spaces that meet the needs of contemporary users (Wilkinson & Reed, 2008).
- **Sustainable Structural Transformation**: The project incorporates innovative, energy-efficient solutions while preserving the original building elements. At Santral Istanbul, existing structural components were reused to minimize energy consumption (Bademli, 2010).

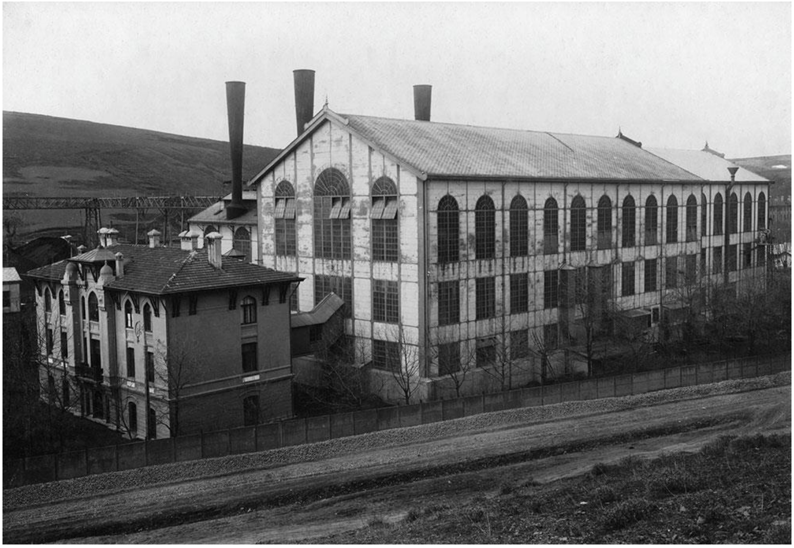

Figure 1. Silahtarağa Power Plant (1910) [https://tr.wikipedia.org/wiki/Silah-tara%C4%9Fa_Elektrik_Santrali]

- **Social and Cultural Contributions:** The success of repurposing projects depends not only on the physical transformation of the buildings but also on their social and cultural impact. Santral Istanbul contributes significantly to the local community by organizing cultural events for students, artists, and the public.
- **Economic Contributions and Return on Investment:** Silahtarağa Power Plant has generated substantial economic benefits within the scope of urban transformation projects. As Santral Istanbul became a cultural center, it brought economic vitality to the area, created new job opportunities, and supported the local economy (Bademli, 2010).

Figure 2. Santral İstanbul [https://www.santralistanbul.org/tr/hakkinda/]

Figure 3. Santral İstanbul [https://www.santralistanbul.org/tr/hakkinda/]

4.2 Haliç Shipyard – Istanbul, Turkey

Original Function: Shipyard New Function:

Cultural and Tourism Complex

Haliç Shipyard is a significant structure deeply integrated with Istanbul's rich history and industrial heritage. Dating back to the 15th century, this shipyard served as a site for shipbuilding and maintenance from the Ottoman Empire through to the present day. Thanks to repurposing efforts, the shipyard has been revitalized as the Istanbul Art Museum, a cultural and tourism complex that preserves Istanbul's cultural heritage and contributes to sustainable tourism.

- **Preservation and Aesthetic Balance**: In the repurposing process of Haliç Shipyard, maintaining the historical character of the structure was prioritized. The project preserved the original architectural elements and aesthetic features while adapting the site to meet modern needs. This balance ensures the cultural heritage value is maintained, allowing the structure to be passed on to future generations (Wilkinson & Reed, 2008). The preservation of historical architectural details, facades, and industrial elements within the shipyard enables it to retain its authentic character in a sustainable manner. Thus, Haliç Shipyard not only reflects Istanbul's historical and cultural identity but also serves as a functional venue for cultural events.
- **Sustainable Structural Transformation**: Sustainable structural transformation strategies were applied during the repurposing of Haliç Shipyard. Existing stone walls and metal frameworks were preserved, reducing the need for new materials and minimizing construction waste (Thormark, 2006). Additionally, low-energy lighting systems and natural ventilation were integrated to enhance energy efficiency. These systems reduce the costs of heating, cooling, and lighting, save energy, and lower the carbon footprint (Yung & Chan, 2012). Sustainable features such as green roofs and rainwater harvesting systems were also incorporated, reducing the environmental impact and contributing to water management.
- **Social and Cultural Benefits**: The transformation of Haliç Shipyard into a cultural and tourism complex has provided substantial social and cultural benefits. The shipyard offers a broad cultural space for Istanbul's residents and visitors, with exhibition halls, concert venues, event spaces, and social areas that create a multifunctional space (Bullen & Love, 2011). This project supports Istanbul's cultural heritage and social fabric, encouraging community connections to this historic site through cultural events. The shipyard offers visitors an opportunity to experience Istanbul's industrial history while serving as a platform for cultural interaction, making it an exemplary project for cultural heritage preservation and social sustainability.

- **Economic Contributions and Return on Investment**: The repurposing of Haliç Shipyard has enhanced Istanbul's tourism potential and contributed to the local economy. Through cultural and artistic events, the shipyard attracts both local and international tourists, increasing commercial activity in the area (Strom, 2002). The project's economic contributions are further supported by increased business for local vendors and the service sector. Additionally, tourism revenues provide benefits to local businesses and create employment opportunities, while also increasing property values in the area. This type of transformation project offers high investment returns and is evaluated as a sustainable, tourism-oriented project that provides long-term contributions to Istanbul's economy.

Figure 4. Haliç Shipyard interior (İstanbul Art Museum) [https://ataturkkitap-ligi.ibb.gov.tr/tr/Kitaplik/Muzelerimiz/Istanbul-Sanat-Muzesi/27]

4.3 Silo City – Buffalo, USA

Original Function: Grain Silo

New Function: Cultural and Event Space

Silo City is a project in Buffalo, New York, that has transformed historic grain silos into spaces for cultural and social engagement. This project emphasizes the preservation of industrial heritage and sustainable transformation principles.

- **Preservation and Aesthetic Balance:** In the repurposing of Silo City, the industrial aesthetic of the structures has been preserved while adapting them for modern uses. The silos' original concrete structure and industrial character have been maintained, transforming them into unique venues for art events and social gatherings. The tall ceilings and spacious interiors provide a distinctive atmosphere for concerts, performances, and exhibitions (Schroeder, 2015). The building's original structure has been harmonized with its new functions, achieving a balance between preservation and aesthetics. This approach preserves the historical value of the space while creating an appealing venue for art enthusiasts and visitors.

- **Sustainable Structural Transformation:** In the Silo City project, existing materials were largely preserved and reused, minimizing the need for new construction materials and reducing the project's carbon footprint. Energy-saving systems were also integrated, with lighting and climate control systems modernized to reduce energy consumption. Large windows allow natural light to flood the space, reducing the need for artificial lighting and creating a bright and inviting atmosphere. This resource-efficient transformation has contributed to the creation of an eco-friendly cultural space (Langston et al., 2018).

- **Social and Cultural Benefits:** Repurposing Silo City into a cultural and event space has boosted social interaction and cultural participation in Buffalo. The project hosts various events, including music festivals, art exhibitions, performances, and social gatherings (Schroeder, 2015). Transforming an industrial building into a social hub has strengthened the local community's connection to this space. The innovative programs at Silo City reflect Buffalo's cultural diversity, supporting social sustainability. Additionally, repurposing this historic building as a cultural space fosters a sense of belonging in the community and offers visitors an opportunity to experience the region's industrial heritage (Bullen & Love, 2011).

- **Economic Contributions and Return on Investment:** The repurposing of Silo City has significantly contributed to Buffalo's economic growth. This project has attracted both local and international tourists, revitalizing the region's tourism and contributing to the local economy (Strom, 2002). The events hosted at Silo City not only increase visitor numbers but also support commercial activity in nearby businesses. The project has benefited local restaurants, cafes, hotels, and retail establishments while also creating new job opportunities. In terms of investment return, Silo City is a sustainable tourism-based project that has provided substantial long-term economic benefits and helped elevate Buffalo's profile on the cultural and tourism map.

Figure 5. Silo City, Buffalo [https://www.behance.net/gallery/29958147/Silo-City-Buffalo-NY]

4.4 Zeche Zollverein – Essen, Germany

Original Function: Coal Mine and Steel Production Facility

New Function: Cultural and Artistic Center, UNESCO World Heritage Site

Zeche Zollverein is a historic coal mine and steel production facility located in Essen, Germany. Representing Germany's industrial heritage, this structure was designated as a UNESCO World Heritage Site following an innovative repurposing process. The preservation of this industrial heritage site as a cultural center was achieved through sustainable transformation strategies.

- **Preservation and Aesthetic Balance**: In the repurposing process of Zeche Zollverein, the industrial aesthetic of the structure was preserved while transforming it into a contemporary cultural center. The original architectural features of the mining and steel structures were maintained and integrated with new functions. One of the iconic elements, the coal mine tower, reflects the industrial heritage identity of the building, while the interiors have been redesigned as modern exhibition spaces and museums (Kraus, 2006). This project achieved aesthetic preservation by staying true to the building's original identity and retaining historical industrial details to create an atmosphere that allows visitors to experience its history. Additionally, preservation work adhering to UNESCO World Heritage standards has given the structure an artistic expression.

- **Sustainable Structural Transformation**: Zeche Zollverein serves as a successful example of sustainable structural transformation. The project preserved and reused existing industrial building materials as much as possible within a sustainable framework (Langston et al., 2018). Retaining original building elements instead of new construction has contributed to reducing the carbon footprint. Modern energy-efficient systems and natural lighting solutions have been integrated to reduce energy consumption. For example, large glass panels and open interior spaces allow natural light to illuminate the exhibition areas, minimizing electricity usage. Such sustainable practices have reduced Zeche Zollverein's ecological impact, allowing the building to function as an environmentally friendly cultural center (Thormark, 2006).

Figure 6. Zeche Zollverein, 1980 [https://commons.wikimedia.org/wiki/File%3A20180114_Zeche_Zollverein%2C_Essen_%2801980%29.jpg]

- **Social and Cultural Benefits:** Zeche Zollverein has brought significant social and cultural benefits. This structure, which bears witness to Germany's industrial history, has become a prominent venue for cultural and artistic events. Through cultural activities, exhibitions, concerts, and creative incubators, the facility fosters community engagement with both the arts and industrial heritage (Bullen & Love, 2011). This transformation of Zeche Zollverein not only offers visitors the chance to experience Germany’s industrial past but also creates new spaces for creative and artistic activities. The project has heightened local interest in the site and fostered an awareness of cultural heritage preservation. Zeche Zollverein has become a center for young creative entrepreneurs, supporting artistic and cultural diversity in the region.

Figure 7. Zeche Zollverein, 2021

- **Economic Contributions and Return on Investment:** The repurposing of Zeche Zollverein has made a significant economic impact on the Essen region and is regarded as a high-return investment. Its designation as a UNESCO World Heritage Site has increased interest in Zeche Zollverein, bringing vibrancy to the tourism sector. As a national and international tourist attraction, Zeche Zollverein has contributed to the local economy, benefiting tourism facilities and commercial enterprises in the area (Strom, 2002). In addition to tourism revenue, the job opportunities and cultural events generated by Zeche Zollverein have supported economic activity, contributing to Essen's sustainable development. These economic benefits ensure a high return on investment, positioning the project as a long-term success story.

5. CONCLUSION

The repurposing of industrial buildings provides significant benefits in terms of sustainable urbanization, cultural heritage preservation, and economic development. Projects like Silo City (Buffalo, USA), Zeche Zollverein (Essen, Germany), Haliç Shipyard (Istanbul, Turkey), and Silahtarağa Power Plant (Istanbul, Turkey) are exemplary cases of preserving industrial heritage while adapting it for modern use. These projects demonstrate that it is possible to retain the historical and aesthetic essence of industrial buildings while creating social, cultural, and economic value.

These four projects succeed in maintaining a balance between preservation and aesthetics. Zeche Zollverein reflects Germany's industrial heritage as a cultural and artistic center while retaining the iconic identity of its mining structures. In Haliç Shipyard and Silahtarağa Power Plant, industrial architectural elements from the Ottoman and early Republic periods have been preserved, returning these structures to society as part of Istanbul's cultural heritage. Silo City, too, retains its industrial aesthetic while providing spaces for art events and social gatherings within its original structure.

From a sustainable transformation perspective, these projects showcase the preservation of existing materials and integration of energy-efficient systems. In Zeche Zollverein and Silahtarağa Power Plant, modern energy-saving systems support environmental sustainability by reducing energy consumption. In Haliç Shipyard and Silo City, natural lighting solutions and the use of original materials contribute to sustainability while lowering carbon footprints. These projects also generate social and cultural benefits. Silo City and Haliç Shipyard have become cultural hubs for locals and tourists, fostering social interaction through exhibitions, concerts, and events. Zeche Zollverein and Silahtarağa Power Plant offer spaces where local communities can connect with the past, promoting cultural sustainability. Preserving industrial heritage and reintegrating it into society fosters a sense of belonging in local communities and enhances cultural engagement.

Economically, these projects have significantly contributed to the development of their regions. Zeche Zollverein and Silahtarağa Power Plant support local economies through tourism potential, creating job opportunities. Meanwhile, Haliç Shipyard and Silo City have stimulated economic activity by opening new commercial opportunities. These projects are high-return investments, serving as sustainable tourism and cultural centers that provide long-term economic benefits to their regions.

These four examples illustrate that the repurposing of industrial buildings is not merely a physical transformation but also a powerful tool for cultural heritage preservation, environmental sustainability, and economic growth. The reintegration of industrial heritage with modern functions plays an essential role in building more sustainable cities for the future. These projects serve as key models, demonstrating that industrial buildings can be transformed to preserve historical connections while offering multifaceted benefits to communities.

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CHAPTER 6

Investigation of Land Use/Cover Changes After the Disease Pandemic Using Remote Sensing Technologies; the Case of Antalya Döşemealtı

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Introduction

Today, remote sensing science and technology makes it possible to monitor the regions where urbanisation is intensifying and the population is increasing due to population growth, and in this context it is possible to make new projections by determining the use and change of land cover. The need for settlement based on world population growth leads to the opening of planned and sometimes unplanned settlement areas by local governments, and land use types are shaped by preparing zoning plans according to regions and creating the necessary infrastructure. In this context, individual preferences also come to the fore.

Important factors influencing individual preferences can be natural, economic and socio-cultural. It is well known that in recent years our country, along with the rest of the world, has been severely affected by the pandemic disease Covid. This pandemic disease has proved to be an important socio-cultural influence in determining the settlement areas of individuals during and after the pandemic disease. In fact, as a result of the fact that people were confined to apartments for months when the pandemic disease was very intense, after COVID-19 people began to prefer houses with gardens or villas according to their economic status. In a study conducted by Kurt (2021), it was observed that with the effects of the COVID-19 virus, people had a reflex to move away from crowded environments or to live in areas far from the city. According to the researcher, construction or urbanisation has increased in areas far from the city centre after the pandemic. One of the important areas to give an example of this behaviour is Antalya province, and the preference for construction in the Döşemealtı region supports the phenomenon mentioned by Kurt (2021).

According to data from the Turkish Statistical Institute (TUIK), Döşemealtı district, an important and developing region of Antalya province, reported a significant increase in population after the pandemic disease. While the population of the district was 63,186 in 2018 before the pandemic disease, it increased to 86,109 in 2023 after the pandemic disease. Considering that the type of settlement in the region is villa format rather than apartment buildings, this change in population is quite remarkable. While a population increase of 11,173 people was observed in Döşemealtı district between 2013 and 2018, when the increase of 22,923 people observed between 2018 and 2023 is examined, it is found that the population increase in the 5-year period after the pandemic disease has approximately doubled (TÜİK, 2024). In a study by Comart and Akıncı (2017), it was found that the Döşemealtı region started to accommodate industrial buildings and luxury housing. According to these data, it is clear that there is a significant demand in the region due to the increase in the district's population. In this context, it is also very important to reveal the effects of urbanisation and industrial construction on land use and land cover in the region.

As it is known, land use and land cover changes have been carried out for many years using remote sensing science and technology. According to Genc (2013), it is possible to monitor land changes in different regions with remote sensing science and technology. There are many national and international studies in this field. In Antalya province, remote sensing studies on land use and land cover change have been carried out at medium and small scales and different methodologies have been tested. For example, Sönmez and Onur (2012) used the fuzzy controlled classification method to determine land use and land cover changes in Antalya province. In a study by Sönmez et al (2009), land use/change in the Kemer district was determined using CORINE medology with IKONOS satellite data. Again, Sönmez and Sarı (2007) monitored land use change in the Western Mediterranean region using remote sensing technology. In a review study by Asokan and Anitha (2019), different remote sensing techniques were evaluated in determining land use changes.

In contrast to other studies carried out in the region, this study aimed to determine the impact of the rapid population growth in the district after the pandemic on land use using remote sensing techniques. In this context, the study used Sentinel-2 satellite data, which has a higher spatial resolution than the Landsat-8 satellite. In addition, the CORINE methodology and legends were used for classification studies.

1.Study Area

Döşemealtı district of Antalya province is located at 37° 1' 23" north latitude and 30° 36' 5" east longitude. The area is mainly forested and agricultural. At the same time, sinkholes formed as a result of the extraction of underground water are also observed in the region.

Figure 1. Study Area

In the Döşemealtı district, where there were active rivers in ancient times, there are now only dried riverbeds. Apart from urban buildings, there are also industrial buildings and mining quarries in the region. The approximate area of the district is 673.1 km² and the average altitude is 300 m (Döşemealtı Kaymakamlığı, 2024).

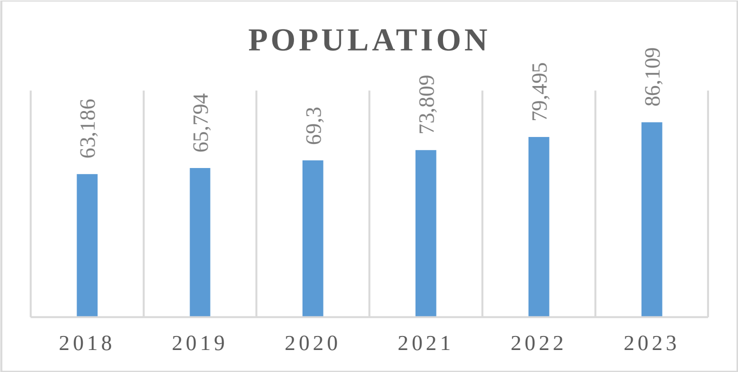
2.Materials and Methods

2.1. Data

In the study, the CORINE legend was used as a training dataset in the process of determining land use classes. The CORINE dataset has been prepared to collect information on the environment since 1985 and has been continuously updated every 6 years since 1985 (Copernicus, 2024). Turkey was included in the CORINE project in 2012. The CORINE dataset consists of 3 different scales, Level 1, Level 2 and Level 3, which indicate how detailed the classification is in the CORINE classification project and which classes are included. The legends of the Level 1 and Level 2 scales were used in the study.

Data from the Turkish Statistical Institute (TUIK) were used to monitor annual population changes in the study area. These data from TUIK are an important dataset showing the change in the regional population after the pandemic disease (Table 1).

Table 1. Döşemealtı Population Change (TÜİK, 2024).



Another dataset used in the study, Sentinel-2 satellite data for the years 2018 and 2023, was used in the remote sensing studies carried out in the area. This data was obtained from the GEE (Google Earth Engine) platform. Sentinel satellites are Earth observation satellites of the European Space Agency: Sentinel-1 is a Synthetic Aperture Radar (SAR) satellite, Sentinel-2 and Sentinel-3 are Earth observation satellites and Sentinel-5 is a tropospheric observation satellite (Copernicus, 2024; ESA, 2024; Sentinels Copernicus, 2024). As the Sentinel-2 satellite also has a higher temporal resolution (5 days) than the Landsat satellites, it can be used to monitor land use at more frequent time intervals for issues such as land change (Altun and Türker, 2021). The spectral bands of the Sentinel-2 satellite used are listed in Table 2.

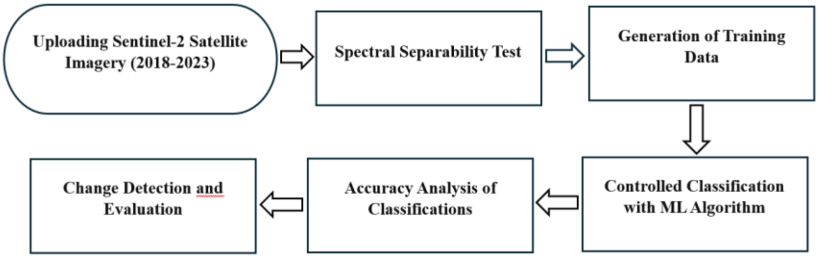
Table 2. The spectral bands of the Sentinel-2 satellite

Spectral Bands	Resolution (m)	Wavelenght (nm)
Aerosol	60	443.9
Blue	10	469.6
Green	10	560
Red	10	664.5
Red Edge	20	703.9
Red Edge-2	20	740.2
Red Edge-3	20	782.5
Near Infrared	10	835.1
Red Edge-4	20	864.8
SWIR	60	945
SWIR-2	60	1371.5
SWIR-3	60	1641
SWIR-4	60	2190

2.2.Method

This study, which examines land cover changes after the pandemic using remote sensing data, consists of several process steps. These steps can be summarised as pre-classification preparation, classification study and accuracy analysis. In this context, the workflow diagram is shown in Figure 2.

Figure 2. Workflow diagram



Prior to classification, a spectral separability test was carried out to determine the bands that best represented the cover types in the area. At this stage, the Jeffries-Matusita method was used. According to Garcia Salgado and Ponomaryov (2015), the method used is a reliable source in terms of determining the separability of spectral bands. As a result of the testing, the near infrared (835.1 nm), red (664.5 nm) and green (560 nm) spectral bands were used for classification purposes, as they were considered to be successful in classification.

During the preparation of the training data set for the classification process, the CORINE legend, which is considered to represent the land use in the area, was used. As in the studies of Başayiğit (2004), Onur et al. (2009) and Sönmez et al. (2009), the level 1 legend prepared according to the CORINE methodology was used as training data in this study. The classes used in the study are shown in Figure 3.

The maximum likelihood algorithm was used in the classification stage. As stated by Comart and Akıncı (2017) and Kuşçu (2005), this algorithm is an algorithm that provides more successful results than other supervised classification algorithms because it performs the classification process by creating variance-covariance matrices of pixel reflectance values.

After the supervised classification process in Döşemealtı district, accuracy analyses were performed to test the accuracy of the classes determined at level 1 according to the CORINE method. In the accuracy analysis, high-resolution satellite data contained in Google Earth Pro software were used as ground truths.

At this stage, the classes assigned to each pixel were compared with the high-resolution satellite image and the accuracy analyses were completed by entering the true-false inputs into the SCP plugin (Aydın and Durduran, 2021).

Çizelge 3. Land cover classes selected according to CORINE land use classes

Land Cover Classes (Level 2)	CORINE Land Use Classes (Level 1)
Urban Structures Industry, Trade and Transportation Units	Artificial Areas
Arable Areas Permanent Areas	Agricultural Areas
Forests	Forest and Semi-Natural Areas
Inland Waters	Water Bodies

3.Results and Discussion

As a result of the controlled classification conducted in Döşemealtı district, the classification accuracy for 2018 was determined to be 81% and the classification accuracy for 2023 was determined to be 78%. This accuracy rate determined as a result of the classification is quite high, and similar accuracy values were achieved in the studies conducted by Reis (2016) and Duran and Doğan (2022).

According to the classification results for the post-pandemic and pre-pandemic periods, the area values calculated for each class are shown in Table 4.

Table 4. Classified land cover areas and distributions according to CORINE

Land Cover Classes (Level 2)	Area (km^2) 2018	Area (km^2) 2023	Increase/Decrease (%)
Urban Structures	54.96	64.33	17.04
Industry, Trade and Transportation Units	10.38	10.54	1.54
Arable Areas	150.78	187.03	24.04
Permanent Areas	56.55	33.33	-41.06
Forests	179.47	156.91	-12.57
Inland Waters	0.08	0.09	12.5
Toplam	**458.64**	**458.64**	

According to the results obtained as a result of the classification process carried out as part of the study, it can be seen that the urban structure increased from 54.96 km2 in 2018 to 64.33 km2 in 2023 (Table 4).

As can be seen from Table 4, in the 5-year change period covering the post-pandemic period, it was found that there was a decrease in forest areas and perennial permanent agricultural areas such as citrus and pomegranate trees due to the 17.04% increase in urban structure. According to the results of the classification carried out in the area, it was concluded that illegal constructions could occur after the pandemic, especially in forest areas that were not opened to construction. It is also assumed that permanent agricultural areas, which should be protected under the Land Use Law, have been destroyed and transformed into urban structures.

These findings, as stated by researchers such as Comart and Akıncı (2017) and Karataş (2020), indicate that most of the rural areas were destroyed by the psychology of moving away from the cities after the pandemic and started to undergo negative changes. It is assumed that the Döşemealtı region, which has a history of agriculture and animal husbandry, has also been affected by this situation.

According to the classification map shown in Figure 1 and Figure 2, when evaluating the regions where urban areas are concentrated, it can be seen that the increase of urbanisation in Döşemealtı District shows a tendency especially from the south to the north of the district. In addition, a significant increase in urban structures was also observed in the east of the district and in areas far from the centre. Considering that these areas were previously agricultural and forested areas, it is clear that the urbanisation pressure in this region has increased after the pandemic disease.

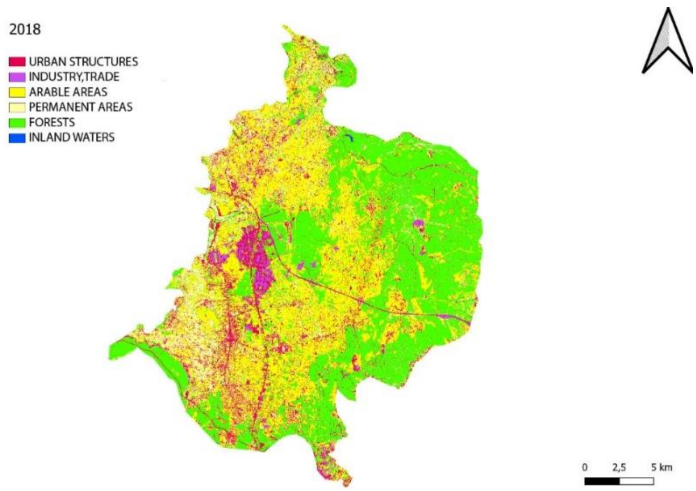


Figure 3. Classification Result for 2018

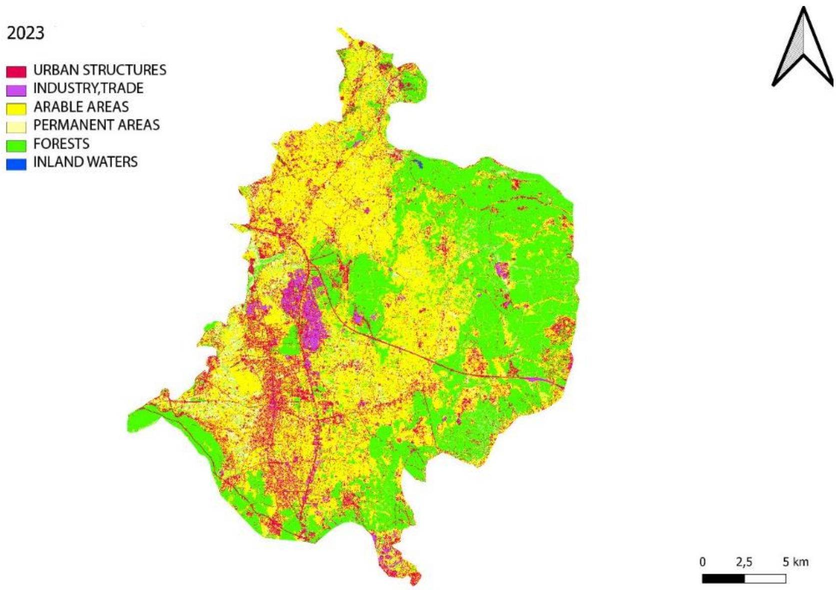


Figure 4. Classification Result for 2023

4. Conclution

As a result of the study, when the changes in land cover distribution in Antalya/Doşemealtı region before and after the pandemic were examined using remote sensing science and technology, it was found that although no radical change was observed in the area, there was a decrease in agricultural and forest areas due to the increase in urban areas in the last 5 years after the pandemic. Although there are zoned areas in the Döşemealtı region, a decrease of about 13% in forest areas not open to development is a remarkable finding. There is an urgent need to determine the occupation of these areas, which are extremely important for the ecosystem of the region, and to take the necessary measures. The results of the study show that people tend to settle outside the city after the pandemic. According to these changes in land cover and land use, it has been concluded that the agricultural and livestock areas of the Döşemealtı region that are not open to development should be protected so that they are not destroyed and that controlled urbanization is an important factor.

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CHAPTER 7

Determination of The Social Carrying Capacity of Günpınar Waterfall Nature Park in Malatya Province

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INTRODUCTION

The purpose of Protected Areas and Nature Parks is to provide recreational benefits to society through their natural, cultural, and historical values while simultaneously preserving these values for future generations in a healthy manner by systematically limiting current users (Göktuğ et al., 2013; Şen, 2020). In such areas, the visitor density resulting from population increases over the years has caused damage, leading to situations where the expectations of visitors cannot be met due to the degradation of the natural, cultural, or historical structure of the recreation resource. To prevent these undesirable outcomes, it is necessary to determine the maximum number of individuals that an open recreation area can serve during recreational activities to minimize potential damage to natural or cultural assets (Göktuğ et al., 2011). One of the analyses developed for this purpose is the Determination of Recreational Carrying Capacity, which seeks to answer how to maintain the balance between conservation and use in protected areas (Göktuğ, 2011; Bekiryazıcı, Satıroğlu and Aydın, 2024).

Recreation is an activity undertaken during free time, which does not aim for any material gain or reward but is entirely focused on the mental and physical rejuvenation of individuals. Most importantly, it involves activities that individuals participate in voluntarily, without any obligation, driven by their intrinsic motivation (Ekşioğlu, 1996; Koyuncu, 2012).

Carrying capacity is traditionally defined as the number of visitors that an area can sustain without degrading its natural resources and visitor experiences. Newer definitions of carrying capacity for protected areas, such as national parks, focus on the acceptability of natural resources and the human impact of visitation, considering the biophysical characteristics (soil, topography, and vegetation) of a protected area, as well as social factors (location). Additionally, travel mode, season of use, group size, and visitor behavior, along with management policies (visitor usage restrictions), are significant determinants of carrying capacity (Manning and Lawson, 2002; Yıldız, Demir, and Yılmaz, 2011; Göksu, 2022).

The concept of recreational carrying capacity emerged in 1964 with Wagar's monographic work on the subject. It was proposed that an increase in the number of visitors to a recreational area not only causes environmental problems but also leads to a decline in park quality. The fundamental objective of recreational carrying capacity is to determine, by management, the maximum number of visitors that a protected area offering recreational opportunities can accommodate without compromising its physical environment and cultural values. Therefore, it is a multifaceted concept with physical, social, and ecological dimensions (Sayan and Ortaçeşme, 2005; Göktuğ and Arpa, 2016).

Social carrying capacity represents a threshold. If exceeded, it negatively affects the social aspects of the user community and impairs the quality of life for both recreation activity participants and residents. This situation can even sometimes lead to tensions between local users and visitors (WTO, 1999; Castellani, Sala, and Pitea, 2007).

The primary objective in social capacity is to measure the highest level of tolerance that users can exhibit towards crowding. To this end, several questions are sought to be answered: What is the connection between the visitors' level of activity in the area and their perspectives on the concept of crowding? Up to what level of crowding can visitors adapt without experiencing a decline in the quality of services provided by the area? After the crowd reaches what level does it necessitate management intervention (Manning, 2002; Göktuğ et al., 2013; Demircan, Aytatlı, and Yıldız, 2018).

The purpose of this study is to determine the social carrying capacity of Günpınar Waterfall Nature Park, which is located within the boundaries of Darende District in Malatya Province and was granted the status of a Nature Park on 26.06.2018 due to its natural resource values and recreational potential. In our developing world, the conscious use and management of protected areas is of great importance, both for the quality of life in the present era and for ensuring the living standards of future generations. This study aims to foster an individual and societal awareness of protected areas and will provide a resource for future academic research.

MATERIAL AND METHOD

The material for this study is constituted by Günpınar Waterfall Nature Park, which is located within the boundaries of Darende District in Malatya Province, positioned between the latitudes of 38°33′35″N and 38°32′34″N, and longitudes of 37°24′16″E and 37°25′8″E. The Development Plan for Günpınar Waterfall Nature Park, prepared by the General Directorate of Nature Conservation and National Parks (GDNCN) in 2019, has been reviewed. Considering the zoning classes and criteria established by this plan, the physical and social carrying capacities have been determined for areas within the boundaries designated as 'Controlled Use Zones' of the Nature Park. The geographical location of the area is presented in Figure 1.

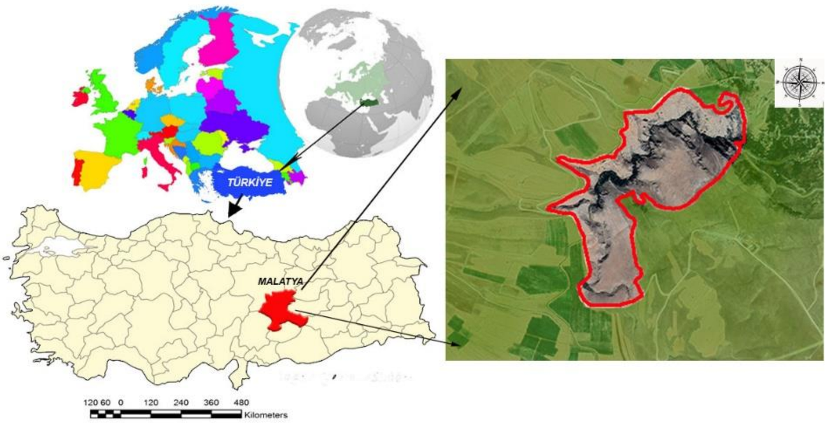

Figure 1. Günpınar Waterfall Nature Park Location Map

Günpınar Waterfall Nature Park, encompassing an area of 135.20 hectares, was declared a Nature Park on 26.06.2018 by the decree number 1312 of the former Ministry of Forestry and Water Affairs, due to its valuable natural resources and recreational potential (DKMP, 2019).

The Nature Park does not contain any private property or pastureland; it is entirely state forest land and is under the jurisdiction of the Directorate of Nature Conservation and National Parks XV. Regional Directorate, Malatya Branch of the Ministry of Agriculture and Forestry. Located approximately 8 km west of Darende District, the Nature Park is situated on the right side of the Elbistan-Darende road, which diverges westward from the D300 highway that passes through the district center (Arınç, 2002; Türkoğlu and Demir, 2020).

Günpınar Waterfall Nature Park, which derives its name from the waterfall within its boundaries, encompasses three distinct ecosystems: aquatic, rocky, and terrestrial. Due to the dynamic topography of the region, the park's highest point reaches an elevation of 1,506 meters, and its lowest point is at 1,240 meters, with an average elevation of 1,408 meters (Karakaş, 2009; Şahin et al., 2012). To ensure the preservation of its resource values, to allow for the use of the area while maintaining a balance between conservation and utilization, and to effectively transmit its natural values to future generations, a Development Plan (Table 1) has been prepared by the Directorate of Nature Conservation and National Parks (GDNCN).

Table 1. Spatial Distribution of Usage Zones According to the Development Plan

(DKMP, 2019)

Protection-Use Zone	Area (ha)	Percentage (%)
Sensitive Protection Zone	5,48	4,05
Sustainable Use Zone	128,14	94,78
Controlled Use Zone	1,58	1,17
Total	**135,20**	**100,00**

In the Development Plan, the boundaries of the area have been determined by considering the balance between conservation and utilization, the values of flora and fauna, and the structure of natural resources (Figure 2).

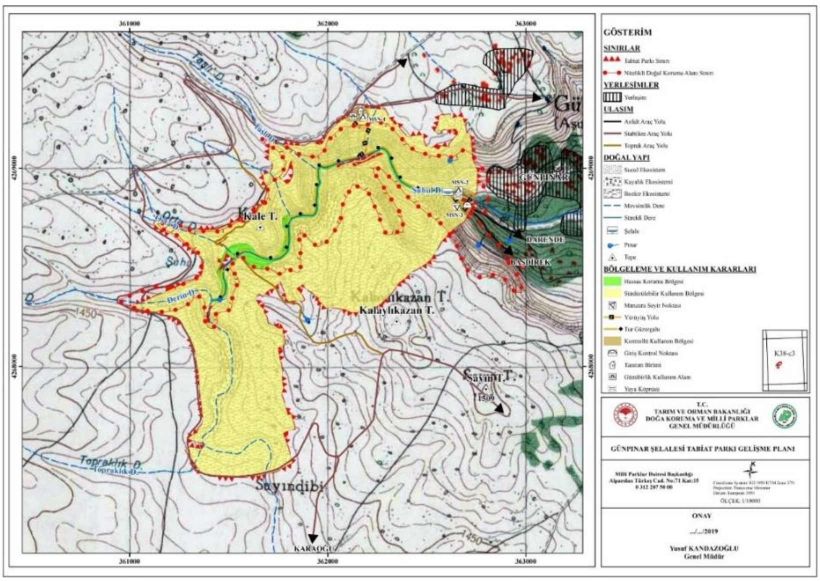

Figure 2. Günpınar Waterfall Nature Park Development Plan (DKMP, 2019)

In the establishment of the zoning system for the Nature Park; the resource values of the site, ecosystem integrity, threats, the level of intervention in the natural structure, traditional uses and socio-cultural values, land use status, and legal and administrative constraints have been taken into consideration (DKMP, 2019).

Sensitive Protection Areas are terrestrial, aquatic, and marine areas that are to be preserved with special measures for scientific research, education, or environmental monitoring purposes, where area usage and all impacts on the area are restricted, and human access may be prohibited when necessary. These are absolutely protected areas where construction is banned by the decision of the Council of Ministers (Anonymous, 2017).

Sustainable Use and Controlled Use Zones are regions that permit activities, tourism, and settlements of low intensity that are compatible in natural and cultural terms, contributing to conservation, and are integrated with, without affecting, the strictly protected sensitive areas or qualified natural conservation areas (Anonymous, 2017).

Considering the definitions and conditions of conservation and use, construction has been prohibited in areas declared as Sensitive Protection Zones, and human use of these areas has been restricted. Only in areas declared as Sustainable Use and Controlled Use Zones are construction, recreation, and tourism activities permitted. Observations in the field have led to the conclusion that there are no facilities within the boundaries of the Sustainable Use Zone, as defined by the Development Plan, that could actively enable recreational activities, and these areas are closed to visitors. Taking all these developments into account, the study has been conducted within the boundaries of Controlled Use Zone-1 (0.64 ha) and Controlled Use Zone-2 (0.94 ha) (Figure 3).

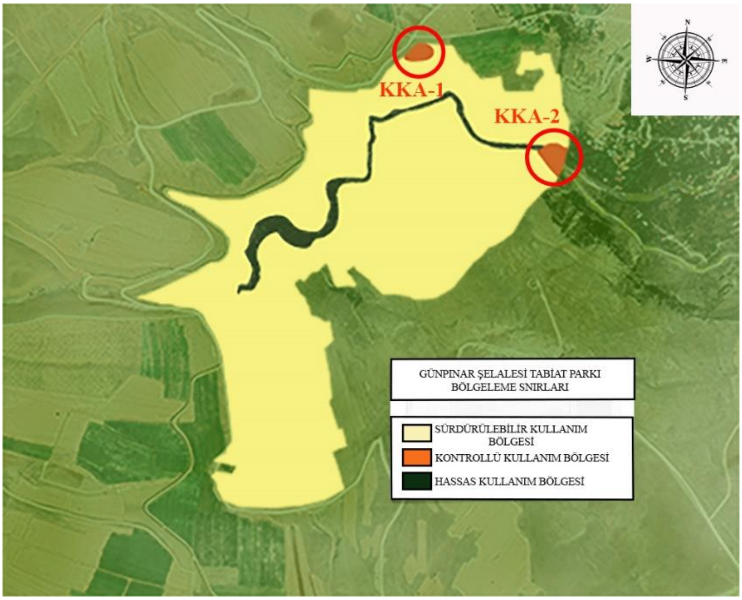

Figure 3. Working Area Boundaries

To calculate the social carrying capacity of a recreational area, it is necessary to gather the opinions of the users. By conducting a survey to collect the views of the area users, and analyzing the responses, a capacity calculation can be performed. Currently, in the Nature Park, since only the Controlled Use Zone-2 (CUZ-2) provides opportunities for recreational activities, a survey study has been conducted exclusively with visitors of this area, and the social carrying capacity for this area has been calculated.

In the survey study, the Universe Size was accepted as the value obtained by taking the average of the visitor numbers for the years 2019-2022 for the study area, with the assistance of data provided by the Directorate of Nature Conservation and National Parks 15th Regional Directorate. The distribution of visitor numbers by months and years is given in Table 2.

Table 2. Distribution of the Number of Visitors to the Nature Park by Months and Years

Months/Years	**2019**	**2020**	**2021**	**2022**
January	0	788	642	286
February	0	1.344	632	343
March	0	205	5.589	5.398
April	0	1	11.780	20.495
May	0	1	14.912	24.425
June	30.196	32.518	17.217	25.646
July	31.911	40.925	26.307	55.143
August	40.688	95.605	20.213	19.194
September	25.971	37.438	2.015	15.200
October	8.477	12.116	1.537	4.559
November	4.104	4.033	1.115	1.117
December	834	1.450	951	1.037
Total	**142.181**	**226.424**	**102.910**	**172.843**
Grand Total	**644.358**			

According to the data obtained; in 2019, 142,181 individuals, in 2020, 226,424 individuals, in 2021, 102,910 individuals, and in 2022, 172,843 individuals visited the Nature Park. When the average of these four years is calculated, the resulting figure of 161,089 has been accepted as the Universe Size for the method. The formula used for calculating the sample size was employed by Esin et al. (2001). The formula is as follows:

n=(N.P.Q.Z_a^2)/((N-1).d^2)

According to the formula:

n: Sample Size

N: Population Size

P: Proportion of X observed in the Population

Q (1-P): Proportion of X not observed in the Population

Za: Z-value for a=0.05 is 1.96

d: Margin of Error

Based on this; the sample size n is calculated as follows:

According to this; n=161.089 x (0.5) x (0.5) x (1.96)2 / 161.088 x (0.05)2=384.16

Considering the sample size and the result obtained from the formula, in this developed method, the minimum number of surveys to be applied with a 95% confidence interval and a ±5 margin of error is 384. Following discussions with users of the study area, a survey was conducted with 386 individuals, and the results have been analyzed in the findings section based on this number.

Although multiple Reliability Analyses are available through the SPSS Statistics 19 Program for measuring the reliability of survey results, the Cronbach's Alpha test is most used. The application of this test yields a value between 0 and 1. The obtained value is interpreted as follows:

- If it is between 0 and 0.40, the test is considered unreliable,

- If it is between 0.40 and 0.60, the test has low reliability,

- If it is between 0.60 and 0.80, the test is quite reliable,

- If it is between 0.80 and 1, the test is highly reliable.

The survey prepared to measure the social carrying capacity was divided into four sections, each posing questions to the users:

• In the first section, demographic information was requested to gain knowledge about the user profile.

• The second section posed questions aimed at understanding the users' preferences for utilizing the study area.

• In the third section, users' opinions were gathered regarding the adequacy of the facilities and infrastructure elements within the Nature Park.

• The fourth section directed questions to measure users' expectations to enhance the recreational quality of the area and to increase its preference among visitors.

To interpret the results obtained from the surveys into statistical data, Frequency Analysis was conducted using the SPSS Statistics Program.

FINDINGS

To calculate the social carrying capacity of Günpınar Waterfall Nature Park, face-to-face surveys were conducted with the users of the actively recreation-open Controlled Use Zone-2 (CUZ-2), and the responses were analyzed to calculate the social carrying capacity for this area.

The reliability of the survey conducted has been measured using Cronbach's Alpha test, which resulted in a value of 0.88. This indicates that the test is highly reliable.

To determine the visitor satisfaction levels at Günpınar Waterfall Nature Park, a survey consisting of five sections was administered to users. The collected survey results were converted into statistical data using SPSS 19 software, and the outcomes were analyzed with a frequency test.

In the first part of the survey, demographic information was included to obtain information about the participant profile, and the answers received from this section are given in table 3.

Table 3. Demographic Data of Survey Participants

Demographic Information	**Variables**	**Number of People**	**Percentage**
Cender	Male	209	54,1
	Female	177	45,9
Age Range	18-25	58	15,0
	26-35	177	45,9
	36-50	120	31,1
	51 years and above	31	8,0
Marital Status	Married	185	47,9
	Single	201	52,1
Educational Background	Literacy	5	1,3
	Primary Education	42	10,9
	High School	182	47,2
	associate Degree /Undergraduate	124	32,1
	Postgraduate	33	8,5
Occupation	Worker	56	14,5
	Officer	65	16,8
	Retired	14	3,6
	Farmer	30	7,8
	Self-employment	68	17,6
	Housewife	37	9,6
	Student	68	17,6
	Others	48	12,4
Income State	0-8.500	170	44,0
	8.501-15.000	157	40,7
	15.001 and above	59	15,3
Do you live in Malatya?	Yes	327	84,8
	No	59	15,2
Those Coming from Outside Malatya	Elâzığ	8	15,1
	Sivas	7	13,2
	İstanbul	7	13,2
	Ankara	6	11,3
	Kayseri	5	9,4
	Adıyaman	1	1,9
	Balıkesir	1	1,9
	Çorum	1	1,9
	Diyarbakır	1	1,9
	Erzincan	1	1,9
	Erzurum	1	1,9
	Gaziantep	1	1,9
	Hatay	1	1,9
	İzmir	1	1,9
	Kars	1	1,9
	Kocaeli	1	1,9
	Mersin	1	1,9
	Niğde	1	1,9
	Rize	1	1,9
	Sakarya	1	1,9
	Şanlıurfa	1	1,9
	Trabzon	1	1,9
	Yozgat	1	1,9

In the second part of the survey, participants were asked questions regarding their usage preferences for Günpınar Waterfall Nature Park. Upon analysis of the responses,

It was found that to the question ‘Is this your first visit to Günpınar Waterfall Nature Park?’ 31.6% of the participants answered ‘yes’ while 68.4% responded with ‘no’

When participants were asked ‘How often do you visit Günpınar Waterfall Nature Park?’ the responses were as follows: 1.6% indicated ‘once a week’ (6 individuals), 4.4% ‘every two weeks’ (17 individuals), 13% ‘once a month’ (50 individuals), 23.8% ‘every three months’ (92 individuals), 28% ‘every six months’ (108 individuals), and 29.3% ‘once a year’ (113 individuals).

In response to the question ‘Which seasons do you prefer to visit Günpınar Waterfall Nature Park?’ the participants indicated: 16.6% preferred autumn (64 individuals), 9.3% winter (36 individuals), 44.6% spring (172 individuals), and 29.5% summer (114 individuals).

In response to the question ‘On which days do you prefer to visit Günpınar Waterfall Nature Park?’ the participants’ responses were as follows: 15.3% indicated weekdays (59 individuals), 62.2% preferred weekends (240 individuals), and 22.5% chose public holidays, special days, or religious festivals (87 individuals).

In response to the question ‘What mode of transportation do you use when visiting Günpınar Waterfall Nature Park?’ the participants answered as follows: 12.4% used public transportation (48 individuals), 16.3% took a taxi (63 individuals), 55.4% drove their own vehicle (214 individuals), and 15.8% rode a bicycle/motorcycle (61 individuals).

In response to the question ‘Who do you prefer to go with to Günpınar Waterfall Nature Park?’ the participants indicated: 14.8% prefer going alone (57 individuals), 40.7% with family (157 individuals), 35.5% with friends (137 individuals), and 9.1% with tours/technical visits (35 individuals).

In response to the question ‘How much time do you spend at Günpınar Waterfall Nature Park?’ the participants’ responses were as follows: 13.7% for 1 hour (53 individuals), 34.7% for 2 hours (134 individuals), 32.6% for 3 hours (126 individuals), 12.7% for 4 hours (49 individuals), 3.6% for 5 hours (14 individuals), 1.6% for 6 hours (6 individuals), 0.8% for 7 hours, and 0.3% for 8 hours (1 individual).

In response to the question 'What is your reason for visiting Günpınar Waterfall Nature Park?' the participants responded: 22.5% for picnicking (87 individuals), 26.4% for resting and breathing fresh air (102 individuals), 19.6% for exercising (76 individuals), 27.6% for taking photographs (107 individuals), 26.1% for studying flora and fauna (101 individuals), 30.7% for escaping the stress of city life (119 individuals), 31.8% for being in a natural environment (123 individuals), 50.4% for watching the waterfall (195 individuals), 18.3% for spending time with family/friends (71 individuals), and 7.5% for academic research or natural observations (28 individuals).

In response to the question 'Why do you prefer Günpınar Waterfall Nature Park?' the participants indicated: 13.7% for ease of transportation (53 individuals), 31.3% for its tranquility and peacefulness (121 individuals), 31.1% for its cleanliness (120 individuals), 31.3% for the availability of picnic areas (121 individuals), 28.7% due to its geographical location (111 individuals), and 70% for the presence of the waterfall (271 individuals).

In response to the question 'Do you think the entry fee (5 Turkish Lira) is too much?' the survey respondents indicated: 9.8% answered 'yes' (38 individuals), and 90.2% answered 'no' (348 individuals).

In response to the question 'Should there be a limitation on the number of visitors at the entrance of the Nature Park?' the participants indicated: 23.6% answered 'yes' (91 individuals), and 76.4% answered 'no' (295 individuals).

In the third section of the survey, participants were requested to evaluate the adequacy of the spaces and facilities within Günpınar Waterfall Nature Park using a three-point Likert scale. These evaluations aimed to gather information on the sufficiency of actively used spaces and amenities. Participants were asked to consider the importance levels of the spaces and facilities according to their own opinions and to rate each as 'Adequate', 'Inadequate', or 'Partially Adequate' (Table 4).

Table 4. Adequacy of Space and Equipment Elements in Günpınar Waterfall Nature Park

Place or Fittings	**Adequate**		**Inadequate**		**Partly Adequate**	
	People	**Percentage (%)**	**People**	**Percentage (%)**	**People**	**Percentage (%)**
Parking Lot	143	37,0	143	37,0	100	26,0
Picnic Units	114	29,5	179	46,4	93	24,1
Bowers	125	32,4	157	40,7	104	26,9
WC	122	31,6	154	39,9	110	28,5
Bin	132	34,2	161	41,7	93	24,1
Countryside Cafeteria	139	36,0	140	36,3	107	27,7
Caution Signs	155	40,2	130	33,7	101	26,2
Security	138	35,8	142	36,8	106	27,5
Waterfall Viewing Terrace	138	35,8	134	34,7	114	29,5
Pedestrian Paths	153	39,6	130	33,7	103	26,7
Children's Play Area	148	38,3	110	28,5	128	33,2
Wheelchair Ramps	128	33,2	156	40,4	102	26,4
Fauntains	139	36,0	142	36,8	105	27,2
Sitting Benchs	141	36,5	146	37,8	99	25,6

In the fourth section of the survey, participants were asked to evaluate, on a five-point Likert scale, the importance of various factors aimed at enhancing the recreational quality and preference for Günpınar Waterfall Nature Park. They were instructed to rate each factor according to their own opinion using the options 'Not Important At All', 'Slightly Important', 'Moderately Important', 'Very Important', and 'Extremely Important' (Table 5).

Table 5. Participants' Evaluations of the Asked Factors According to Their Importance Level

Factors	**Factors**	**People**	**Percentage (%)**
Geographic Location	Not Important At All	41	10,6
	Slightly Important	88	22,8
	Moderately Important	103	26,7
	Very Important	108	28,0
	Extremely Important	46	11,9
Transportation Facilities	Not Important At All	21	5,4
	Slightly Important	80	20,7
	Moderately Important	128	33,2
	Very Important	117	30,3
	Extremely Important	40	10,4
Size of Area	Not Important At All	27	7,0
	Slightly Important	73	18,9
	Moderately Important	137	35,5

	Very Important	110	28,5
	Extremely Important	39	10,1
Security	Not Important At All	31	8,0
	Slightly Important	78	20,2
	Moderately Important	119	30,8
	Very Important	113	29,3
	Extremely Important	45	11,7
Number of Reinforcement Elements (Garbage, Toilet, Fountain, etc.)	Not Important At All	23	6,0
	Slightly Important	90	23,3
	Moderately Important	117	30,3
	Very Important	94	24,4
	Extremely Important	62	16,1
Parking Lots	Not Important At All	22	5,7
	Slightly Important	82	21,2
	Moderately Important	127	32,9
	Very Important	109	28,2
	Extremely Important	46	11,9
Cafeteria/Buffet/Countryside Coffee House	Not Important At All	25	6,5
	Slightly Important	83	21,5
	Moderately Important	133	34,5
	Very Important	105	2,2
	Extremely Important	40	10,4
Number of Picnic Units	Not Important At All	23	6,0
	Slightly Important	93	24,1
	Moderately Important	114	29,5
	Very Important	106	27,5
	Extremely Important	50	13,0
Presence of Waterfall Viewing Terrace	Not Important At All	31	8,0
	Slightly Important	84	21,8
	Moderately Important	129	33,4
	Very Important	96	24,4
	Extremely Important	46	11,9
Having a Children's Playground	Not Important At All	28	7,3
	Slightly Important	97	25,1
	Moderately Important	120	31,1
	Very Important	96	24,9
	Extremely Important	45	11,7
Having Walking/Pathways	Not Important At All	32	8,3
	Slightly Important	92	23,8
	Moderately Important	118	30,6
	Very Important	102	26,4
	Extremely Important	42	10,9
Existence of Scenic Viewpoints	Not Important At All	24	6,2
	Slightly Important	91	23,6

	Moderately Important	122	31,6
	Very Important	106	27,5
	Extremely Important	43	11,1
Number of Sitting Benches	Not Important At All	23	6,0
	Slightly Important	92	23,8
	Moderately Important	131	33,9
	Very Important	92	23,8
	Extremely Important	48	12,4
Existence of Local Products Sales and Exhibition Units	Not Important At All	28	7,3
	Slightly Important	97	25,1
	Moderately Important	129	33,4
	Very Important	96	24,9
	Extremely Important	36	9,3
Existence of Sports Fields	Not Important At All	24	6,2
	Slightly Important	92	23,8
	Moderately Important	144	37,3
	Very Important	85	22,0
	Extremely Important	41	10,6
Existence of Bicycle/Hiking Routes	Not Important At All	22	5,7
	Slightly Important	95	24,6
	Moderately Important	130	33,7
	Very Important	100	25,9
	Extremely Important	39	10,1
Presence of Barbecue Areas	Not Important At All	23	6,0
	Slightly Important	83	21,5
	Moderately Important	133	34,5
	Very Important	101	26,2
	Extremely Important	46	11,9
Restaurant/Countryside Restaurant Presence	Not Important At All	24	6,2
	Slightly Important	94	24,4
	Moderately Important	133	34,5
	Very Important	95	24,6
	Extremely Important	40	10,4
Presence of vehicle and construction site sounds	Not Important At All	29	7,5
	Slightly Important	92	23,8
	Moderately Important	137	35,5
	Very Important	83	21,5
	Extremely Important	45	11,7
Number of Plants and Diversity of Species	Not Important At All	31	8,0
	Slightly Important	96	24,9
	Moderately Important	132	34,2
	Very Important	86	22,3
	Extremely Important	41	10,6

DISCUSSION AND CONCLUSION

In this study, the social carrying capacity of Günpınar Waterfall Nature Park was calculated with the aim of preserving the area's natural values, establishing a conscious user and management profile, and contributing to the transfer of these natural values to future generations while ensuring their protection. A survey study was conducted with visitors of the Nature Park, and the data obtained from the surveys were converted into statistical information and interpreted using the SPSS 19 software.

From the past to the present, significant developments have occurred in the classification of protected areas due to the increase in academic analysis, observation, and research. Consequently, numerous classes of protected areas have been established in accordance with national regulations, international organizations, and international treaties (Göktuğ et al. 2011). Today, the recreational activities within these areas exhibit diversity, both due to these classifications and the geographical location. In the selection of recreation types and venues, individuals' gender, marital status, age ranges, and income levels are considered the most significant factors. Furthermore, the distance of the recreation area is also regarded as an important factor in its preference (Demircioğlu Yıldız, Demir, and Yılmaz, 2011).

According to the survey results, most participants indicated that they had visited the area before and prefer to visit at least once a year. Additionally, participants generally prefer to visit the area with their family. Based on these results, it can be concluded that the area's users are regular visitors, prefer to visit repeatedly, and choose to come with their families due to considerations for a family's sensitivity (such as safety, privacy, etc.).

According to the responses given by the survey participants, the most important reasons for visiting the Nature Park are to watch the waterfall, to be in a natural environment, and to escape the stress of city life. The Nature Park derives its name from the Günpınar Waterfall located within its boundaries, which is also how it is known among the local population. The fact that a significant proportion of participants reported choosing the area to watch the waterfall supports this. Moreover, it is observed that most participants visit the area during the months when the waterfall is most powerful.

According to survey results and comments from the local community, the primary reason for visiting the Nature Park is the Günpınar Waterfall, after which it is named. Recent developments have added new features to the area, such as a glass observation terrace, new walking paths, and landscape improvements. In addition, enhancements aimed at increasing the waterfall's appeal are expected to yield positive outcomes in visitor numbers and recreational quality. For this reason, implementing the spaces designed in the Development Plan is of great importance. New terraces, positioned higher than the existing glass terrace, could be constructed around the waterfall, and new tour routes could enable visitors to observe the waterfall from above and wander around it. These implementations will not only enhance the attractiveness of the nature park but also positively impact on the diversity of recreational activities and tourism potential, thereby facilitating the growth of regional and local dynamics.

ACKNOWLEDGEMENTS AND INFORMATION NOTE

This article, Atatürk University, Graduate School of Natural and Applied Sciences, Landscape Architecture Master's Degree, completed in 2023 in the Department of Landscape Architecture.

The article complies with national and international research and publication ethics.

Ethics Committee approval in the study, Ethics Committee of the Atatürk University dated 06.04.2023 and E-77040475-000-2300116813 It should be said that it was taken with the decision no.

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CHAPTER 8

A Multi-Criteria Analysis and Planning Strategies for Green Spaces in The City of Antalya

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1. Introduction

A city is a legal entity that has reached a certain population size and density within a specified area, responding to the needs of housing, work, transportation, and recreation, forming a center in relation to its surroundings, and serving as a hub for both agricultural and non-agricultural (industrial-service) activities. As stated in the European Union's Urban Environment Thematic Strategy, cities are areas where environmental, economic, and social issues converge most intensely. Urban areas play a significant role in achieving the sustainable development goals (SDGs) of the United Nations (Anonymous 2010). The rapid growth and development of cities lead to diversification in urban land use, where green spaces play a crucial role in improving social, economic, ecological, and environmental conditions and enhancing the quality of urban life.

Green spaces hold significant importance in urban areas for human life and needs. These areas serve various physical and ecological functions, such as facilitating circulation and physical comfort among different urban uses, adding aesthetic value to cities, offering recreational opportunities, and reducing noise and pollution. For green spaces to fully perform these functions, they should be planned systematically within urban planning, adhere to certain standards, and be of sufficient size with a balanced distribution within the urban fabric. Open and green spaces not only provide amenities for urban dwellers but also play an important role in shaping the city (Karagüzel et al., 2000).

The purpose of urban open and green space planning is to meet the active and passive recreational needs of urban residents, ensure the orderly establishment of cities, control development, allocate land for various uses to serve different purposes in a systematic manner, and create aesthetic and functional spaces.

Each city has a unique identity and character, and there is no standard green space planning applicable to all cities. The identity and character of cities should consider their physical, environmental, social, and cultural features, as well as demographic and climatic characteristics when formulating a green space strategy.

The term "strategy" means "to direct, guide, send, lead, and manage." In general, a strategy is a set of plans and programs aimed at achieving multi-faceted objectives. A green space planning strategy, therefore, refers to the approach and measures to be taken to create an aesthetically and functionally sound green space system in cities (Manavoğlu, Ortaçeşme 2015).

In Turkiye, physical development planning laws and regulations form the basic legal framework that guides the urban planning process. In these regulations, the approach toward green spaces is to provide certain amount of green space (m^2) per capita. The 1985 Physical Development Law Nr. 3194, which is still in effect, stipulates 7 m^2 of green space per capita. This amount was increased to 10 m^2 per capita with the Regulation on the Principles of Making and Amending Physical Development Plans published in the Official Gazette Nr. 23804 on September 2, 1999. However, these standards set by legal regulations are not fully met in practice.

In addition to numerical inadequacies, there are other issues related to green spaces in Turkish cities. One of the most significant issues is the lack of green space planning within a system. The absence of a provision in the existing physical development legislation for creating a green space system in our cities, the lack of a green space planning strategy extending from macro to micro scale, and the fragmented and altered decisions in physical development plans are among the main reasons why cities lack sufficient green spaces.

The expectations of urban residents from green spaces provide significant insights into the perspective that should be adopted for urban green space planning. One of the most important data sources for urban green space planning is social data. The social and economic status, demographic structure, and the different needs and expectations of people from various age groups and educational backgrounds influence the planning approach.

To achieve sustainable development goals in urban areas, to improve quality of life, and to create healthy environments, it is necessary to develop planning strategies for urban green spaces and integrate these strategies with the spatial planning decisions of the city.

Identifying and evaluating data for green space planning in cities requires comprehensive studies involving multiple analyses. In recent years, the multi-criteria analysis approach used in various scientific studies has contributed to determining land use changes, identifying the green space potential of cities, and forming green space policies and strategies in urban planning. This study aims to create planning strategies for the green spaces in Antalya city of Turkiye using a multi-criteria analysis approach based on various analyses.

2. Material and Method

2.1. Material

The study area includes five district municipalities, namely Konyaaltı, Muratpaşa, Kepez, Döşemealtı, and Aksu, within the boundaries of Antalya Metropolitan Municipality (Figure 1). The area covers approximately 138,000 hectares.

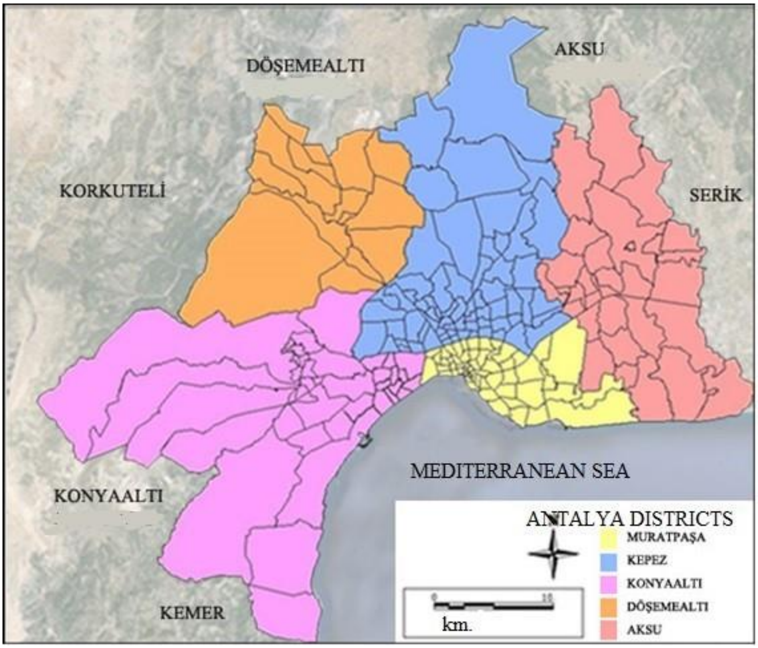


Figure 1. Study Area

The research material consists of:

- 1/25,000, 1/5,000, and 1/1,000 scale physical development plans of Antalya and their explanatory reports,
- Aerial photographs and satellite images,
- Books, articles, and scientific research findings related to urban open and green spaces, urban green space planning, and the green space systems,
- Scientific articles from international research regarding the methodology of the study,

- Questionnaire data conducted with users in the study area and interviews with municipalities.

2.2. Method

The study consists of three main stages (Figure 2).

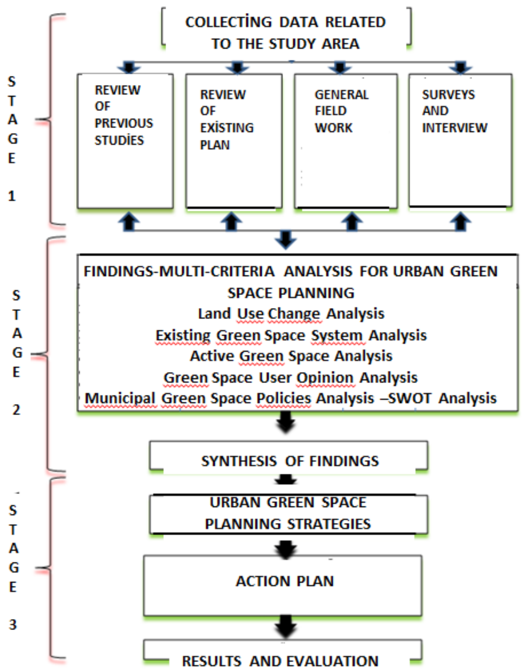


Figure 2. Flow Diagram of the Study

In the first stage, data related to the study area were collected. Previous studies were reviewed, existing city plans were examined in terms of green spaces, and field studies were conducted to gather general qualitative and quantitative data.

The second stage is the multi-criteria analysis phase. The aim was to produce data that would facilitate the development of green space planning strategy development for the city through six key analyses:

- Land Use Change Analysis
- Existingt Green Space System Analysis
- Active Green Space Analysis
- Green Space User Opinion Analysis

- Municipal Green Space Policy Analysis
- SWOT Analysis

In the third stage, strategies for green space planning for the city of Antalya were developed (Table 1). These strategies were based on the data obtained, syntheses made and aimed at addressing the identified issues. The strategies were developed based on the analyses conducted in the second stage and were tailored to each specific area of analysis.

Table1. Topics for Developing Green Space Planning Strategies

No	Analysis	Aims and Objectives	Strategies
1.	**Land Use Change Analysis**	One of the important parameters of a green space system is to ensure the sustainable development of forests and agricultural areas, while considering urban sprawl within the city's planned development strategies.	1.1. Agricultural Areas
			1.2. Forest Areas
			1.3. Spread of settlement areas
			1.4. Spatial transformation - ecology
			1.5. Urban planning
			1.6. Green space strategies
2.	**System Analysis**	To develop planning strategies that contribute to the urban ecology and microclimate by planning green spaces within a system throughout the city.	2.1. Green space systems
			2.3. Continuity of green spaces
			2.4. Fragment-corridor relationship
3.	**Existing Green Space System Analysis**	To ensure the efficient use of green spaces by urban residents by ensuring the regular distribution of active green areas across the city, meeting specific standards, being of adequate size, and including various amenities.	3.1. Ensuring standards
			3.2. Impact area-accessibility
			3.3. Hierarchy
			3.4. Planning
			3.5. Size
			3.6. Change
			3.7. Urban transformation
4.	**Green Space User Opinions Analysis**	To create green spaces that meet the needs and expectations of individuals, ensuring that users can benefit from green areas to the highest level.	4.1. Recreation
			4.2. Safety
			4.3. Activities and uses
			4.4. Expectations and needs
			4.5. Accessibility
			4.6. Management and planning

5.	**SWOT Analysis**	Developing plans and strategies that will maximize the use of strengths and opportunities, while minimizing the impact of threats and weaknesses	5.1. Urban identity
			5.2. Environment-Ecology
			5.3. Conservation
			5.4. Legal status
			5.5. Sustainability

Land Use Change Analysis:

The aim of this analysis is to determine the changes in the land cover of Antalya city over the years and to identify how forest and agricultural areas have been affected by these changes. LANDSAT satellite images from 1987, 2002, 2006, and 2010 were acquired, pre-processed, and classified using the Unsupervised Classification Method. The preliminary classifications conducted on the computer were verified through field studies, aerial photographs of the region, Google Earth images, and maps, resulting in thematic maps. Land use classification was done according to CORINE Level I and II.

Existing Green Space System Analysis:

In this analysis, the presence of a systematic structure for the existing green spaces in the study area was examined. All active and passive green spaces and open areas were considered. In the analyses focusing on patch-corridor relationships and system structures, existing green spaces were identified using Google Earth images, and spatial maps were produced with the help of the ArcGIS program.

Active Green Space Analysis:

In this analysis, the active green spaces within the boundaries of the Antalya Metropolitan Municipality were investigated at the neighborhood level in terms of size, number, and quality. Data on active green spaces were obtained from relevant municipalities and verified using 1/1000 scale Development Implementation Plans and Google Earth images. The data were analyzed in two ways. The first analysis focused on the spatial distribution of green spaces. Layers identified on Google Earth images were transferred to the ArcGIS program, resulting in spatial distribution and accessibility maps for green spaces. For the creation of accessibility maps, a distance of 200 m to playgrounds (Nyhuus, 1992) and 300 m to neighborhood parks (Anonymous, 2000) from residential areas was used. The second analysis determined population, area, per capita active green space, and changes in active green spaces using the MapInfo program, and thematic maps were produced.

Green Space User Opinions Analysis:

In this context, 391 face-to-face user surveys were conducted with a 5% statistical error margin. The survey, consisting of 52 questions, aimed to reveal the needs, problems, usage, and planning expectations of city residents concerning existing green spaces. The survey responses were transferred to SPSS 13, where Frequency Analysis was used for demographic data explanation, and Chi-Square Analysis was performed to determine user preferences.

Municipal Green Space Policies Analysis:

Another analysis conducted as part of the study involved interviews with relevant municipal officials. Discussions were held with the administrative staff and experts from Kepez, Muratpaşa, Aksu, Döşemealtı, and Konyaaltı municipalities and the Metropolitan Municipality to gather information on topics such as funding for green spaces, the importance of green policies and strategies of local governments, and policy development.

SWOTAnalysis:

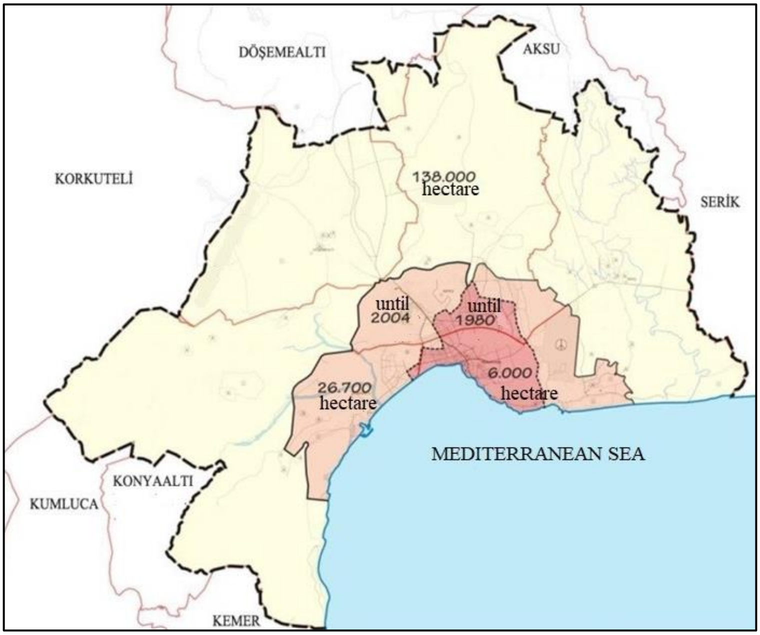
This analysis aimed to identify the strengths, weaknesses, opportunities, and threats of the study area, considering its international, national, and regional position, natural structure and resources, current situation, issues, potentials, and demands related to the area.

3. Findings

3.1. General Characteristics of the Study Area

Antalya, one of Turkiye's most important tourism centers, is a coastal city. It is in the southern part of the country, on the Mediterranean coast. To the north, it borders the provinces of Burdur, Isparta, and Konya; to the east, it borders Karaman and Mersin; to the west, it borders Muğla. The southern border is the Mediterranean Sea. The length of Antalya's coastline reaches 630 km. Covering 2.7% of Turkiye's land area, Antalya is home to 2.5% of the country's population. The province of Antalya includes 19 districts: Muratpaşa, Akseki, Alanya, Elmalı, Finike, Gazipaşa, Gündoğmuş, İbradi, Kale, Kaş, Kemer, Korkuteli, Kumluca, Manavgat, and Serik. The total area of the province is 2,059.1 km² (Antalya Governorship, 2024).

In 1980, the city had an administrative boundary of 6,000 hectares, which grew to 26,700 hectares by 2004 and reached approximately 138,000 hectares in 2008 (Figure 3).



Figurel 3. Study Area Administrative Boundary Change

On December 11, 2012, the law numbered 6360, titled "Law on the Establishment of Metropolitan Municipalities in Thirteen Provinces and Twenty-Six Districts and Amendments to Certain Laws and Decrees with the Force of Law," was passed and published in the Official Gazette, making the boundaries of Antalya Metropolitan Municipality coincide with the provincial administrative boundaries (Figure 4).

Figure 4. The Location of the Study Area Within the Borders of Antalya Metropolitan Municipality

The historical fabric, cliffs, and recreational areas in the area where the city center is located have integrated with the Kaleiçi Yacht Harbor and have become a symbol of the city. The Konyaaltı and Lara Beaches, which extend along a linear path on the eastern and western sides of the city, are open spaces of national and international importance.

The province also contains surface water sources that serve as important elements of a green space system and function as natural corridors. To the east, there are Aksu, Kopak, Acısu, and Düden rivers, and to the west, there are Boğaçay and Sarısu rivers, along with many smaller and seasonal streams. Prehistoric urban, archaeological, and natural sites can be found within the study area.

Urban conservation areas in the city center, such as Kaleiçi, Balbey, and Haşimişcan, are located within the Muratpaşa district. Archaeological and natural sites are predominantly found in the Konyaaltı district, while Vakıf Çiftliği, the only natural heritage site in the Kepez district, is one of the city's most important green spaces. Aksu district is rich in archaeological sites. Döşemealtı district also contains archaeological-natural and archaeological heritage sites.

Within the study area, there are various protected areas with different status. The area includes two national parks, two nature parks, and two wildlife conservation areas. There are six tourism conservation and development regions and a tourism center within the research area.

When examining the populations of the district municipalities within the research area, the most populous district is Muratpaşa with 442,663 residents, accounting for 41% of the total city population. It is followed by Kepez district with 425,794 residents, or 40% of the total population. These two districts together make up 81% of the population of the study area. The population of Konyaaltı district constitutes 12% of the total population, while the rural districts of Aksu and Döşemealtı account for 7% of the total population.

3.2. Green Space Analysis of the Study Area

3.2.1. Land Use Change Analysis

The goal of the land use change analysis is to detect land use changes in the city of Antalya using remote sensing data. The study aims to detect the changes in forests and agricultural lands, which are important parameters of a green space system, during the urbanization process, determine which areas urban sprawl threatens, and develop planning strategies for these areas. For this purpose, land use change analysis was conducted using remote sensing data.

Remote sensing refers to obtaining information about the physical characteristics of objects on the Earth's surface without direct contact and measuring them in two or three dimensions. The satellite data used in remote sensing studies are diverse. In this study, LANDSAT data were used.

The sensors of the Landsat satellite series primarily include Return Beam Vidicon (RBV) camera system, Multispectral Scanner (MSS) system, and Thematic Mapper (TM). The LANDSAT Enhanced Thematic Mapper (ETM) was introduced with LANDSAT 7. ETM data include visible, near, mid, and thermal infrared spectral bands of the electromagnetic spectrum. Each of these sensors scans the Earth in a 185 km wide strip. The characteristics of the satellite images used in the study are given in Table 2.

Table 2. Characteristics of the Satellite Images Used in the Study

Satellite	Date	Resolution	Bands
LANDSAT TM	26.08.1987	30m	1,2,3,4,5,6,7
LANDSAT TM	20.06.2006	30m.	1,2,3,4,5,6,7
LANDSAT ETM	23.07.2010	30m	1,2,3,4,5,6,7

In the study, land use has been classified into four categories:

1. Artificial areas – residential areas
2. Artificial areas – other uses (Industry, commerce and transportation units, quarries, landfills, construction sites, non-agricultural green spaces)
3. Agricultural areas
4. Forest and semi-natural areas

According to the results of the land use change analysis conducted using satellite images from 1987, 2002, 2006, and 2010, residential areas and other uses made up 13.2% of the study area in 1987, and this proportion increased to 36.6% by 2010. Forest areas, which covered 55.2% of the city in 1987, decreased to 40.7% in 2010. Similarly, agricultural areas, which covered 31.6% of the city in 1987, decreased to 22.7% by 2010.

Thus, over the 23-year period, the formation of artificial areas in urban areas increased, while agricultural and forest areas decreased.

3.2.2. System Analysis of Existing Green Spaces

The green space system elements in the study area were examined in terms of the patch-corridor relationship and the type of the city. The spatial distribution of existing open-green spaces was analyzed, and it was determined that the city, with its forest areas, agricultural lands, large green spaces, small green spaces, and both natural and artificial corridors, has significant potential for developing a green space system.

When evaluating the patch-corridor relationship, both active and passive green spaces were taken into account. The existing active and passive green spaces and green corridors in Antalya, as well as the components that could form Antalya's green space system, are shown in Figure 5 and Table 3.

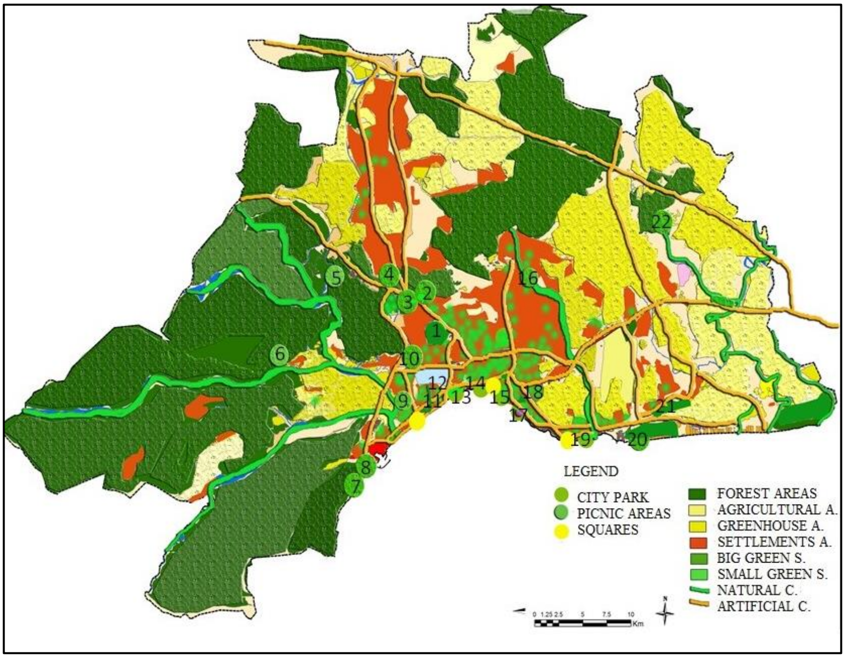


Figure 5. Green spaces and green corridors in Antalya

Table 3. List of green spaces and green corridors in Antalya

Big Green Spaces	Small Green Spaces	Corridors Between Green Areas	Green Areas Surrounding the City
(1) Vakıf Çiftliği (2) Urban Forest (3) Zoo (4) Düzlerçamı Picnic Area (5) Güver Canyon (6) Doyran Picnic Area (7) Topçam, B. Çaltıcak, K. Çaltı-cak Picnic Area (8) Sarısu Picnic Area (9) Uluç mesire alanı (10) Avni Tolunay Picnic Areas (11) Tematic Park-Olbia Canyon (12) Akdeniz U. Botanical Garden (13) Atatürk Kültür Park (14) Atatürk Park (15) Karaalioğlu Park (16) Düden Waterfall (17) Falez Park (18) Narenciye Garden (19) Düden Park (20) Lara Dune Areas-Picnic Areas (21) Yamansaz Wetland (22) Kurşunlu Waterfall	Şehitler Park Sakarya Park Yavuz Özcan Park Neighborhood Park Cemeteries	Natural Corridors; (Boğaçayı, Düden, Aksu, other valleys D1, D2, D3, D4, D5, D6, D7, D8, D9, D10 Artificial Corridors; Y1, Y2, Y3, Y4, Y5, Y6, Y7, Y8, Y9, Y10, Y11, Y12, Y13, Y14	Agricultural Areas Forest Areas

When viewed the city as a whole, large green spaces in the city, which are considered essential, include reserve green areas, recreational areas, regional parks, and city parks. Vakıf Çiftliği, located within the Kepez district, is one of the city's important passive green spaces. Other significant green areas include Şehitler Park, Sakarya Park, Kent Ormanı (City Forest), and the zoo, located within Kepez district; Düden recreational area; Atatürk Park, Atatürk Culture Park, Karaalioğlu Park, Falez Park, Düden Park, Lara Sand Dune Area, and Yamansaz Wetland Area, located within Muratpaşa district; and Uluç recreational area, Avni Tolunay recreational area, Sarısu recreational area, and Doyran recreational area, located within Konyaaltı district. Smaller green spaces typically consist of neighborhood parks, cemeteries, and similar green areas. Other areas include the previously mentioned natural and artificial corridors, as well as agricultural and forest areas within and surrounding the city.

3.2.3. Active Green Space Analysis

There are a total of 887 active green spaces in the study area. The total surface represented by these active green spaces is 4,471,053 m². This means there is 4.2 m² of active green space per capita in Antalya. When neighborhoods are examined in terms of the number of green spaces, it was found that there is at least one active green space in 127 out of 184 neighborhoods. In other words, 69% of the neighborhoods have active green spaces. In terms of green surface, Muratpaşa and Kepez lead. When examining the ratio of active green spaces to the district area, it is observed that Muratpaşa has the highest ratio at around 2%, compared to the other districts.

3.2.4. Green Space User Opinion Analysis

According to the results of the survey conducted in this context, users generally think that parks and other green spaces have a positive effect on public health, beautify the city, and make cities more livable. Users desire to live in a city rich in green spaces, prefer neighborhoods with parks, and want their homes to be close to parks. When choosing parks, users tend to prefer large city parks with views, such as Karaalioğlu Park, Atatürk Park, and Atatürk Culture Park. Users, especially, find the sizes of neighborhood parks insufficient, and they believe that the facilities in these parks do not meet the needs of various age groups. According to users, the most significant problem with parks is security. This is followed by cleanliness, insufficient facilities, and the inadequacy of the number and park size. Chi-square analyses revealed that there are differences in these opinions among people living in different districts.

3.2.5. Municipal Green Space Policy Analysis

Interviews with municipal officials and experts revealed that there is no general approach for creating a green space system in the municipalities. Regarding the financing of green spaces, the ratio of the budget allocated for green spaces to the total budget was found to be 19.4% in Kepez, 14.5% in Konyaaltı, and 11.7% in Muratpaşa. It was noted that the budgets for green space activities in all municipalities had increased compared to previous years. Interviews also revealed that municipalities prioritize children playgrounds and neighborhood parks when creating green spaces.

3.2.6. SWOT Analysis

Antalya city has strong points in terms of underground and surface water resources, numerous south and north corridors that contribute to the city's microclimate, diversity of flora and fauna, coastal ecosystems, wetlands, national and nature parks, conservation areas, beaches, recreational areas, wetlands, surrounding forests and agricultural areas. These factors contribute to the potential of the city's green space system.

Weaknesses include rapid urbanization and migration, building development in coastal areas, the conversion of agricultural lands into residential areas, zoning and property issues in green space practices, the lack of adequate tools for planning social and service areas, including green spaces in physical development plans, and the obstacles posed by informal settlements in green space implementation.

One of the most important opportunities for creating a green space system in the study area is the implementation of the Ecological Transition Conservation Corridor decision, which was made following the Ecological Land Management Plan. This decision creates a legal tool for developing an integrated urban green space system and ensuring its sustainability. The Expo 2016 Garden Exhibition, which was held in Antalya in 2016, is another significant opportunity for the development of green spaces in the city.

Threats to the city's green spaces include tourism developments in sensitive and fragile coastal areas, the conversion and sale of forested areas for different uses, population growth and migration, physical development decisions that increase building density in physical development plans and regulations, and the pressure of urban rent on green spaces.

4. Green Space Planning Strategies for Antalya City

The results of the multi-criteria analyses conducted have provided the necessary data for determining green space planning strategies for Antalya city. A total of 14 objectives have been set to establish a sustainable green space system in Antalya; for these objectives, a total of 60 strategies have been defined along with 60 actions for implementing these strategies.

The protection of agricultural areas, as a component of urban green space systems, has been established as a strategic goal. To achieve this, physical development plans should include measures to stop opening agricultural areas to urban development and conducting agricultural planning studies in the Konyaaltı-Çakırlar region, which is the last citrus orchard area of the city.

Table 4. The Green Space Strategies for Antalya City

Strategic Objectives for Green Areas in the City of Antalya:
1. To protect and develop agricultural areas
2. To protect and develop forest areas
3. To protect and develop ecological values
4. To ensure urban development is planned
5. To coordinate urban planning with green space planning
6. To develop innovative tools for the planning of urban green spaces
7. To ensure the contribution of green spaces to the urban ecology and microclimate
8. To provide equal opportunities for the use of green spaces
9. To establish an urban open green space hierarchy
10. To increase the quantity and quality of green spaces
11. To ensure easy access to green spaces
12. To enhance the social functions of green spaces
13. To build capacity and establish participatory mechanisms for green space management
14. To ensure the contribution of green spaces to the city identity of Antalya

The protection of forest areas has also been designated as a strategic goal. To achieve this, forest areas must be designated as absolute protection zones in physical development plans, forests like Lara Obruk Pine Forests and others in various parts of the city must be protected from dense urban development, and efforts should be made to address the planning issues of forested lands. Additionally, projects should be developed to ensure that forests around the city are accessible for recreational purposes.

Within the strategic goal of protecting and improving ecological values, efforts should focus on preserving natural values, biodiversity, genetic resources, and landscapes in terrestrial, coastal, aquatic, and marine areas. This includes transforming informal settlement areas located on ecologically valuable treasury lands into healthy spaces through urban renewals, ensuring the protection and sustainability of the city's flora and fauna, and reflecting ecological protection decisions in higher-level city planning. Legal regulations must be adhered in order to protect the ecological structure and landscape.

In line with the strategic goal of planned urban development, one of the basic strategies involves the creation of green buffer zones between urban and rural areas. To achieve this, the zoning decisions in the north of the city must ensure the protection of the "ecological movement band," urban capacity, threshold, risk, value, and density analyses should be conducted in conjunction with urban planning.

To achieve coordination between urban planning and green space planning, strategies include creating landscape plans from macro to micro scales and ensuring their integration into urban plans, planning open and green spaces within a system of spatial integrity, and providing necessary data for national, regional, and local landscape programs. This includes creating a national landscape program, a regional landscape master plan, and green system plans.

The strategic goal of developing innovative tools for green space planning involves the development of green space policies and strategies, creating a participatory green space strategy guide for the city, updating digital data in planning, using geographic information systems and remote sensing technologies, and establishing a Green Space Information System for the city.

To contribute to the urban ecology and microclimate, strategies include planning the city's open-green spaces as a system composed of large and small green spaces, natural and artificial corridors, and agricultural and forest areas. Ensuring the continuity of green spaces throughout the city and creating north-south corridors for urban development areas are also important strategies.

The strategic goal of providing equal opportunities for benefiting from green spaces involves ensuring a regular distribution of active green spaces across the city, so that all individuals—regardless of age or disability—can benefit from them. The strategies include increasing the number of active green spaces in all districts, resolving property and ğhysical development issues, and making green spaces accessible for people with disabilities.

For the creation of a hierarchy in urban open green spaces, strategies include designing active green spaces at neighborhood, district, and city scales, ensuring that areas without physical development plans align with urban green space systems, and creating neighborhood parks, city parks, and regional parks in a connected way.

Increasing the quantity and quality of green spaces involves designing active green spaces to meet the legal standard of 10 m² per person and creating larger parks and green spaces, especially in areas with insufficient green space. This includes creating parks and thematic gardens for tourists as well as for residents.

To improve social functions of green spaces, strategies include ensuring that green spaces serve social, cultural, and sporting activities, improving the spatial quality of popular parks such as Karaalioğlu Park and Atatürk Cultural Park, and organizing events at parks like Falez Park and Düden Park to allow public participation.

The strategic goal of developing capacity and creating participatory mechanisms involves employing landscape architects in municipalities, strengthening local governance, and establishing monitoring mechanisms to integrate public opinions into green space projects. Coordination among institutions involved in green space development is also crucial.

The contribution of green spaces to the city's identity is a strategic goal, aiming to preserve the natural identity elements of Antalya such as coasts, cliffs, and cultural sites, and encourage the revitalization of historical garden cultures through the promotion of public-private sector involvement in cultural and historical garden projects.

5. Discussion and Conclusion

Antalya is one of the cities most affected from urbanization in Turkiye. Since the 1950s, rapid urban growth driven by migration has created housing demands, and illegal housing production has become one of the primary obstacles for implementing green space decisions in physical development plans. The Tourism Incentive Law, enacted in 1982, has significantly impacted Antalya, particularly in coastal areas where tourism has led to secondary housing production, turning these areas into tourism zones.

The results of this study confirm these trends and transformations over time. According to satellite images from 1987, urban spatial changes were concentrated along the coasts, and the central and coastal areas experiencing the most significant urban development. By 2002, with the city's transition to a metropolitan status, development accelerated, particularly on the western coasts and the northern parts of the city, with tourism shaping the urban fabric. From 2010 onwards, the city expanded further north and west, converting agricultural areas into urban zones, and rural areas were connected through transportation networks.

As one of the fastest growing cities in Turkiye, Antalya's population is continuously increasing. This rapid growth has intensified pressures on green spaces. Although the surface area of active green spaces has increased over the years, the per capita green space remains below the 10 m^2 standard, with 4.2 m^2 per person. However, it is still in a better condition compared to cities like Istanbul and Ankara, where the per capita green space is under 2 m^2.

In terms of green space size, Antalya's parks tend to be smaller than those in other countries. Over 50% of the green spaces in the city are smaller than 2000 m^2, limiting their functionality. The distribution of green spaces is also uneven, with central and coastal areas having better access, while the northern regions suffer from housing and property issues.

This study demonstrates that Antalya can improve its green space system by implementing strategies to extend the reach of green spaces and integrating them more effectively into urban planning processes.

Acknowledgment

This study was supported by Akdeniz University, Administration Unit of Scientific Research Projects (Project No. 2011.03.0121.004).

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CHAPTER 9

Analysing Konya City Mevlâna Street in terms of Pedestrian Safety

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INTRODUCTION

Pedestrian transport is the most common and important type of transport. A pedestrian is a person who spends at least part of their journey on foot. In addition to ordinary walking, a pedestrian may use a variety of walking aids such as wheelchairs, motorised scooters, walking sticks, walkers, skateboards and roller skates. A person is also considered to be a pedestrian when running, exercising, climbing, sitting or lying down on the road network.

A pedestrian is defined as a road user who usually travels on foot and is vulnerable to motor vehicles. Driver behaviour poses a risk to pedestrians using different parts of the road network. Periodically published pedestrian accident statistics show that pedestrian accidents result in a high number of fatalities. Therefore, ensuring pedestrian safety in urban areas is an issue that needs to be addressed carefully. When pedestrian fatality statistics in traffic accidents are analysed, it is seen that pedestrian fatalities in Turkey are much higher than in many other countries.

While pedestrian transport had the largest share of urban transport in cities before the industrial revolution, its importance started to decrease with the introduction of automobiles. Automobile-oriented urban development policies have led to uncontrolled urban sprawl, making it difficult to provide pedestrian transport.

Today, in developing countries such as Turkey, pedestrian safety in cities has become an increasingly important issue with the increase in population and urbanisation. Along with this, some obligations have emerged on people in the fields of housing, transportation, socialisation and cultural areas. It is seen that pedestrian circulation and pedestrian safety are gradually decreasing and even disappearing, especially in city centres, within the intensive motor vehicle traffic in growing cities (Dündar and Özgün, 2024).

Due to the intensive use in urban centres, there are transportation options such as public transport, private vehicles, rail transport system. This vehicular traffic leads to limited use of pedestrians in poorly designed urban centres. Although the areas serving pedestrian use are limited due to the non-pedestrian uses within the borders of Mevlâna Street, which is the study area, there are also measures to be taken for safety.

The Alaaddin Hill park, mosque, tomb, banks, bazaar, bazaar, bedesten, shops, museum and food and beverage venues on Mevlâna Street are the elements that intensify pedestrian use in the area. According to World Health Organisation data, 23% of the deaths in traffic accidents are pedestrians (Republic of Turkey Ministry of Environment, Urbanisation and Climate Change, 2016). Therefore, pedestrians have to be the road user group with primary priority in terms of road traffic safety. In order to increase the safety of all road users, especially pedestrians, the problems that pedestrians face in traffic and that endanger their safety should be examined and these problems should be eliminated as much as possible.

While sidewalkss should be road sections where only pedestrian movements are allowed, in our country, these areas are frequently subjected to misuse where motor vehicles are parked. In the study area, pedestrians can sometimes be negatively affected by other unprotected road users. (Dündar and Özgün, 2024). In places where there are no bicycle paths in the area, bicycle and motorbike users may prefer to continue their journeys on pedestrian sidewalks to avoid being affected by motor vehicles.

Due to the food and beverage venues in the area, motorcycles used for commercial purposes by courier services for distribution use the pedestrian sidewalks when moving in the opposite direction of traffic. These situations increase the possibility of pedestrian accidents. Different types of pedestrian crossings should be created on the street for pedestrians to cross the street and pedestrians should be provided to cross safely. However, although the street is long, there are not enough pedestrian crossings and arrangements that ensure safe crossing. In addition, the low number of traffic lights that provide safe crossing at pedestrian crossings and the inadequacy of the signal duration make crossing difficult.

The inadequacy of ramps in the area generally poses a problem for disabled individuals, parents using prams and elderly people. The lack of embossed floors in the area also poses a risk for disabled people.

1. Research Area Definition

Konya, which is the largest province of Turkey in terms of area, generally consists of high plains. Naturally, it is surrounded by various plateaus, lakes and mountains. The city has been used as a settlement since prehistoric times.

Mevlâna Street, which is the study area, constitutes the main axis in the historical city centre of Konya and is the axis connecting Alaaddin Hill and Mevlâna Tomb which has a primary importance in the city identity. The street, which is located between Alaaddin Hill, where there are findings from the Prehistoric Period, and the tomb of Mevlâna Celaleddîn'i Rûmi, who lived in the

XXIIIth century, has an important place in terms of Konya's historical and cultural heritage (Figure 1).

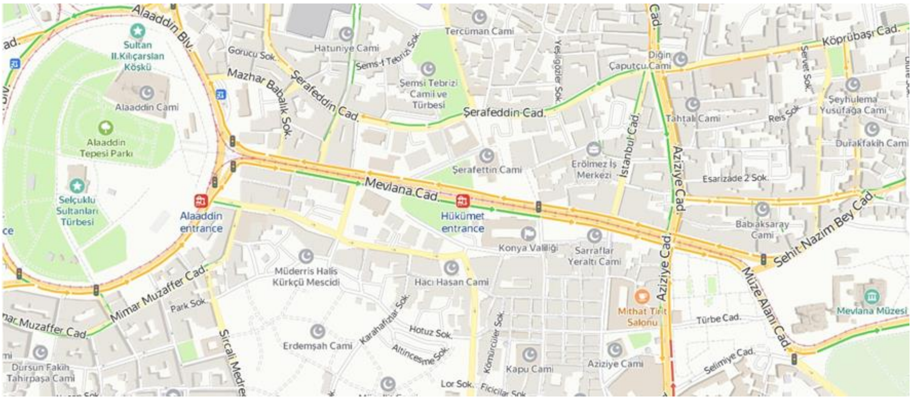

Figure 1. Mevlâna Street, Konya (Google maps, 2024).

In this region, which stands out with its historical, commercial and touristic qualities, various public and commercial buildings have taken place over time, some of which have been modified or re-functionalised, while others have been demolished for reasons such as road construction. For example, the Konya İş Bank building, built in 1951, is an example of the Second National Architecture Period (Çınar and Erdoğan, 2021). Mevlana Street hosts various cultural events. The historical buildings in the area are particularly concentrated around Alaeddin Hill.

1. Concept of Transport

Transport refers to the movement of people and goods from one place to another and is defined as an important element that establishes a connection between land uses (Zorlu, 2017). Transport has two basic structures: infrastructure and superstructure. The most important components of infrastructure are roads and terminal areas, while superstructure includes traffic and vehicles.

What is expected from transport services is the smooth and controlled transport of people or goods for a certain purpose. While people move for various socio-cultural activities, goods and values are transported for production and consumption. In this context, transport can be broadly defined as the transmission of news, the transport of goods and goods and the transport of energy.

Urban transport is a concept that emerged with the formation and development of cities and covers all mobility (passenger, freight, vehicle, pedestrian, bicycle, etc.) within the city boundaries. Urban transport elements play a major role in the realisation of economic and social activities in cities (Akbulut, 2016).

1.1. Types of Transport

It is not enough for urban dwellers to live in cities in order to enable them to realise their daily activities more easily. In addition, a transport classification that focuses on the individual is also necessary. Due to the large difference between pedestrian and vehicular transport speeds (pedestrian 4 km/h; vehicle 30 km/h), a classification from pedestrian priority transport to vehicle priority transport has emerged in urban traffic (Tellan, 1999).

Considering the historical development of urban transport, it is seen that different transport systems were used in different periods and different classifications were made. Urban transport is generally handled in two sections as individual and public transport. While individual transport consists of pedestrian, bicycle and automobile, public transport consists of minibus, bus, light rail systems, metro and suburban (Akbulut, 2016).

- Urban public transport

Public transport is a form of urban transport and at the same time a form of public service provided to urbanites. It is planned and provided as an urban transport service by city administrations in order to meet the travel needs in cities. Urban public transport refers to public transport systems used to carry passengers within the city. These systems aim to manage passenger traffic in the city, reduce traffic congestion, minimise environmental impacts and provide an accessible transport option for all citizens (Figure 2) (Kılınçarslan, 2012).

Figure 2. Priority scheme in urban transportation (Özerk, 2015).

- **Automobile transport**

Automobile transport refers to the travelling of individuals and small groups in private or rented vehicles. It is one of the most common modes of transport today and provides great flexibility, comfort and independence. However, it also has some disadvantages such as traffic congestion, environmental impacts and high costs (Sutcliffe, 2012).

- Bicycle transport

Cycling refers to individuals travelling short and medium distances by bicycle. Cycling, which is both an economical and environmentally friendly mode of transport, also provides many health benefits. Increasingly popular in cities and rural areas, cycling has an important place among sustainable transport solutions (Vuchic, 2007).

- Pedestrian transport

Pedestrian transport refers to the movement of individuals from one place to another on foot without using any motorised vehicle. Pedestrian transport is of great importance in the planning of cities and daily life. Pedestrian paths can be defined as pedestrian flow surfaces reserved for the use of pedestrians only and closed to motorised vehicle traffic (Şenkaynak, 2010).

The concept of walkability is directly related to pedestrian transport. Walkability can be ensured by the creation of areas in the built environment that will enable pedestrians to reach certain points safely and comfortably, have quality, visual appeal and support walking. In addition, pedestrian spaces that offer physical activity opportunities to individuals and support sustainability offer more value in terms of walkability (Girginer and Cankuş, 2008). Walkability cannot be considered independent from the built environment in cities because the physical qualities of the built environment determine the level of mixed use, accessibility and permeability of the space. Since pedestrian traffic is location dependent, there is a flow. This flow, which occurs through orientation, gathering and dividing actions, can be managed with good planning and design (Haidary, 2020).

Pedestrian transport is a healthy, economical, environmentally friendly and social mode of transport. Planning cities to be pedestrian-friendly both improves the quality of urban life and contributes to sustainable urbanisation. Encouraging pedestrian transport and providing the necessary infrastructure should be an indispensable part of modern cities (Girginer and Cankuş, 2008).

3. Pedestrian Safety Concept

Understanding and taking precautions against traffic accidents, which also threaten pedestrians in cities, is critical for improving the safety and livability of cities. In order to ensure safety and comfort in pedestrian and vehicle traffic, it is necessary to make necessary traffic regulations for both pedestrians and vehicles.

Pedestrians, together with cyclists, are the most vulnerable road users in terms of safety against vehicles. For this reason, in addition to vehicle-vehicle collisions in traffic safety analyses, some studies focus only on vehicle-pedestrian collisions. Studies have shown that all risk points are located on major streets with high pedestrian mobility (Yüksekol, 2012). Pedestrian safety is a critical issue for cities and many local governments are implementing various practices through traffic regulations and infrastructure improvements. In order for these practices to be effective, cooperation and awareness raising between local authorities, traffic police, drivers and pedestrians are necessary. In this way, pedestrian safety in urban areas can be ensured and accidents can be prevented.

3.1. Risk Factors Causing Pedestrian Injuries

Pedestrian injuries are related to factors such as traffic accidents, infrastructure deficiencies and human factors. These risk factors can be analysed under the following headings: inadequate visibility of pedestrians, deficiencies in pedestrian services, problems related to the physical space design of pedestrian roads.

3.1.1. Inadequate visibility of pedestrians

Poor visibility of pedestrians is an important factor leading to traffic accidents and injuries. Factors such as nighttime and low light conditions, inadequate lighting, visual obstructions and visual distractions increase the risk of drivers hitting pedestrians.

Improving pedestrian visibility is a critical step to ensure pedestrian safety (WHO, 2017). Providing crossing treatments such as raised islands and traffic signs, increasing the intensity of lighting on the roadway increases the visibility of pedestrians at pedestrian crossings, especially at night. This intervention has been associated with significant reductions in night-time pedestrian accidents. Increasing pedestrian visibility; adding reflective elements to backpacks, shoes and clothing, as well as choosing light coloured clothing are simple measures that increase the visibility of details.

3.1.2. Deficiencies in pedestrian services

Inadequate attention to pedestrian services in the planning and design of urban pedestrian routes can have negative effects on pedestrian safety and comfort. This situation may cause pedestrians to encounter risky situations in terms of safety in public spaces.

Although issues such as the lack of seating areas and shaded areas that serve pedestrian use may seem to serve pedestrian comfort, they will indirectly jeopardise pedestrian safety as they will cause insufficient rest and fatigue (WHO, 2017).

'Curb extensions' can be used before pedestrian crossings to provide pedestrians with a more visible safe place and a good view to observe traffic. This has the added advantage of reducing the crossing distance for pedestrians and slowing vehicle speeds by creating a narrowing of the roadway (Yasan et al. 2021). Similarly, signalling and push-button systems at pedestrian crossings are also elements that increase pedestrian safety.

3.1.3. Problems Related to Physical Space Design on Pedestrian Roads

One of the most important factors affecting space design in cities is the movement habits of people. People shape urban transport by actively moving in their daily lives. In order for pedestrians to move safely and comfortably, open or semi-open spaces away from heavy vehicle traffic should be created. These spaces should be free from vehicles and have versatile functions. Nodes where pedestrian and vehicular roads intersect are areas that show density and should be determined as focal points.

As mentioned before, the design of pedestrian spaces is not independent from urban design. Therefore, well-designed public spaces, especially those associated with pedestrian axes, will allow pedestrians to spend time and refresh themselves in these spaces, thus creating more comfortable and therefore safer pedestrian spaces. In design, depending on the movement habits of pedestrians specific to that place; movement, pause and gathering areas should be organised.

When designing pedestrian-oriented roads in urban spaces, importance should be given to arrangements that will guide individuals easily. Slope of 1-3% is ideal on pedestrian roads and should not be more than 7-8%. Ramps should be used instead of stairs and embossed walking bands should be placed for the visually impaired. High materials should be avoided for wheelchair users, visual warnings and illuminated systems should be used for the hearing impaired. Wayfinding should be facilitated with information signs, vegetative materials and lighting systems should be added for an aesthetic and safe environment (WHO, 2017).

Physical environmental arrangements to be made in order to increase the access of disabled people in cities will facilitate the participation of individuals with temporary mobility restrictions (elderly, pregnant women, people with prams, children) in social life. Unfortunately, most pedestrian areas in our country contain various obstacles that restrict both disabled and non-disabled people. Design models that are not suitable for disabled people in cities restrict the independent movement and participation of individuals with physical, sensory and cognitive disabilities in social life. The use of Braille alphabet in public spaces, increasing the number of audio guidance devices, making directional markings (embossed surfaces, etc.) for the independent movement of disabled individuals, and building ramps where necessary are important measures to be taken.

Accessibility to urban outdoor spaces and built environments designed to provide comfort and convenience (accessibility) is very important for disabled people. It is of great importance for every individual to be able to access and benefit from rights and services in all areas of life in participation in community life. The most important condition for the elderly and mothers with children as well as the physically disabled to socialise in urban spaces is the availability of accessibility.

4. Practices Related to Pedestrian Safety in Cities

Pedestrian safety is a critical issue for cities and many local governments are implementing various practices through traffic regulations and infrastructure improvements. In order for these practices to be effective, cooperation and awareness raising between local authorities, traffic police, drivers and pedestrians are necessary. In this way, pedestrian safety in cities can be ensured and accidents can be prevented.

The issues to be considered in the design of urban pedestrian spaces are discussed under the following headings. These can be considered as pedestrian roads and sidewalks, pedestrian crossings, ramps, paving materials, traffic slowing applications, pedestrian speed-density relationship.

Pedestrian Roads and Sidewalks

The standards for footpaths and sidewalks can be summarised as follows:

Width: The clear width of the footway should be at least 150 cm. Safety strips may be up to 50 cm on the property boundary and 120 cm on the kerbstone side.

Height: The height of the sidewalk should not exceed 15 centimetres in any place.

Slope: The slope of the sidewalk should be 2-3 per cent towards the carriageway for surface water drainage.

Kerb Stone: The kerbstone should be 0.70 - 1 metre long and 0.15 - 0.20 metres wide.

Pavement Material: The footway should be paved with easily removable and reusable material such as cobblestones or concrete paving blocks.

Absence of Obstacles: There should be no obstacles such as flower beds, stones, iron, etc. on the pedestrian pavement that will prevent the pedestrian from walking safely.

Manhole and Facility Covers: The covers of manhole, chimney control and similar facilities belonging to the infrastructure built on the pedestrian sidewalk should be in the same plane with the coating surface. (Turkish Standards Institute (TSE) (2023)

Pedestrian Crossings

In our country, pedestrian traffic has generally been neglected and more focus has been placed on motor vehicle traffic. Measures such as pedestrian crossings and traffic lights have been taken to correct this situation. However, drivers generally do not comply with these rules. More effective solutions should be sought for the safe passage of pedestrians.

Technological solutions such as the "Push-Button Pedestrian Crossing Signaling System" can be used to ensure the safe passage of pedestrians. This system allows pedestrians to cross the street in a safe and controlled manner (Seçkin, 1997).

Ramps

Ramps used in outdoor areas provide a stepless and inclined passage by combining planes at different elevations. The features of these ramps may vary depending on the area and infrastructure where they will be used. Sidewalk ramps, which are especially suitable for wheelchairs and walking-impaired individuals, should be located at least next to the stairs. Generally, the appropriate ramp slope should be between 5% and 8% (Seçkin, 1997). Table 1 shows the design principles of ramps.

Table 1. Design principles of ramps (Arslan ve Acar, 2020).

	EVALUATION CRITERIA
RAMPS	The maximum ramp slope of the distance up to 10 cm is 10%
	The maximum ramp slope of the distance up to 25 cm is 8%
	The maximum ramp slope of the distance up to 50 cm is 5%
	If there is a transition from a ramp to a second ramp, at least 250 cm flat rest areas should be made.
	There should be a flat and different textured area of 1.5 m length at the beginning and end of the ramps
	Handrails should continue for 45 cm at the beginning and end of the ramp
	If the length of a ramp is more than 6 m, a 150 cm long landing is placed in between
	The surfaces of the ramps should be covered with a hard, stable, non-slip and very slightly rough material.

Traffic Calming Applications

The mobility demands of road users using urban road infrastructure often conflict with the access and safety expectations of vulnerable road users. This can lead to increased accidents at intersections and pedestrian crossings. Low speeds are necessary to ensure harmony between cyclists, pedestrians and local access. Road safety experts have developed various physical features to slow down drivers. According to Hamilton-Baillie, reducing the linearity of roads increases driver attention. Reducing yellow lines and creating parking pockets helps slow drivers down (Barkham, 2016). Traffic calming applications aim to reduce vehicle speeds and encourage drivers to choose alternative routes by using geometric differences and design, thus creating a more livable environment for the surrounding area. The use of traffic calming systems in the area can reduce the conflict between pedestrian and vehicle movements. In addition, police control is also necessary to ensure compliance with the rules. While Konya City center attracts attention with its historical texture and commercial potential, it does not provide sufficient accessibility for the elderly, children and disabled. While vehicle traffic causes problems in entering and exiting, the inadequacy of green areas and resting points also poses problems for pedestrians.

Pedestrian Speed-Density Relationship

The rapid increase in population in developing cities and the resulting increase in vehicle traffic and construction activities on the streets, make traffic and construction noise even more important (Zannin et al., 2002). Pedestrianization is a humanitarian approach that increases livability, provides comfortable circulation and safety for pedestrians, and contributes to the increase in the use of streets and avenues and economic vitality, especially in city centers. Especially in cities with historical accumulation, historical city centers are pedestrianized and offered to people's use.

However, some wrong decisions taken during the restoration of historical structures can cause the loss of the values of the historical texture. A harmonious environment can be created by protecting natural and cultural values. Therefore, in order to create a contemporary environment, cities should be designed where people are at the center of attention and pedestrians are always superior and prioritized.

Pavement Materials

The main goal in the design of pedestrian paths and sidewalks connecting different areas and activities in outdoor spaces is to provide accessibility along with safe transportation for all users. In urban spaces, on the pedestrian path for free circulation; There should be sufficient width, movement area, flat and non-slippery surface, guidance and warning elements. The flooring material selected for pedestrian paths should be non-slip and facilitate circulation, underground installations and manhole covers should not protrude and care should be taken to ensure that the ground is at the same level by avoiding sudden level changes.

Attention should be paid to the presence of tactile surfaces at pedestrian crossings. It is extremely important that the beginning of the ramp can be felt. The road surface should be brought to the same level as the sidewalk to prevent disabled people using wheelchairs from having difficulty in overcoming the height difference. Depending on the width of the pedestrian sidewalk, plants, electricity, traffic signs and poles and similar facilities to be planted on the sidewalk and the vehicle path should be placed in a strip of at least 75 cm and at most 120 cm wide along the pedestrian sidewalk and should be placed in the same alignment (Seçkin, 1997).

5. Problems Related to Pedestrian Safety on Mevlana Avenue

Mevlana Avenue, which connects Alaaddin Hill and Mevlana Tomb, is a densely populated avenue due to its important location in the historical city center and also the attraction of gastronomy and other trade areas serving tourism; therefore, it serves dense vehicle and pedestrian traffic. The fact that important bus lines pass through Mevlana Avenue causes accumulations in vehicle traffic in the area. The rehabilitation and pedestrianization works carried out around the Mevlana Tomb aim to increase public transportation and reduce vehicle traffic. The restoration works carried out in the Bedesten and neighboring area, located right across from the Mevlana Tomb, have revitalized the area in recent years and increased the number of visitors. A religious center began to form around the Mevlana Tomb, which was built at the end of the 13th century to the east of the historical center located on Alaeddin Hill, and a busy commercial area expanding south and north developed between these two focuses (Önge, 2018). The number of visitors to the Mevlana Museum has also increased, and the city center has once again become an area preferred by pedestrians. This area serves functions such as commercial areas, touristic product sales, restaurants, and cafes.

In recent years, there has been a diversification of trade on Mevlana Street, and the duration of tourists' stay in this area has also increased. Approximately 1 million 200 thousand people have visited the Mevlana Museum since the beginning of 2023 (between January 1 and May 23). Thus, the historical city center has once again become an area used intensively by pedestrians. Commercial functions are not limited to production alone, but have also taken on many functions such as touristic product sales points, restaurants, and patisseries. It has become remarkable by leaving the fronts of commercial areas open.

There are many problems in terms of pedestrian safety in the area. For example, the inadequacy of green areas, rest areas, and urban furniture on the street are among the issues that users complain about. In addition, there are access problems on the street, especially for the elderly, disabled, and children. In many parts of the sidewalks on the street, there is no difference in elevation between the vehicle and pedestrian path, which makes it difficult to create a clear boundary with the vehicle path. In some areas, vehicles park on the sidewalks, causing pedestrians to have to cross the vehicle path.

The problem on Mevlana Street is the traffic, speed, and noise passing through that area in transit. The fact that there is a case of shortcut use in the area increases the seriousness of the problem. Apart from the additional traffic volume it causes in the area, motor vehicle drivers using shortcuts drive faster than local motor vehicle drivers. This situation poses a risk to pedestrians in the area. Speed calming studies can improve the real and perceived safety of pedestrians and cyclists in the area and therefore their quality of life by working on the problems of high speed and shortcut use. Mevlana Street is an area with high traffic because it is subject to heavy use. Thus, there are times when pedestrian and vehicle movements overlap.

Settlement areas were formed to the north and east of the Mevlana Tomb, and especially the Çelebi Neighborhood, where the çelebis descended from Mevlana settled in the last periods of the Ottoman Empire, became the most distinguished settlement area of the city (Yenice, 2011). Bus lines serving the entire city pass through Mevlana Street and use Kayalıpark, located at the northeastern end of the study area, as a terminal point. A total of 129 bus lines pass through (Gezgin, 2014). The area where the Mevlana Tomb is located and the square were arranged, the rehabilitation, correction and revitalization applications of the Şems Tebrizi Tomb and its surroundings, the Bedesten and the residential areas in the east-west section and the areas to the east and west of the Şerafettin Mosque were completed, and the traditional bazaar area was turned into pedestrian zones. In addition, parallel to the pedestrianization works, it is aimed to reduce heavy vehicle traffic, expand public transportation by building a tram line between Alaeddin and Yeni Adliye, and it is suggested that Mevlana Street will be closed to vehicle use in the future and reserved only for public transportation, pedestrians and bicycles. It is planned to reduce traffic density with this application.

Since Mevlana Street is also an open area with heavy use, vehicles such as private cars, motorcycles, trams and bicycles are used. In addition to the heavy pedestrian movement, the heavy movement of these vehicles increases the risk of accidents. Since the traffic lights in the area do not turn on at sufficient speeds at pedestrian crossings, most pedestrians have difficulty crossing the road.

The width and layout of the sidewalks on Mevlana Street are insufficient to ensure that pedestrians can move comfortably and safely. In particular, the stalls, signs and other obstacles placed in front of the shops reduce the functionality of the sidewalks. This means that pedestrians have to share vehicle traffic with pedestrian traffic. Most of the sidewalks on the street are at the same level as the roadway. It has been observed that vehicles are parked on the sidewalks in some parts of the area. This situation has forced pedestrians to cross the roadway instead of the sidewalk. It has been observed that the roots of the trees on the sidewalk have lifted the pavements in some areas. Such deterioration can cause pedestrians to trip and get injured. The walking paths for disabled individuals in the area are only on one side of the road. This deficiency makes it difficult for disabled individuals to find their way and negatively affects pedestrian safety.

When the application area and pavement status of the plants in the research area are examined; it has been determined that there are applications that pose obstacles in the entire area. Since the plants are located in the middle or adjacent to the sidewalks, they prevent the passage of pedestrians using the walking path.

While revealing the status of urban equipment elements in the research areas in terms of disabled accessibility; seating units, garbage cans and lighting elements have been examined. Only the seating units located in the exhibition area on Mevlana Street and the Metropolitan Municipality Sarraflar Underground Bazaar are benches located in the area and are placed at regular intervals. There are benches in a few places on the Mevlana axis, but these are also positioned incorrectly.

When examined in terms of ergonomics, it has been seen that the height of the benches from the ground is 45 cm and the height of the backrest is 70 cm. The garbage cans are fixed on the ground on the walking paths and prevent the movement of the user. Two types of garbage cans, small and garbage containers, fixed to the ground, have been used in the area. High lighting elements have been used at regular intervals in the research area. The height measurements of the lighting elements are above the head-saving height of 220 cm. It has been determined that the amount of reinforcement elements in all areas is quite insufficient and that it restricts the width of the road in terms of usage and negatively affects not only disabled access but also all pedestrian traffic. The surroundings of the existing reinforcement elements are surrounded by stimulating elements from tactile surface elements and have different textures and color contrasts.

Different types of pavement materials were used in the area, and in some parts the different types of materials used caused confusion in terms of defining and directing the space (Figure 3). It is thought that the reason for this situation is that the damaged pavement materials were removed and covered with different types of materials.

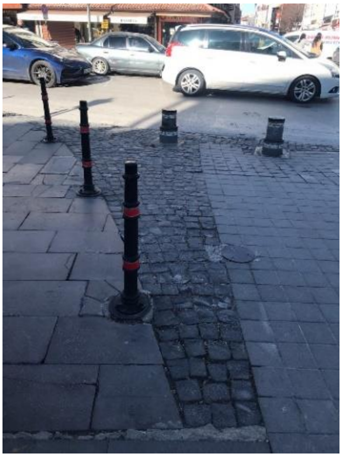

Figure 3. Changes pavement materials on Mevlana Street (Original, 2024).

The pedestrian crossing and two-way ramps arranged for the transition from the tram stop to the area are in accordance with the standards. The height differences in the pavements of the pedestrian crossings on the street pose a security risk. In places where motor vehicle and pedestrian traffic intersect, the light durations that allow passage are insufficient. With the push-button pedestrian crossing system to be placed in these parts, pedestrians can cross the street in a safe and controlled manner and the speed of pedestrian traffic can be increased.

The sidewalks on the traffic axes providing the transition from the tram stop to the area provide accessibility standards with a tactile surface for the visually impaired and a ramp arrangement with two-way slopes for wheelchair users. It was observed that the ramps were in accordance with the standards in width, but there were no guardrails, tactile tapes and the appropriate 8% slope application. The elevation differences in the area were provided with sloping roads or ramps arranged from the street sidewalk to the lower level. In the implemented ramps, there is no 150 cm long and different textured perceptible surface application for the visually impaired at the beginning and end of the ramp. In this context, ramps pose a problem for the disabled in terms of use and access.

The pedestrian paths on Mevlana Street are not very reassuring but inviting. There are tree species, flowers, and seating elements in certain parts of the area that will increase the attractiveness. Although it is designed with an aesthetic and functional arrangement, some deficiencies and deteriorations in the area pose a risk. The fact that there are different types of shops in the covered bazaar close to the area increases the use of the area as a meeting point. The activities in these areas affect the interaction of people with the pedestrian paths.

When Mevlana Street in Konya is examined, it is seen that there are few studies on pedestrian movements. The pedestrian crossing surface and two-way ramps created during the transition from the tram stop to the area have also been arranged in accordance with the standards. Mevlana Street is a crowded street because it is surrounded by shops with traditional architecture, cafes and souvenir shops. Although most of the pedestrian crossings in the area are short, since the heights of the cube stones used as flooring are not equal to each other, elderly people wearing high heels, walking sticks, pedestrians with baby strollers, etc. will have difficulty trying to cross the street. This situation is both aesthetically inappropriate and poses a risk in terms of safety. Since motor vehicle traffic and pedestrian traffic intersect in the area,

It has been observed that the light durations used for crossing the street are insufficient. Buttons for crossing can be used at the starting points of pedestrian crossings in the area. Thanks to the 'Push-Button Pedestrian Crossing Signaling System', pedestrians can safely cross within 1 minute at the latest. If this system is used in Mevlana Street in Konya, it will at least have a positive effect on pedestrian traffic speed and prevent pedestrian-related accidents (Figure 4).

Figure 4. Push-button Pedestrian Crossing Signaling System (Original, 2023)

As is the case throughout our country, pedestrians are not considered as the primary element of traffic in Konya city center. Since the roads in the historical center of the city were planned before vehicle traffic, they have a limited road network. With the increased use of motor vehicles in urban transportation, existing roads have been arranged according to the needs and standards of motor vehicles. Therefore, the sidewalks required for pedestrians are insufficient and do not comply with the standards (Figure 5).

Figure 5. Example of pedestrian access barrier on Mevlana Street (Original, 2024)

The existing sidewalks in the area have been narrowed for various reasons for use for other purposes, and therefore the pedestrian paths have been interrupted. The pedestrian paths have been created without considering pedestrian continuity by placing garbage containers, electricity poles, taxi rank booths or bus stops. Due to such reasons, pedestrians are forced to walk on roads reserved for vehicle traffic and their safety is at risk. Therefore, the obstacles on the pedestrian paths should be removed and the safety of pedestrians should be increased by bringing them to standard widths (Figure 6).

Figure 6. The obstacles on the pedestrian paths at Mevlana Street (Original, 2024).

Since the pedestrian crossings on Mevlana Street were planned not for pedestrians but for motor vehicle traffic, their use is inadequate. Some intersection arrangements in the Konya city center were also designed without considering pedestrians. For example, pedestrians are at great risk in such arrangements where pedestrian and vehicle movements are intense, such as the intersection behind the Metropolitan Municipality, in front of the Mevlana Tomb, the Monument, the Muhacir Bazaar, and the Kunduracılar multi-storey intersection.

Figure 7. Unsafe pedestrian crossings on Mevlana Street (Original, 2024)

A large part of the city center of Konya is arranged with level crossings, and pedestrian crossings on the tram line, especially at the Municipality, Fair and Zafer stops and on the Adliye tram passing through Mevlana Street, are dangerous crossings for pedestrians, and tram and pedestrian traffic share the same area. Pedestrians cannot cross safely due to the free right turns provided to vehicles at many intersections. Although there are signs saying “pedestrians have the right of way” at places where these right turns are free, vehicles are required to give way to pedestrians, but pedestrians are forced to give way to vehicles.

A number of technical errors that will cause difficulties for disabled individuals have been encountered between Alaaddin Hill and Mevlana axis.

- The ramps in the area are too steep for a wheelchair user and are dysfunctional.

Figure 8. Mevlana Street ramp solution example (Original, 2024).

These trees not only prevent people from walking on their paths comfortably, but also pose an obstacle for wheelchair users.

Figure 9. Alaaddin Hill sidewalk arrangement (Original, 2024)

The stairs used to descend from Alaaddin Hill are suitable for adults but are dangerous for children. It is not possible for disabled individuals to use the stairs that have been built. There are no landings, railings or ramps for disabled individuals in the area. Although there are guiding surfaces for the visually impaired on the main axis, there are problems with the usage map. Visually impaired paths can suddenly cut off and direct the user from the area to different places.

Figure 10. Mevlana Street and step solutions without warning surfaces (Original, 2024)

It has been observed that limiting elements are frequently used in the area to regulate vehicle and pedestrian traffic. No material has been used in the tramway passing through the middle of the pedestrian crossing between vehicle traffic on Mevlana Street in order to ensure safety. There are no obstacles separating the tramway from the pedestrian and vehicle path, except for the ground elevations in the stop areas. While different usage areas in outdoor areas should be separated from each other by creating flooring differences, this separation is mostly done with concrete barriers and buoys. These barriers, which are fixed to the ground at a height of 45-50 cm, are also used to prevent vehicles from passing to the sidewalk. However, it has been observed that these barriers are damaged by vehicles and the sidewalks are occupied (Tutkan 2010). The lighting on the axis between Alaaddin Hill and Mevlana Tomb is designed in accordance with the historical and cultural importance of the area. These lighting systems both provide an aesthetically pleasing appearance and ensure safety. High energy efficiency LED fixtures have been preferred on Mevlana Street. These fixtures offer both environmentally friendly and economical solutions due to their long life and low energy consumption.

The height and spacing of the lighting poles on the street have been adjusted to suit the needs of both pedestrians and vehicle traffic. They have been placed at certain intervals to ensure pedestrians can walk comfortably and ensure their safety.

In addition to road lighting in the area, parking areas, walking paths and squares have also been carefully illuminated. The lighting elements used in these areas have been selected to meet both aesthetic and functional requirements.

Considering the high traffic volume and heavy pedestrian traffic in the area, sufficient and homogeneous lighting has been provided to increase safety. The location of the lighting poles has been strategically determined to ensure that pedestrians and vehicles can move safely.

CONCLUSION AND RECOMMENDATIONS

The study examining pedestrian access in terms of safety on Mevlana Street has comprehensively evaluated the current situation on the street and the factors affecting pedestrian safety. The findings can be summarized as follows:

Traffic density and vehicle speeds;

Mevlana Street is an area used intensively by locals and tourists. Therefore, vehicle traffic is intense and continuous. Observations and speed measurements show that many drivers exceed the speed limits and drive dangerously, which threatens the safety of pedestrians.

Deficiencies in pedestrian crossings and signaling;

The number of pedestrian crossings on the street is insufficient and signaling systems are either not working or inadequate at some of the existing crossings. Insufficient signal times cause pedestrians to rush and cause unsafe crossings.

Insufficiency of sidewalks and walking areas;

The width of the sidewalks is insufficient at many points and there are places where pedestrians cannot use them comfortably due to obstacles. Narrow sidewalks cause pedestrians to hit each other and spill onto the road, especially during busy hours.

Lighting problems;

Inadequate lighting systems on the street in some areas reduce pedestrian safety at night. Inadequate lighting makes it difficult for drivers to notice pedestrians and increases the risk of pedestrians falling and being injured.

Disabled access problems;

The necessary arrangements for disabled individuals are inadequate and the inadequacy of ramps and their lack of standards restrict the movement of disabled individuals. In addition, the lack of guide paths for the visually impaired and their deterioration are also important problems.

These results indicate that various improvements should be made regarding pedestrian access and safety on Mevlana Street.

Based on the results of this study, the following recommendations are presented to increase pedestrian safety on Mevlana Street:

Traffic regulations and speed control:

- Speed breaker barriers and electronic speed control systems (radars) should be installed to reduce vehicle speed.

- Regular inspections by traffic police and penalties should be applied to drivers who do not comply with speed limits.

- Speed calming studies, studies on high speed and shortcut usage rates can be carried out to increase the real and perceived safety of pedestrians and cyclists in the area and therefore their quality of life.

Improving pedestrian crossings and signaling systems:

- The number of pedestrian crossings should be increased and existing crossings should be renewed. The number of crossings should be increased especially in areas with school and tourist density.

- Signaling systems should be modernized at pedestrian crossings so that pedestrians can cross safely and pedestrians should be given the right of way for a longer period of time.

Widening sidewalks and walking areas:

- The width of sidewalks should be increased and physical obstacles should be removed. In this way, pedestrians will be able to walk more comfortably and safely.

- Penalties for irregularly parked vehicles should be tightened and parking on sidewalks should be prevented

- The occupation of pedestrian sidewalks by many shops and workplaces in the historical city center should be stopped and necessary deterrent measures should be taken for this.

Improvement of lighting systems:

- Existing lighting systems should be reviewed and additional lighting poles should be placed in inadequate areas. In this way, pedestrian safety will be increased at night.

- LED lighting systems can be preferred in order to save energy.

Provision of disabled access:

- In order for disabled individuals to move safely, appropriate ramps should be built on sidewalks and pedestrian crossings and existing ramps should be brought into compliance with standards.

- Guide paths should be created for the visually impaired and maintenance and repair of existing roads should be carried out regularly.

Social awareness and education:

- Regular information campaigns should be organized to increase the awareness of pedestrians and drivers to comply with traffic rules. These campaigns can be organized by local governments and civil society organizations.

In order to improve pedestrian transportation on Mevlana Street in Konya in the future; efforts should be made to move vehicle traffic in the historical city center out of the center, and it should be closed to vehicle use and reserved only for public transportation, pedestrian and bicycle use. Historical and touristic sites should be seamlessly integrated with pedestrian transportation.

The implementation of these suggestions will significantly increase pedestrian safety on Mevlana Street and provide a safer pedestrian experience for both locals and visitors.

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CHAPTER 10

Evaluation of the Contribution of School Gardens to Ecosystem Services

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1. Introduction

With the negative and rapid climate change process, cities are expected to face great challenges in adapting to extreme weather conditions and managing this negative process well (Kreibich et al., 2014). It is predicted that the increase in temperatures may cause global discomfort, economic loss, migration and mortality rates (Haines, Kovats, Campbell-Lendrum, & Corvalan, 2006), and in addition to these, it is expected that more than one climate crisis will occur in many different parts of the world with the increase in extreme weather events (floods, droughts, fires, storms, etc.) (Forzieri et al., 2016; Laino & Iglesias, 2024) In addition to global climate change, there is an ongoing urbanization process both in Turkey and the world. Due to both economic and social needs, the majority of the world's population lives in cities and demands this. The urbanization process continues faster and more intensely in line with these demands. When this fast and intensive process is managed and implemented without the necessary planning and design, negative conditions come with it and living standards decrease. The most important of these negative conditions is urban climate conditions.

It is known that the urban climate is more polluted, hotter, rainier and less windy than rural and natural areas (Givoni, 1991). This situation, together with the predicted temperature increase and extreme weather events, causes the impact of climate change to be felt more in urban areas than in rural areas. Despite these negativities, since the urbanization process is seen as necessary for sustainable urban development, studies and strategies are being developed for cities that have adapted or will adapt to the changes and reduce the negativities of climate change. Planning approaches for sustainable development are attracting considerable attention worldwide in order to encourage the efficient use of resources, the creation of green transportation systems, the protection of nature and the integration of green texture into urban structure (Haaland & van den Bosch, 2015). Planning approaches for sustainable development are seen to focus on problematic areas such as industrial zones and urban brownfields throughout the city (Van Der Waals, 2000; Wan, Chen, Liu, & Jin, 2024). However, if the main goal is to reduce the effects of a global problem, it is inevitable that this approach will be insufficient. With this awareness, current studies bring the urban fabric to the agenda and produce solutions that aim to adapt the city to climate change with all its components (Kim, Song, Joo, Choi, & Park, 2024).

Holistic climate change adaptation approaches argue that cities should adopt nature-based solutions (NBS) and encourage cities to benefit from the benefits provided by nature. Nature-based solutions, which include ecosystem-based adaptation, are based on the ecosystem services provided by nature and plants. Ecosystem services are the basic benefits and products produced by ecosystems due to their structures and functions (Ahmadi Mirghaed, Mohammadzadeh, Salmanmahiny, & Mirkarimi, 2020). Nature-oriented solutions aim to mitigate the negative effects of climate change with the ecosystem services provided by plants by investigating the interaction between ecosystem services and urban impacts (Babí Almenar et al., 2021). Despite the examples implemented for these purposes, these specific solutions remain insufficient or localized, and the need for ecosystem services provided by urban green spaces continues to increase (Costanza et al., 1998; McPhearson, Hamstead, & Kremer, 2014).

In urban landscapes, the beginning of all natural processes and therefore ecosystem services is the presence of water, vegetation and soil. Even the smallest area where these three elements meet in the city is quite valuable. However, it is possible for these valuable areas to be overlooked in the complex structure of the city. Including these areas in planning and design and establishing the relationships between the gains to be obtained from these areas and other areas and creating habitat networks within the city will provide great gains in the city (Guneroglu & Bekar, 2019; Guneroglu, Bekar, & Kaya Sahin, 2019; Pearlmutter et al., 2021) Because habitats and habitat spots create various gains for the user and the city. Some of the plants in habitat spots support many issues such as aesthetic value with autumn coloration, fruit-bearing plants support fauna, birds according to branching structure, and microclimate correction according to leafing. When the ecosystem services of habitats are examined, it is observed that these areas do not provide only one service gain, but also create multi-functional areas where many gains come together. In order to obtain maximum benefit from an area, these gains must be controlled. For example, using a species with a high carbon storage potential or a species with high pollen production in all green areas does not mean that maximum benefit will be obtained. This approach actually increases the fragility of the city. However, the gains of habitats must be evaluated both on a habitat basis and in the city as a whole. For successful results, it is necessary to know which gains are expected and which functions of plants and habitats will provide these gains (Sjöman & Anderson, 2023). Following the scientific studies conducted within the scope of ecosystem services and creating wide impacts worldwide, many scientific projects have been carried out by the Millennium Ecosystem Assessment (MEA) and Ecosystems and Biodiversity Economics (TEEB) studying the relationship between ecosystem services and human well-being. In these studies, ecosystem services are classified into four main categories: regulatory, supportive, provisioning and cultural services (MEA, 2005; Sjöman & Anderson, 2023). Although the gains are grouped under four headings, these gains are interrelated, have many variables and are interdependent. Separating the gains from each other and saying that there should only be certain gains in an area can lead to negative results. Because a tree can provide aesthetic value with its flowers, microclimate regulation with the shade it casts, medical source with its leaves, carbon storage with its trunk and recreational value with the space it creates. However, the fact that a plant can provide these does not mean that that habitat will provide these gains (Salmond et al., 2016). Therefore, the gains should be calculated and evaluated on a habitat basis, not on a species basis.

Providing ecosystem services are direct products provided by habitats and plants. These services include food, water, wood and other raw material products. The main role of plants in these services is; food production, raw material production, water source control, air quality improvement. Plants are one of the basic food sources necessary for the survival of humans and animals. They are very important for life not only in terms of the food they create but also with the photosynthesis cycle they perform while producing food. Plants produce food using sunlight, carbon dioxide and water through the photosynthesis process. The food produced by plants is very important for fauna as well as humans. In addition, plants are important raw material sources for various industries. The raw material provided by plants is quite extensive, especially in the fields of wood, fiber, medicine and biofuel. Providing services include creating and regulating water resources. Because plants play a critical role in the water cycle. Thanks to their root systems, they ensure that water is retained in the soil and control water evaporation. Plants absorb carbon dioxide from the air during the photosynthesis cycle and produce oxygen, which improves air quality (Salmond et al., 2016). In addition, their leaves act as filters for air pollution and help capture particles in the air (Nowak & Crane, 2002).

Supporting ecosystem services include the basic processes required for other ecosystem services to be provided. These services include issues such as biodiversity, soil formation, nutrient cycling and habitat provision. Plants play an important role in soil formation and soil protection (Onur & Gulpinar Sekban, 2022). Root systems stabilize the soil and prevent erosion, thus reducing the risk of erosion and helping to reduce soil losses. In addition, organic structures such as fallen leaves, branches, fruits and seeds dissolve in the soil and transform the soil into nutrient-rich soil. This increases productivity. In addition, plants create shelter for wildlife both individually and in line with the habitat structure they create, and provide fauna with shelter, reproduction and feeding areas, which are the basic needs of life. This gain is very important for the sustainability of ecosystems. Because this gain directly causes an increase in biodiversity. In nature-based solutions, there is a sustainable balance taken as an example in the forest ecosystem. Biodiversity is considered quite necessary for this balance. Therefore, the supporting ecosystem services provided by habitats are needed to increase the biodiversity of urban areas. Another service provided by plants is the absorption of carbon dioxide in the atmosphere, thus reducing greenhouse gas concentrations in the atmosphere, thus combating climate change. Trees absorb carbon dioxide from the air in their biomass through photosynthesis. The amount of this absorption varies according to environmental conditions, plant species, and plant age. Plants do not combat climate change by simply absorbing carbon dioxide from the atmosphere. Plants make a positive contribution to the microclimate with their leaf area and cover value.

The most important gains provided by plants and habitats for cities to have a climate change-resistant structure are gathered under the title of regulatory ecosystem services. Regulatory ecosystem services include indirect benefits provided to people by ecosystems by regulating various environmental and biological processes. These services include improving air and water quality, climate regulation, erosion control and disease control. Plants' carbon storage, water vapor formation, transpiration, VOC production and oxygen production can all be evaluated within the scope of regulatory ecosystem services. Plants play an important role in climate regulation on a local and global scale. They regulate the climate with mechanisms such as shading, evaporation and carbon storage. While they create local improvements by reducing the effect of the urban heat island with the water vapor and transpiration they provide, they increase the life welfare of users on a global scale thanks to their carbon storage. In addition to these gains, it is observed that floods are experienced more frequently in urban areas with the increase in extreme weather conditions due to climate change. These negativities arise from the fact that cities have insufficient green areas in terms of quality and quantity and extremely impermeable surfaces. Plants help retain water in the soil by reducing surface runoff and reducing the risk of flooding, while their roots help retain rainwater in the soil and allow water to infiltrate into the soil (Onur, 2024).

Cultural ecosystem services include spiritual, aesthetic, educational, ecotourism and recreational benefits resulting from human interactions with nature. Plants add visual aesthetics to natural and man-made landscapes, making the environment more attractive and providing areas for outdoor activities. Plants facilitate activities such as walking, picnicking and camping by individuals, thanks to their ability to define and create spaces. At the same time, plants, which leave a mark on human memory and culture with their phenological characteristics, have been the subject of tales, poems, paintings and mythological narratives. Monumental trees constitute an important part of cultural heritage by reflecting social history.

In the field of education, plants are used as a basic resource in disciplines such as ecology, botany and environmental sciences. The formation of urban ecosystems reflects and is affected by the cultural context in which they are located. Cultural structure, socio-economic status and management strategies determine the formation of habitats and plant tissue (Gülpınar Sekban, Bekar, & Acar, 2019; Güneroğlu & Bekar, 2018; van Heezik, Freeman, Porter, & Dickinson, 2013). While these elements create aesthetic value and recreational opportunities, they also affect ecosystem services such as carbon sequestration, surface runoff control, biodiversity and air quality (Onur, 2023).

This mutual interaction between cultural context and ecosystem services can lead to the improvement or deterioration of local environmental processes. Therefore, effective planning and management of cultural ecosystem services are critical for a sustainable environment. Habitats should be protected and developed by considering the ecological gains as well as the aesthetic and spiritual benefits provided by plants. In short, culture, nature and ecosystem services are interconnected and this relationship offers multidimensional gains for both individuals and societies (Bekar & Gülpınar Sekban, 2018; Bekar & İsmailoğlu, 2018; Bekar & Sekban, 2018).

Evaluating ecosystem gains is quite difficult and complex (Güneroğlu & Bekar, 2020). Urban green areas provide more social, cultural and recreational gains than other green areas. However, urban green areas provide significant regulatory services, but most of them cannot be directly perceived by the user. In cities resilient to climate change, these habitats planned and designed for sustainable gains should be considered holistically and not only urban parks should be examined within this scope. Many components that constitute the city, such as private housing gardens, mass housing gardens, streets that include the circulation network, children's playgrounds, public open spaces, education and training areas, should be considered as a whole.

The importance of ecosystem services provided by plants plays a major role not only in natural ecosystems but also in university campuses, which are components of the built environment created by humans. Educational campuses have many open, closed, and semi-open spaces that allow students and staff to be in touch with nature in their daily lives. These spaces appear as direct application areas of ecosystem services provided by plants.

School gardens are important open spaces that contain natural and artificial landscape elements within their boundaries, support education-training processes, and encourage social interaction (Acar & Bekar, 2017). Since they allow physical activity and are a social and cultural meeting point for users, educational gardens are versatile areas that support both individual and social gains. Since these gardens are rich in terms of physical environmental features and user diversity, they can be considered as a small model of cities and offer ecological, aesthetic, and social benefits.

It has been scientifically proven that natural areas reduce stress, relieve mental fatigue and contribute to learning processes. The nature-based design of green areas in school gardens has positive effects on the mental and physical health of individuals. Areas that encourage physical activity, such as walking paths and sports areas in gardens, support a healthy life and increase the learning capacity of users. In addition, these areas are places where individuals can come together to socialize, make cultural transfers and strengthen their sense of belonging.

School gardens are not limited to individual benefits, but offer a structure integrated with the urban landscape (Bekar & Güneroğlu, 2018). These areas contribute to the ecological and aesthetic dynamics of the city and support important gains such as biodiversity, ecosystem services and urban identity. The planning and management of green areas is of critical importance in terms of sustainable urbanization and social welfare. In this context, the qualified design of educational gardens can create a role model for the city and also contribute to the sustainability of the urban environment. Considering both individual development and environmental benefits, educational gardens are an important bridge between natural and urban areas.

The aim of this study is to highlight the potential of school gardens in terms of ecosystem services and to emphasize the environmental, social and economic gains of these areas. It draws attention to the fact that school gardens used as educational areas not only provide physical activities and social interaction opportunities for students, but also constitute an important part of the urban ecosystem. In this context, it is aimed to measure the ecosystem service values of school gardens and to develop design and management approaches to increase these values. It is known that school gardens, which are handled with correct planning and qualified design, provide important ecosystem services such as carbon sequestration, supporting biodiversity, increasing air quality and contributing to the water cycle (Bekar, Yalcinalp, & Meral, 2020). In this section, it is emphasized that school gardens should be evaluated not only as educational areas but also as strategic green areas that contribute to the sustainability of the urban landscape. In addition, the positive effects of these areas, where natural and social benefits come together, on student and user health, the potential to increase individuals' interaction levels with nature and their contributions to the urban ecosystem will be examined.

Another aim of this study is to propose applicable methods to measure the value of ecosystem services of school gardens and to show how these methods can be integrated into decision-making processes. The recognition of ecosystem service value aims to develop the understanding that school gardens are not only educational areas but also have the power to transform and sustain the urban environment. This awareness will enable the development of more effective policies and practices by revealing the multifaceted contributions of educational areas in terms of ecology, aesthetics and social aspects.

2. Materials and Methods

2.1. Material

Within the scope of the study, the Kanuni Anatolian High School Project School in Trabzon province was selected as the study area in line with the objectives determined. The Kanuni Anatolian High School building started its educational life under the name "Frontistrion" by the Greek community on September 15, 1902. It was used for military purposes during the War of Independence and was used by the Trabzon Teachers' School (Dâr-ul-Muallimîn) after the declaration of the Republic. In 1933-1934, Trabzon High School also moved to this building and then Trabzon Teachers' School was transferred to Istanbul. In 1940-1941, Trabzon High School moved to another building and this building was reopened as the Trabzon Boys' Teachers' School in 1949. It was converted into a Teachers' High School in 1975 and this educational institution was closed in 1978. It was reopened as Trabzon Anatolian High School in 1982, and its name was changed to "Kanuni Anatolian High School" in 1995. It was given the status of a Project School in 2019 (Kanunianadolulisesi, 2024). Kanuni Anatolian High School Project School has medium-sized open space opportunities with its deep-rooted history. There are green areas hosting various plant species, sports complexes, walking paths and socializing areas in the school garden (Figure 1). The historical background of the area gives identity to the study area both as landscape and space (Bekar & Güneroğlu, 2018; Bekar & Sekban, 2018).

Figure 1. Different locations in the work area

2.2. Methods

Different vegetation types within the study area were identified as a result of the field study (Figure 2). All tree and shrub plant individuals within the area forming the vegetation structure were identified on-site one by one. In the field studies, along with species identification, physical measurements of the plants were made to identify the ecosystem services provided by the area.

Within the scope of the study, 3 different ecosystem service values, including the "Carbon Storage Value" provided by the plants, were measured. The i-Tree Eco v6.0 program was used to calculate the ecosystem gains provided by the plants.

Figure 2. Some plant species found in the area

3. Results

Within the scope of the study, 22 different plant species were identified (Table 1).

Table 1. Plant species identified in the study area

Ficus carica	*Cupressus sempervirens*
Yucca Elephantipes	*Abies nordmanniana*
Spiraea vanhouttei	*Hibiscus sp.*
Hydrangea macrophylla	*Tilia platyhyllos*
Ligustrum vulgare	*Chamaerops excelsa*
Rosmarinus officinalis	*Punica granatum*
Canna indica	*Laurus nobilis*
Mespilus germanica	*Jasminum fruticans*
Liquidambar orientalis	*Cryptomeria japonica*
Cedrus deodara	*Euonymus japonicus*
Rosa sp.	*Pinus canariensis*

The trunk circumference of the plant species identified in the study area was measured at 130 cm, which is accepted as the breast level. The measured trunk circumferences were used in the calculations required for ecosystem services. However, when the general trunk diameter profile of the study area was examined, the maximum dbh measured in the study area was determined as 179 cm. Within the scope of the study, the current structure could be analyzed and the leaf area, leaf biomass, dry weight and average status of the plants were calculated (Table 2).

Table 2. Data on leaf area, leaf biomass, dry weight and average condition percentage of the study area

Measured property	Measured value	Measured property	Measured value
Leaf area (ha)	1,644	Leaf biomass (ton)	1,49
Dry weight (ton)	373,793	Mean condition percentage (%)	97,80

Carbon Storage (tons), Annual Carbon Storage of Trees (tons/year), Carbon Dioxide Equivalent (tons/year) were calculated for the carbon value of the study area (Table 3).

Table 3. Carbon Storage (tons), Annual Carbon Storage of Trees (tons/year), Carbon Dioxide Equivalent (tons/year) in the study area

Measured property	Measured value	Measured property	Measured value
Stored Carbon (tons)	211,9	Annual Carbon Storage of Trees	1,67
Carbon Dioxide Equivalent (tons/year)	776,9		

As a result of the analyses carried out in the study area, it was determined that the vegetation was dominated by coniferous and evergreen plants. When the plant composition of the area was examined, it was seen that it consisted of 67% coniferous and evergreen plants. These plant species play an important role in carbon sequestration potential since they do not shed leaves throughout the year and continue their photosynthesis processes without interruption. It was determined that the trunk circumference of coniferous trees was higher compared to other species. This situation shows that coniferous trees have a higher biomass accumulation and therefore carbon storage capacity. In addition, the presence of broad-leaved trees that shed their leaves in the area is also remarkable. These species with large leaf surface areas increase the total leaf area value of the area and thus contribute to carbon storage processes. It can also be stated that the leaves shed thanks to the seasonal cycles of broad-leaved species add organic matter to the soil and these processes have positive effects on the carbon cycle.

The balanced distribution between coniferous and deciduous tree species in the study area indicates an ecosystem structure that optimizes carbon storage capacity. While coniferous species stand out with their stem biomass and continuous carbon storage capacity, deciduous species support photosynthetic activity by increasing the leaf area index. This creates a balance mechanism that increases the carbon storage potential of the area within the scope of ecosystem services.

As a result, the co-existence of coniferous and deciduous species in the vegetation of the area provides a rich structure in terms of biodiversity and strengthens the carbon storage capacity. This finding shows that the area has an important structure that can provide ecosystem services in a sustainable way.

4. Conclusions

School gardens, as an important component of urban ecosystems, have a significant role in terms of carbon storage potential. Although they are small-scale areas, with the right planting and management strategies, these areas can contribute to both reducing carbon in the atmosphere and strengthening ecosystem services. With qualified planting studies, the biomass of plants can be increased, which allows the plant dry weight to increase and therefore more carbon to be stored through biological processes. Carbon storage in natural or designed green areas generally occurs through organic carbon accumulated in the leaves, branches and root systems of plants. In order to increase this capacity in school gardens, it is recommended to use perennial plants with high biomass potential that are suitable for local climate and soil conditions. Fast-growing tree species, shrubs and grassy areas in particular can increase carbon storage capacity. In addition, a multi-layered landscape design supported by ground covers and seasonal plants can maximize the carbon storage potential of these areas. Plant Selection and Planning: It is important to select local and climate-friendly plant species to increase carbon storage capacity in school gardens. Tree and shrub species with high carbon storage capacity should be preferred. Using different plant species at different heights and layers increases the carbon storage capacity of the garden. Increasing the organic matter content of the soil and sustainable soil management practices support carbon storage. Awareness can be created by providing students with information about the carbon cycle and ecosystem services. This supports long-term environmental sustainability. Regular measurement of carbon storage capacities in school gardens guides the strategies to be developed by evaluating the effectiveness of these areas. As a result, increasing the carbon storage capacity of school gardens as part of ecosystem services contributes to both the local environment and the fight against global climate change. Qualified planning and management of these areas offers significant gains for urban ecosystems.

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CHAPTER 11

A Multi-Faceted Evaluation of a Roof Garden with Different Approaches

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1. Introduction

Throughout history, people have tried to integrate natural elements into the built environment, bringing new dimensions to urban and architectural approaches by bringing gardens not only to the ground but also to the upper parts of buildings. The origin of roof gardens is generally accepted as the Hanging Gardens of Babylon, one of the seven wonders of the world (Gülpınar Sekban & Bekar, 2019). Although there is historical uncertainty about exactly how these gardens were constructed, they are considered one of the earliest examples of the extension of plant use in architecture to vertical and horizontal surfaces (Osmundson, 1999).

Although there is limited information on the existence of roof gardens in Medieval Europe, it is known that gardens were moved to higher floors for decorative, recreational and aesthetic purposes in the palaces, mansions and villas of the nobility, especially in Renaissance Italy (Roehr & Laurenz, 2008). The Industrial Revolution and the subsequent inadequacy of green areas, along with the intense urbanization, made rooftop greening a necessity rather than a luxury. During this period, it is observed that in some cities in Europe, especially in Germany and the Scandinavian countries, roof garden applications were evaluated as a strategic tool to reduce the urban heat island effect, improve water management and increase ecological diversity (Köhler, 2008).

Le Corbusier, one of the pioneers of modern architecture, included roof gardens among his "five-point" principles and predicted that the upper surfaces of buildings in the cities of the future could be used as green areas (Sendai, 2012; Sendai & Tsukano, 2013). In the rapidly expanding metropolises of the post-World War II period, especially in North America, the first institutionalized examples of roof gardens emerged as aesthetic arrangements on terraces on high-rise buildings; they later diversified to serve multidimensional purposes such as energy efficiency, insulation, rainwater management, and the development of urban ecosystems (N. Dunnett & Kingsbury, 2004).

Today, roof garden applications have become more sophisticated both technologically and ecologically under the concept of "green roof". Modern green roof systems are equipped with waterproofing, lightweight soil mixtures, durable plant species and even automatic systems for irrigation and maintenance; they provide environmental, social and economic benefits. This transformation has occurred as a result of the integration of historical accumulation into contemporary architecture, landscape and planning understanding, and has made roof gardens an important part of sustainable urban design (Berardi, GhaffarianHoseini, & GhaffarianHoseini, 2014).

Today, green roofs provide countless opportunities with the developing technology and are considered as high areas with recreational potential where the city can breathe (Berardi et al., 2014). Green roof systems are considered as a sustainable architectural strategy that provides environmental, aesthetic, functional and economic benefits by moving the decreasing green areas to the top of the buildings as a result of the increasing population and building density in the cities. These systems consist of elements such as vegetation, growing medium (substrate), drainage, waterproofing and root-holding layers added to the roof layer of the building (Ekşi & Uzun, 2016). Green roofs are generally classified based on criteria such as intended use, type of vegetation, maintenance requirements, material thickness and structural load capacity. Green roofs are roughly divided into three classes: extensive, intensive and hybrid models. Extensive green roofs are generally characterized by low maintenance, light weight and a thin layer of growing medium. The typical soil or substrate depth of these systems varies between 5-15 cm, which puts minimal additional stress on the structural static load. Vegetal selections mostly consist of species with a short root depth, such as sedum, grassy plants, mosses and lichens, which are resistant to drought and harsh climate conditions (Ekşi & Uzun, 2016). The aim of extensive systems is generally to provide ecological benefits (rainwater retention, heat island reduction, microhabitat creation) and to protect the roof surface.

Intensive green roofs require a thicker growing medium (usually more than 20 cm) and therefore higher structural load capacity than extensive systems. These structures allow for a wide range of landscaping, including shrubs, small trees, flowering plants, and even water features and walkways. As a result, intensive green roofs often exhibit garden-like qualities, providing spaces for users to relax, socialize, and interact with nature (Nigel Dunnett, Nagase, Booth, & Grime, 2008).

Semi-intensive green roofs are a transition between extensive and intensive systems. In these systems, the depth of the growing medium and the variety of plants are kept at a moderate level, combining the advantages of both systems in a balanced way. For example, semi-intensive roofs can accommodate low-maintenance plants such as sedum together with medium-sized shrubs or grasses. This creates roof areas that are relatively easy to maintain but visually more diverse, accessible and usable. These types of roofs offer a wider variety of plants and partial user interaction while keeping irrigation and maintenance costs at a reasonable level.

Regardless of the type of green roofs, these areas are designed to produce holistic solutions at the building scale, compatible with the goals of sustainability, ecological balance, aesthetics and quality of life in urban areas (Nigel Dunnett et al., 2008). Green roofs offer various perspectives on how structural and natural design elements can be applied in architectural, landscape, sustainability and urban design practices. There are different and resounding examples of green roofs in many countries around the world. The most important of these are Chicago City Hall Green Roof (Chicago, USA), Namba Parks (Osaka, Japan), California Academy of Sciences (San Francisco, USA), Vancouver Convention Center West (Vancouver, Canada), ACROS Fukuoka Prefectural International Hall (Fukuoka, Japan), Bosco Verticale (Vertical Forest), (Milan, Italy), Zorlu Center (Istanbul, Turkey), Şişhane Park (Istanbul, Turkey). When these and other similar designs are examined, it is seen that the designs are shaped according to the space and user needs, and that they all address the concept of green roof in different ways.

A specific space or architectural element can be approached by designers from different perspectives; needs, context, material and aesthetic approaches directly affect this diversity. Indeed, “When this and other similar designs are examined, it is seen that the designs are shaped according to the space and user needs, and that they all address the concept of green roof differently.” This statement strikingly emphasizes the diversity and flexibility in question.

Today, increasing urbanization and population density have made the need for sustainable solutions more obvious than ever. Green roofs are design strategies that provide ecological benefits by creating green areas on the upper surfaces of buildings, increase environmental sensitivity and add a new dimension to the urban landscape. However, the concept of green roof, instead of a single design template, offers a framework that designers and practitioners reinterpret according to the geographical, climatic, structural and aesthetic requirements of the space. In this context, a green roof can sometimes be considered as a recreation area, sometimes as an ecological laboratory where local plant species are exhibited, and sometimes as a technical surface that manages rainwater and saves energy.

The versatility of design not only provides visual variety, but also transforms the experience of physical and social space (Pouya, 2019). Different communities, cultures and socio-economic conditions can reinterpret a similar space with a completely different design approach. In this way, design becomes a dynamic process, not a static product. At the center of this process is always an innovative, participatory and multi-dimensional approach that analyzes and responds to the conditions of the users and the space. As a result, the different ways of applying the green roof concept stand out as a concrete indicator of the flexibility and creativity of design.

2. Development of Design Proposals

Within the scope of the study, 4 different design approaches were determined for a 200 m² university campus roof area and design proposals were developed. Each design reflects different concepts on the same roof area. The perimeter of the roof area is surrounded by railings for security purposes and it is assumed that water insulation and drainage are provided at the ground level. The following criteria were adopted as general design approaches and the proposals were developed within this framework.

- The roof area was considered as a rectangular form (e.g. 10 m x 20 m), it was thought that there could be planting and benches along the long edges, walking paths and main function areas in the middle parts. In all designs, the exit point from the building to the roof is located in a corner or on the edge of the area.
- Drainage channels and water collection areas are hidden under the coatings; light soil mixture suitable for roof gardens and light-structured elevated landscape elements will be used in all plant areas.
- Safety, ease of maintenance and protection of water insulation were prioritized in all designs.

Within the framework of these general design suggestions, a simple resting area concept has been created within the scope of Design 1, where minimal, calm, only ground cover green texture is at the forefront. There are no showy trees or high plant layers in this design. A simple landscape is targeted. In this context, the following design decisions have been created for Design 1;

Plants: Low-maintenance, drought-resistant, ground cover plants compatible with thin-based soil (e.g. Sedum, grass-like special roof mixtures) can be used. These plants can cover a large part of the area.

Walkways: A 1.5 m wide walkway can be designed from wooden deck (natural or composite) material, passing through the center line of the area and reaching the benches. This path will sometimes be widened with small wooden platforms, allowing users to stop and look at the view.

Benches: 3-4 simple, backed wooden benches can be placed on the sides of the walkway. Benches can be positioned directly on the ground level, on the extension of the wooden deck area within the ground cover plant texture.

Material and Color Palette: Natural wood tones and different shades of green can be used in the design.

Within the scope of the design suggestions carried out within the scope of the study, the 2nd Design includes a roof garden concept that encourages biodiversity and interactive use, with edible plants (vegetables, herbs, small fruits) and flowers that will attract butterflies. In this context, the following design suggestions were created for the 2nd Design;

Plants: Versatile suggestions have been developed within the scope of plants. First of all, edible garden decisions have been made in the design. Vegetables (tomatoes, peppers, greens), aromatic herbs (basil, rosemary, thyme) and perhaps small fruits (strawberries) can be grown in the area in raised wooden pots with increased depth (Daneshyar, 2024). Designing a butterfly garden that supports the concept of the area will contribute to the biodiversity of the roof garden. For this; areas that contain colorful flowers and butterfly-friendly plants will be designed. For example, care will be taken to use nectar flowers such as *Lavandula sp., Echinacea sp. , Verbena sp.*. These areas can be designed in wooden pots at different elevations.

Walkways: Instead of straight linear paths, slightly curved circulation paths can be created within the area. Organic-looking, non-slip rubber or natural stone textured materials can be used as coating. Transition can be provided between edible garden areas and butterfly gardens. Benches: 3-4 benches can be placed at points where users can observe natural life, especially near butterfly gardens. In addition, a few benches close to the edible garden area can provide a view where users can interact with the garden (İsmailoğlu & Bekar, 2018).

Aesthetics and Function: Pots positioned at high altitudes, flowers in different colors, plant selections reflecting seasonal changes can offer users a small garden experience. This design can create learning and observation opportunities. Within the scope of the design suggestions carried out within the scope of the study, the concept for the 3rd design was created for an area where students and staff can socialize, where medium-sized trees can provide shade, and which serves more of a sitting and gathering function. In this context, the following design suggestions were created for the 3rd design;

Tree Pots: Small-sized trees (e.g. *Acer palmatum, Prunus cerasifera, Olea europaea, Punica granatum, Osmanthus heterophyllus*) can be placed in wide-based pots made of light materials that will not overload the roof. These trees create semi-shaded areas. (Gülpınar Sekban & Bekar, 2018). Micro spaces can be created by placing flower pots around the walking path.

Walkways: A wide main walkway can be created in the center, and narrower side paths can be created between the tree pots on the edges. The floor covering can be natural stone texture or composite deck.

Benches and Seating Groups: Benches can be positioned on the edges of the walkways, next to the tree pots. In addition, a few larger seating units (L-shaped fixed seating elements or modular benches) can be used to create socialization corners. Studying, chatting or small group activities can be organized in these corners (M Bekar, Acar, & Şahin, 2017).

Plants: Under the tree pots, ground cover or shrub plants are added, and the spaces between can be colored with bulbous plants that will provide seasonal flowering.

Within the scope of the design suggestions carried out within the scope of the study, the 4th design was created with a concept that aims to create a more dynamic topography setup, a miniature water feature and a natural park feeling. While the root volume of the trees is increased with elevations (artificial hills), it can offer a visually interesting experience to the user. In this context, the following design suggestions were created for the 4th design;

Mounds and Trees: Raised plant beds or mounds made of light material can be created in certain areas of the roof. Lightweight trees can be planted on these mounds. The mounds will increase the soil depth and provide space for the tree root system. It will also add visual movement to the roof silhouette.

Mini Ornamental Pool: A shallow water feature of approximately 2-3 m^2 can be designed as a decorative mini pool or reflection pond. The surroundings of this pool can be enriched with short flowers and maybe a few water plants. The sound of water will add peace to the roof.

Walking Paths: Organically shaped paths can be created between the hills. These paths will occasionally widen to create mini seating areas or small pockets where benches can be placed.

Benches and Socializing Areas: Benches can be positioned near the pool, in the shade of the trees and between some hills. In a few areas, mini socializing areas are created with 4-5 person seating units, modular poufs or light fixed tables.

Plant Selection: The trees on the hills can be relatively small ornamental trees resistant to urban conditions. Polyculture flowers and ground covers are used around them to create a natural roof park feeling.

Material Palette: Natural colors, the calming blue of the water, grass and flower tones, organic-shaped floor coverings can be used.

As a result, a space can have multiple approaches and multiple design patterns and purposes (Güneroğlu & Bekar, 2020). These four different designs reflect different concepts on the same 200 m² roof area. Each design transforms the roof space into a different field of experience with its selected plants, materials and usage scenarios. The design of a space is considered as a constantly evolving, multi-layered practice at the intersection of different disciplines such as architecture, landscaping, interior design, urban planning and industrial design throughout the historical process (Makbulenur Bekar & Gülpınar Sekban, 2018; Güneroğlu & Bekar, 2017). This clearly shows that even a single physical space can be organized in very different ways with countless design approaches. These differences are shaped by a number of factors such as the functional requirements of the space, user profiles, cultural context, climatic conditions, material technologies and aesthetic understandings (Gulpınar Sekban & Düzgüneş, 2021). At this point, design should focus not only on the diversity of visual stimuli, but also on the livability of the space, environmental sustainability, ergonomics, economic feasibility and the capacity to respond to social needs. Therefore, the aim of designers is not only to present a formal innovation, but also to bring together aesthetics and functionality in harmony by addressing the multi-layered requirements of the space with a holistic approach.

Today’s design approach emphasizes that there is no longer a single “correct” solution or “ideal” form, but rather that each space must be reinterpreted in line with its own unique contextual parameters. This gives designers great freedom but also imposes responsibility. It is important to push the boundaries of creativity, but not to ignore the fundamental needs of the space. Various design methodologies – such as user-centered design, participatory design processes, computational design approaches, biophilic principles or sustainability principles – can create different design scenarios even within a single space, thus offering strikingly different experiences, identities and aesthetic understandings within the same physical framework (Güneroğlu & Bekar, 2017; Kahveci & Onur, 2021). These multifaceted approaches aim to maximize the potential of the space, balancing the abstract visual qualities of aesthetics with the concrete requirements of functionality (M Onur & Koç Altuntaş, 2020). Elements such as the texture of the materials used in the design of the space, color palette, light, acoustics, air circulation, circulation schemes, ergonomic solutions, flexible usage scenarios and an infrastructure structure open to future transformations determine the holistic quality of the design (Makbulenur Onur & Acar, 2024). The aim here is not only to construct the space as an aesthetic "stage" when viewed from the outside, but also to ensure the interaction of the users with the space, the continuity of experience and satisfaction therein. Therefore, every choice to be made in the design process has the potential to transform, develop or limit the dynamics of use of the space. Therefore, the design should skillfully blend the contextual, functional, economic, technological and socio-cultural characteristics of the space, taking into account both objective and subjective criteria.

3. Conclusions

The fact that a single space can be organized in very different ways with different design approaches reveals the multidimensional, flexible and innovative structure of design practice. The main thing here is to produce solutions that will bring together the specific requirements of the space and the habits, needs and expectations of the users on a common ground. In this approach, aesthetics ceases to be an elegant and visually pleasing arrangement of the form and becomes a value layer that enables functionality, enriches the experience and highlights the qualities of the space. Thus, design contributes to improving the quality of the space under the guidance of creative diversity on the one hand and user-centered, functional and sustainable principles on the other.

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CHAPTER 12

Health-Oriented Interior Architecture Principles for Primary Care Centers (PCCs): Ergonomics, Air Quality, Lighting, and Acoustics

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Introduction

The Primary Care Centers (PCC) application was started as a pilot in 2005 and was expanded throughout Türkiye as of 2010. This model, which replaces the health center system, provides lifelong health monitoring and basic treatment services for individuals. As the cornerstone of primary health care, PCCs provide individuals with easy access to health services and regular follow-up and constitute an indispensable part of the social health system (Keskin, 2018). The interior architecture of such centers is of great importance for the recovery process of patients and the performance of healthcare professionals. For this reason, the Fifth Chapter of the regulating the design of PCCs determines the physical conditions of Primary Care Centers (Turkish Ministry of Health, 2013). Health-oriented interior architecture aims to maximize not only functionality but also user comfort. In this context, elements such as air quality, lighting design, and acoustic control should be carefully considered to provide a healthy, safe, and comfortable environment in health centers.

Indoor air quality is among the most critical issues in PCCs. Inadequate or incorrect design of ventilation systems can cause harmful particles and volatile organic compounds (VOCs) to accumulate indoors, increasing respiratory diseases (Mølhave, 1991). Additionally, the materials used in PCCs are also an important factor affecting VOC emissions. Choosing the right material can reduce health risks by supporting clean air circulation.

In addition, correct lighting not only illuminates the environment; It also has positive effects on attendants' mood, sleep patterns, attention level, and general well-being. The integration of natural light into the space and the use of the correct light color and intensity in artificial lighting increases the comfort of patients and contributes to the efficiency of healthcare professionals. Research shows that correct lighting arrangements have positive effects on attendants' mood and contribute to the healing process (Iyendo and Alibaba, 2014).

Acoustic comfort is also important for both patient privacy and reducing noise-related stress. The noise level in PCCs should be kept low and sound insulation should be provided to ensure that patients and healthcare professionals are in a comfortable and peaceful environment (Selim et al 2024). Acoustic arrangements are one of the basic elements of creating a safe, calm, and healthy indoor environment in health centers.

Ergonomic design and proper furniture arrangement play a crucial role in enhancing the comfort of both patients and healthcare professionals in Primary Care Centers (PCCs). These design principles not only foster a healthier and more user-friendly environment, but they also contribute to the efficiency and effectiveness of healthcare services. By creating spaces that prioritize ease of use and comfort, healthcare professionals can perform tasks with greater ease, while patients experience a more pleasant and supportive setting. This alignment of functionality and well-being ultimately elevates the quality of healthcare services, ensuring both staff and patients benefit from an optimized space.

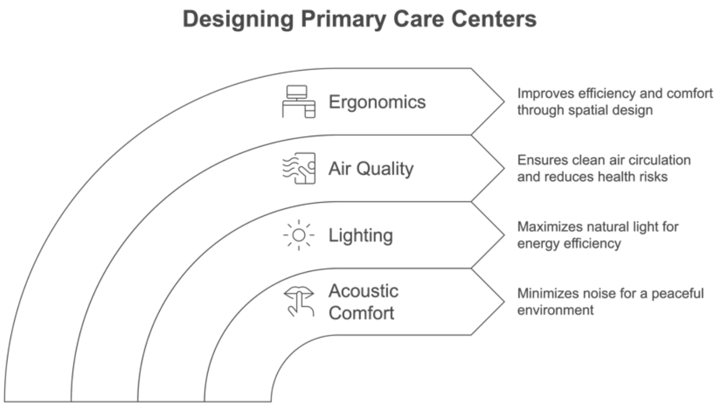

Figure 1: Diagram showing four main factors in Designing Primary Care Centers

In this study, how to ensure ergonomics, air quality, lighting, and acoustic comfort in health-oriented interior architecture will be discussed by examining the effects of the physical environment of Primary Care Centers, which are considered the first step of health care institutions (Fig. 1). When designing these elements, attention must be given to material, color, and furniture selection. For instance, when selecting sound-absorbing materials for acoustic control, it is also important to choose natural materials and colors that reduce glare and improve mood. Additionally, building materials should be selected for their ability to avoid releasing particulate matter and volatile organic compounds (VOCs), which is crucial for maintaining a healthy environment. These design principles form a comprehensive framework that ensures a healthy and supportive interior environment for both patients and healthcare professionals in PCCs.

The Importance of Indoor Air Quality in Primary Care Centers

Although the outdoor environment usually comes to mind when air pollution is mentioned, since people spend 90% of their time indoors, air pollutant levels indoors can be 5 to 100 times higher than outdoors, depending on function (Farha et al., 2022). This makes the effects of indoor air quality on health even more important. Indoor air quality in heavily used health spaces such as Primary Care Centers has a direct impact on the health and comfort levels of users. Pollutants such as particulate matter, carbon dioxide (CO_2) and volatile organic compounds (VOCs) that accumulate indoors can negatively affect air quality and lead to health problems such as respiratory illnesses and allergic reactions. Ensuring high air quality in healthcare centers not only protects the health of patients but also positively affects the productivity of healthcare professionals.

Accumulation of particulate matter in PCCs is a significant health risk that can cause respiratory illnesses. Particularly fine particles such as PM10 and PM2.5 can reach the lungs and damage the respiratory system when inhaled. The increase in particulate matter indoors can reduce air quality and pave the way for chronic respiratory diseases such as asthma and bronchitis. The high level of carbon dioxide, as well as the increase in particulate matter, indicates that there is not enough ventilation in the interior (Alptekin, 2007; Sağlam, 2019; Eren, 2021). Increased carbon dioxide levels can result in symptoms such as fatigue, headaches, and distraction. Controlling CO_2 levels in PCCs is critical to ensure a healthy environment and increase users' concentration and productivity.

The choice of building materials preferred in interior architecture directly affects indoor air quality (Zorlu and Karadayı, 2020). Volatile Organic Compounds (VOCs) are chemicals that can be emitted from a variety of sources, especially interior finishing materials such as paint, furniture, and cleaning materials. Prolonged exposure may cause symptoms such as headache, eye and throat irritation, and respiratory problems. It is also known that some VOCs have carcinogenic effects (Eren, 2021). VOC levels should be kept under control by choosing low-VOC materials in the interior architecture of health centers and using appropriate ventilation systems (fig.2).

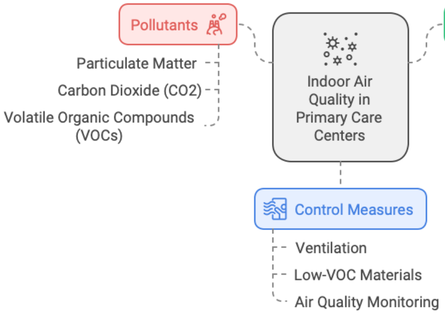

Fig. 2. Diagram showing three basic aspects of indoor air quality in PCCs

For these reasons, optimizing indoor air quality in PCCs should be a priority goal to ensure user health and comfort. An effective ventilation system, use of healthy indoor materials, and regular air quality measurements are critical for a safe and healthy indoor environment.

Proper Ventilation Strategies: Use of Natural and Mechanical Ventilation

Providing clean air circulation in PCCs is of critical importance in protecting the health of both patients and healthcare professionals. Ventilation systems provide healthier indoor air quality by removing indoor pollutants and harmful gases such as CO_2. Correct use of natural and mechanical ventilation methods contributes to the creation of a health-oriented interior by increasing hygiene and comfort, especially in health centers.

Natural ventilation aims to provide fresh air flow indoors by strategically positioning openings such as windows and doors. Openings designed taking into account the prevailing wind direction increase air mobility and prevent the accumulation of particles and bad gases. This method reduces the need for mechanical systems by providing energy efficiency (Eren, 2021; Alptekin 2007). A correct natural ventilation design should be optimized according to the layout and air flow of the central rooms. Positioning windows to provide cross ventilation increases airflow, reducing the impact of particulate matter and VOCs.

Mechanical ventilation systems offer an effective solution, especially in areas where air circulation is not sufficient or where there is heavy use. Mechanical systems provide air exchange at regular intervals to maintain the desired air quality in the interior. Central ventilation systems effectively remove particles, allergens and other pollutants with their filtering feature. In PCCs, fresh air circulation provided by mechanical ventilation, especially in heavily used areas such as examination and waiting rooms, protects user health by reducing the spread of disease (Eren 2021). Ventilation source, airflow rates, relative humidity, and temperature are significantly related to indoor bacterial diversity and composition. Less diverse microbial communities were found in rooms with mechanical ventilation than in windows-ventilated rooms. Additionally, hospitals with centralized air conditioning and mechanical ventilation (ACMV) systems provide better indoor air control over chemical and particulate pollutants compared to those with decentralized ventilation systems (Phuah 2012; Kembel et al., 2012; Stockwell et al. 2019; Farha et al. 2022).

Although the above-mentioned studies have shown that central ventilation systems are more effective in controlling indoor air quality, it is certain that the integrated design of mechanical and natural ventilation systems will provide the best results. A harmonious integration of natural and mechanical ventilation systems saves energy as well as improving air quality. While natural ventilation may be the primary method used during the day, mechanical ventilation can be activated, especially when density increases or when outdoor air quality is low, to ensure continuity of indoor air quality. Thus, it is possible to create a healthy, comfortable, and sustainable interior by using both methods together.

Consequently, using both natural and mechanical ventilation with the right strategies in PCCs supports health-oriented interior architecture by providing clean air circulation. This strategy improves users' health conditions while also promoting energy savings.

Supporting Air Quality with Heating, Cooling and Humidity Control

Temperature and humidity balance play a critical role in supporting indoor air quality in Primary Care Centers. Temperature and humidity levels directly affect both user comfort and indoor air quality. Appropriate heating, cooling and humidity control practices increase the comfort of users, including patients and healthcare professionals, while also ensuring that the space provides a healthy atmosphere. Arrangements made to ensure air quality are also used to ensure that microorganisms, infection risk and dust are at lower levels. Increasing temperature and humidity is a factor that accelerates the formation of bacteria and fungi (Özcan et al. 2009; Alan, 2008).

The temperature level in health centers should be adjusted to provide users with a comfortable environment both physically and psychologically. Temperatures that are too high or too low can adversely affect the health of vulnerable groups, especially the elderly and children. Environments kept within the ideal temperature range support the quality of health care by increasing user comfort. During summer months, cooling systems ensure that the interior remains fresh and healthy. In healthcare centers, cooling systems must be equipped with air filtration features to optimize their impact on air quality. These systems constantly refresh the air inside, reducing microorganisms, allergens and pollutants and ensuring that the air breathed by patients and healthcare personnel remains clean.

Humidity level is a second factor as important as temperature for a healthy indoor environment. While very high humidity can reduce air quality by giving rise to bacteria, fungi and mold growth, low humidity levels can cause skin dryness and respiratory irritation. For this reason, it is recommended to keep the humidity level between 40-60% in health centers (Alan, 2008). Good humidity control prevents the proliferation of microorganisms in the environment, maintains hygienic conditions and supports the respiratory health of users.

Table 1. Factors Affecting Air Quality in Primary Care Centers and Their Effects on Health

Factors Affecting Air Quality	Definition	Effects on Health
Particulate Matter (PM10, PM2.5)	Fine dust and pollutants in the air	Respiratory diseases, asthma, allergic reactions
Carbon Dioxide (CO_2)	Accumulation in respiration and enclosed spaces	Fatigue, headaches, concentration loss
Volatile Organic Compounds (VOCs)	Chemicals emitted from sources like paint, furniture	Headaches, eye-throat irritation, carcinogenic effects
Humidity Level	The moisture content in the air	High humidity: Mold formation; Low humidity: Dryness in the respiratory system
Temperature Control	Ideal temperature ranges	High/low temperatures, loss of comfort, health risks

Integrated systems in which heating, cooling and humidity control work together in health centers support air quality sustainably. These systems help keep indoor air quality stable, ensuring user comfort even under changing seasonal conditions. Especially thanks to its smart control features, temperature and humidity levels are constantly monitored and automatically adjusted, when necessary, which saves energy. As a result, appropriate temperature, cooling, and humidity control in PCCs improves indoor air quality and optimizes user comfort. Effective management of these elements provides a more efficient environment by protecting the health of both healthcare recipients and employees.

Effects of Lighting on Patients and Healthcare Professionals

Indoor lighting in Primary Care Centers is an important factor that both accelerates the healing process of patients and supports the performance of healthcare professionals. While lighting quality increases the efficiency of the time spent in the space, it also creates positive effects on the general health of the users.

Proper lighting can support patients' mental health and speed up their recovery process. Especially spaces with natural light help patients feel more energetic and positive. Natural light sources help regulate the hormones melatonin and serotonin, improving sleep patterns and promoting psychological relaxation. Additionally, the fact that natural light supports the body clock can also have positive effects on the immune system (Küçük, 2023). For healthcare professionals, correct lighting increases the level of attention and concentration and reduces the risk of making mistakes. Healthcare personnel, especially those working at a busy pace, may tire faster and their productivity may decrease in inadequate or unstable lighting conditions. Proper lighting reduces eye fatigue, enables employees to focus for long periods, and helps them cope with the workload (Kazanasmaz, 2003).

The use of natural light can be increased in health centers with windows, skylights and transparent materials. In this way, the amount of natural light entering the interior throughout the day is optimized, saving energy and supporting the positive effects of lighting on health. Directing natural light into the space and preventing unwanted glare increases the benefits of lighting. In addition, compatible artificial lighting solutions with natural light ensure that the space has the ideal illumination level at all hours of the day. Correspondingly, indoor lighting in PCCs supports the efficiency and health of the space by enabling patients to recover faster and healthcare professionals to perform more effectively. Correct lighting designs combined with the effective use of natural light optimize both physical and psychological health in these centers.

Psychological and Physiological Effects of Light and Color Selection

Light and color choices in Primary Care Centers are one of the most important design elements that determine the atmosphere of the place. Correct light and color choices play a critical role in reducing stress levels, creating a relaxing environment, and providing a user-focused space experience. These elements have both psychological and physiological effects on patients and healthcare professionals. Well-planned light and color arrangements help reduce the anxiety levels of those in the space. In particular, lighting in soft and warm tones creates a relaxing atmosphere by contributing to the reduction of stress. Choosing warmer and neutral tones instead of cold white light helps patients feel more comfortable and increases the motivation of healthcare professionals. In addition, peaceful color palettes such as pastel colors or natural tones create a calming effect on the interior and positively support the healing process of patients (Güller, 2007).

User-oriented light and color choices ensure that the space is functional and user-friendly (Özbudak et al. 2003). For example, the use of more vibrant colors and lighting in waiting areas distracts users and makes the waiting time easier; Softer and more relaxing color tones in examination rooms contribute to patients feeling safe (Manke, 1996; Şahiner and Erbay, 2022). Correct artificial lighting design integrated with natural light ensures that the space remains in optimal lighting conditions for users at all hours of the day. The right combinations of color and light have a direct impact on individuals' mood and physiological responses. Cool colors like blue are known for their calming and focus-enhancing properties, while yellow and green tones are energizing and create a positive mood. Colors also direct bodily responses by affecting heart rate and blood pressure. Similarly, the intensity and color of the lighting prevent eye fatigue, supporting both user comfort and health.

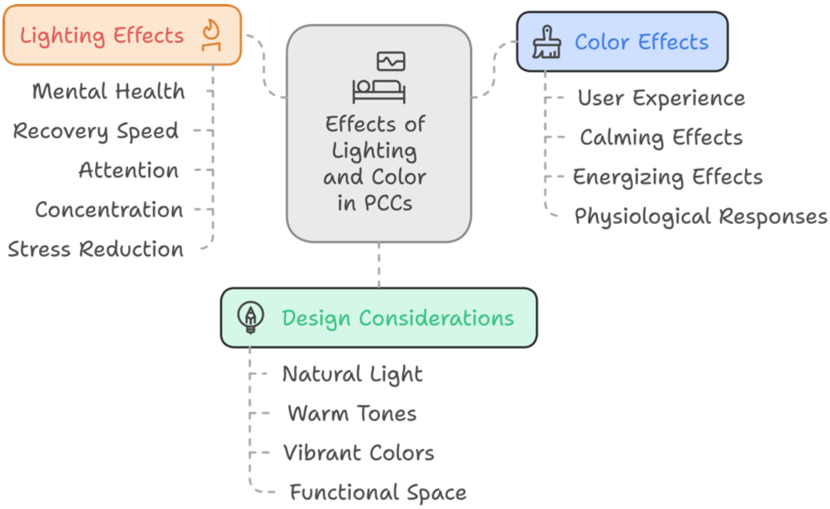

Figure 3. Diagram showing the effects of Color and Lighting in PCCs

Careful consideration of these elements in PCCs not only provides visual comfort but also increases the functionality of the space, providing a supportive environment for both staff and patients. Design decisions create an effective and user-friendly environment that adapts to individuals' needs, striking a balance between psychological comfort and physiological health. In addition to improving the quality of healthcare services, these approaches also make significant contributions to improving patient experience and employee efficiency.

The Impact of Acoustic Comfort on Health and Acoustic Solutions

Acoustic comfort in PCCs is of great importance in terms of user health, and functionality of the space. Especially in these environments with intense sound flow, acoustic solutions that control noise and protect patients' privacy directly affect the comfort of both patients and healthcare professionals. A properly planned acoustic arrangement provides a healthier and more peaceful environment by minimizing echoes, noise, and unwanted sounds in the space. For this purpose, the first thing to do is to ensure Noise Control. Management of external and internal noise in health centers ensures that patients are in a stress-free and calm environment. Intense noise can increase the stress levels of patients and negatively affect productivity by distracting employees (Clarke, 2011; Okcu and Zimring, 2007). Therefore, it is important to use sound insulation materials on walls, floors and ceilings for noise control. Additionally, the use of sound-absorbing panels in crowded areas such as waiting areas contributes to keeping the environment quiet and comfortable.

However, it is also necessary to produce acoustic solutions that protect privacy. Ensuring patient privacy is critical in healthcare settings, especially in areas where personal information is shared, such as examination rooms. Solutions such as acoustic separator panels or soundproof door systems prevent conversations from spilling out and make patients feel safe (Højlund, M.K. (2016). While such acoustic arrangements increase patient confidence by protecting privacy, they also enable healthcare professionals to provide services in a more comfortable working environment. It allows. Research shows that improving acoustic comfort increases patients' comfort level and contributes to their healing process. At the same time, a noiseless environment for healthcare professionals increases their service quality by strengthening their concentration and communication abilities. A quiet and balanced acoustic environment increases employees' job satisfaction and motivation by reducing symptoms of stress and fatigue (Ryherd et al. 2008).

Acoustic arrangements made in PCCs create a healthier and more comfortable environment for both patients and healthcare professionals, thanks to elements such as sound insulation and noise control. These regulations help individuals feel safe and comfortable, especially by ensuring that privacy is protected. It also increases employee productivity by minimizing distractions and provides a peaceful atmosphere for patients. Acoustic solutions not only optimize the functionality of the space but also contribute to creating a more effective and reliable service environment by improving the user experience.

Air Quality and Acoustic Performance Criteria in Material Selection

In order to improve the interior quality in PCCs, critical criteria such as air quality and acoustic performance should be taken into consideration when selecting materials. In this regard, natural, sustainable materials that support air quality, do not emit volatile organic compounds (VOCs), and are natural and sustainable should be preferred. Materials that do not emit VOCs provide a healthy environment for both patients and healthcare professionals by preventing the spread of chemicals indoors (Yu and Crump, 1998). For example, low-VOC paints, water-based finishes, and natural floor coverings help prevent the buildup of toxins indoors. Natural materials such as wood, stone, and bamboo not only support environmental sustainability, but also protect air quality by minimizing VOC emissions. While these materials bring a natural atmosphere to health centers, they offer an environmentally friendly design approach thanks to being obtained from sustainable sources.

The use of materials with sound-absorbing and insulating properties is of great importance in ensuring acoustic comfort. For example, acoustic panels, insulated ceiling materials, and sound-absorbing fabrics reduce the indoor noise level, providing patients and employees with a more comfortable environment. In addition, textile-coated surfaces, and special acoustic panels reduce echo, creating a calm atmosphere in health centers.

Air quality and acoustic performance are directly related to material selection. The use of the right materials not only supports fresh air circulation, but also increases user comfort by balancing indoor sound levels. For example, wall coverings with high acoustic insulation prevent sound transmission between spaces, while also contributing to air quality with their VOC-free structure (Mølhave, 1991; Zorlu and Karadayı, 2020).

As a result, the right material selection to support the air quality and acoustic performance of indoor spaces in PCCs should be provided with natural and sustainable products that do not emit VOCs. These choices increase the functional efficiency of the health center and allow patients and healthcare professionals to be in a healthier and more comfortable environment.

Ergonomics and User Experience in Health-Oriented Design

Ergonomic interior architecture has a significant impact on the health and comfort of patients and healthcare professionals in PCCs. The ergonomic design makes the space user-friendly, thus reducing physical strain that may occur during long-term use and improving the user experience. Furniture and arrangement planning should ensure ease of movement for both groups. Comfortable seating areas, especially in waiting areas, help patients feel more comfortable while waiting, while ergonomic furniture in examination rooms ensures that patients are in a comfortable position. For elderly patients and individuals with limited mobility, these arrangements increase the accessibility of the health center (Janowitz et al., 2006).

Healthcare workers also face physically demanding tasks during long and intense working hours (Güler et al. 2015; Özçelik Kaynak et al. 2018). Therefore, ergonomic furniture such as adjustable-height tables and chairs protects the physical health of employees and supports them to work more efficiently. At the same time, designing workstations in an orderly and accessible manner allows operations to be carried out faster and more efficiently.

Furniture arrangements improve the user experience by increasing the functionality of health centers. Easily accessible arrangements in the reception area make it easier for patients and visitors to find their way around the space, while arrangements in examination rooms optimize the movement space of both patients and healthcare professionals (Aydemik and Yenimahallelli, 2016). Flexible and modular furniture solutions can be easily adapted to the needs of health centers, thus coping with different examination needs and patient density.

Ergonomic design and correct furniture arrangements increase comfort for both patients and healthcare professionals in PCCs, while also supporting the efficiency of healthcare services. While these approaches create a healthy and user-friendly space experience, they also improve the quality of healthcare services.

Conclusion

The contribution of interior architecture to user health and comfort in Primary Care Centers has been demonstrated by considering air quality, lighting, acoustic arrangements, and ergonomic approaches. A health-oriented design approach not only meets functional needs but also improves physical and psychological well-being of the users. While protecting the health of patients and healthcare professionals through measures such as ensuring high indoor air quality and controlling harmful particles and VOC levels, correct ventilation strategies ensure a constant flow of clean air in the space.

The integration of natural light into the space and the use of artificial lighting in appropriate colors and intensity supports the healing process of patients and increases the efficiency of healthcare professionals. Likewise, ensuring acoustic comfort and protecting patients' privacy through sound insulation improves the user experience by creating a peaceful atmosphere in the space. Ergonomic design principles enable users to be in the space comfortably and healthily, while also taking functionality to the next level.

These design principles recommended for PCCs provide a guiding framework for creating user-oriented, healthy, and comfortable spaces. Correct implementation of these elements will enable PCCs to provide healthier services to society and will contribute positively to the general health status of individuals.

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CHAPTER 13

Urban Living Labs: An Innovative Participation Tool for Smart City Development

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1. INTRODUCTION

Today, more than 55 per cent of the world's population lives in urban areas, and by 2050, this is expected to rise to 68 per cent (The United Nations, 2024a). Cities have become increasingly complex systems as urban populations grow and as globalization, innovation and smart services evolve. The World Bank emphasizes that cities are the engine of economic development, with more than 80 per cent of global GDP generated in cities and argues that good management of cities will increase productivity and innovation, thereby achieving sustainable growth (World Bank, 2023). Cities are thus at the centre of global socio-economic activity, hosting most of the world's population and generating economic expansion. In addition, cities are increasingly competing to attract financial and human capital. This is forcing city leaders to do more with less (Halegoua, 2020).

City leaders have been forced to do more with less as cities have been placed at the centre of policy-making and as cities compete to attract financial and human capital. Cities have become more complex due to rapid change and transformation, and they face social, economic, and environmental challenges due to the rapid depletion of natural resources, climate change, misuse of information, inequalities, conflict, and corruption. Experts emphasize that innovative and inclusive approaches are needed to address this complexity (Ersoy & van Bueren, 2020; Öztaş Karlı & Açıksöz, 2021; Sharifi et al., 2024; The United Nations, 2024b). There is also a need to share the benefits of urbanization with all segments of society and make cities more sustainable and livable. Various approaches have been developed in this direction, such as green city, eco-city, livable city, digital city, smart city, and others. In parallel with the spread of telecommunications technology and the development of services over the internet, the smart city approach emerged in the 1990s (Fernandez-Anez et al., 2018).

Smart cities adopt a human-centred approach to create more livable, sustainable and efficient urban environments by using technology as a means to facilitate citizen participation and interaction. Within this framework, the smart city approach likens the city to a laboratory for generating innovative solutions (Chronéer et al., 2019). By enabling bottom-up innovation with various actors, urban living labs offers a comprehensive approach for collecting data on citizens' problems and needs from real-life environments through collaborative methods, developing policies for the city with the participation of stakeholders and experiencing the implemented policies. They thus enable the development of new technologies and solutions for unforeseen and complex situations tailored to the needs of stakeholders (Verbeek et al., 2020). By inviting residents to participate, urban living labs foster collaboration and contribute to developing more inclusive, resilient and sustainable urban communities. Using them as a tool for participation in smart city development encourages the creation of innovative solutions in line with the needs, desires and habits of citizens and, hence, more sustainable and livable urban built environments. Accordingly, this study aims to provide a comprehensive overview of the literature on using urban living labs as a participatory tool in smart city development.

2. SMART CITY

The Smart City approach is an innovative, transparent, inclusive, and people-centred vision of urban development that aims to find effective solutions to many of the problems faced by increasingly complex cities, such as the degradation of natural resources, lack of access to essential services, low living standards, traffic congestion, crime, and socio-economic inequalities. It seeks to make cities more resilient regarding resource allocation and service delivery, ensure that all segments of society share the benefits of urbanization, manage natural resources wisely, and create more sustainable and livable cities (Gil-Garcia et al., 2016; Granier & Kudo, 2016; Camero & Alba, 2019; Levenda, 2019). This approach uses the latest technologies, such as Information and Communication Technologies (ICT) and the Internet of Things (IoT), to collect information in cities through sensors and various other means. It analyses the collected data and develops comprehensive strategies on many issues, including energy, transport, education, health, equity, equality, poverty, employment, social cohesion, housing, access, public investment, security, resource management and inclusiveness using smart city applications (Ruhlandt, 2018; Yigitcanlar et al., 2020). The Smart City approach is an interdisciplinary concept aiming to create livable and sustainable living spaces by balancing human/social capital, institutional components, technological capabilities, and up-to-date information systems.

The concept of a smart city is not static, making it hard to define (Hollands, 2008). The concept has evolved from a sector-based approach to a more holistic view that places governance and stakeholder engagement at the heart of development strategies (Fernandez-Anez et al., 2018). Technologies, particularly ICT, are a key component in the smart city concept, but they are insufficient to define the smart city approach (Inclusive Urban Agenda, 2016). It is widely recognized that the smart city concept embraces sustainability, high quality of life, inclusiveness, and technological innovation. The focus is on human resources, social learning, and the creation of smart communities that can achieve sustainable economic growth (Meijer & Bolívar, 2016; Giffinger et al., 2018;

Öztaş Karlı & Açıksöz, 2021; Lim & Yigitcanlar, 2022). Therefore, it must have a collaborative governance structure that leads to the development of economic, social, and environmental policies that improve sustainability and quality of life (Moura & Silva, 2021).

However, a key component of smartness in the urban context is technology. It is undeniable that information and communication technologies will be at the heart of how future cities will function. Smart cities use ICT to ensure that all the components of the city are coordinated, that services are efficient and of high quality, that information is shared with the public, and that the welfare of citizens is ensured (Webster et al., 2018; Halegoua, 2020). ICT is used to collect and analyze real-time information about the city continuously and introduce policies for the city in light of this data. Although advanced technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT) can potentially improve cities in terms of economic development and innovation, they can also give rise to social uncertainties. Accordingly, smart cities are struggling to strike a balance between the use of information and communication technology (ICT) and making the residents themselves the central axis. Developing cities solely through the innovative use of digital data and technology can lead to the neglect of social rights and democratic values and weaken the connection between people and space (Alizadeh & Sharifi, 2023). For this reason, the smart city phenomenon should mean much more than the use of information technologies in cities.

Early definitions of smart cities were technology-centric, emphasizing information and communication technologies (ICTs) (Yigitcanlar, 2021). However, current definitions focus less on ICT and more on human and social capital, such as sustainable economic growth, the efficient use of social resources, management of natural resources, and participatory governance (Baccarne et al., 2014; Van Waart et al., 2015; Van Geenhuizen, 2018; Webster et al., 2018; Ateş & Erinsel Önder, 2019). This is due to a shift from sovereignty to influence in the smart city discourse. The World Bank also emphasizes the importance of human capital in smart cities, recommending developing citizen-centric technologies that encourage citizen participation and the establishment of participatory governance mechanisms (Alizadeh & Sharifi, 2023). While the importance of technology in collecting and managing urban data cannot be denied, technology alone cannot provide perfect solutions for all aspects of urban life (e.g., education, health, transportation, energy, and governance) without human capital. Therefore, people are at the heart of functioning smart cities, and the interactions and collaborations between different stakeholders are prerequisites for transforming cities into user-centred innovation hubs (Shapiro, 2006; Meijer &

Bolívar, 2016). The collective knowledge, skills, abilities, and experiences of the people living in the city constitute human capital. Harnessing this human capital in the decision-making process not only meets the needs and aspirations of society but also increases people's trust in each other through community interaction, leading to a sense of responsibility and ownership of the city.

Smart cities are increasingly being implemented worldwide to address urban challenges and create smarter, more resilient cities for the future. According to Yigitcan and others, in 2018, smart city applications are being used in 178 cities globally to improve sustainability, enhance the quality of life, and drive economic development by leveraging advanced technologies such as IoT, data analytics, and AI (Yigitcanlar et al., 2018; Soeiro, 2021). These applications typically focus on areas such as smart energy, water management, transportation, urban planning, and governance. Notable examples include Singapore's Smart Nation Programme, San Diego's use of ICT, Ottawa's Smart Communities initiative, Barcelona's adaptive infrastructure, Amsterdam's energy-efficient systems, and Stockholm's energy efficiency, air pollution, and waste management technologies (Hollands, 2008; Bibri et al., 2023). Cities such as Helsinki, Zurich, Copenhagen, London, Seoul, and Milton Keynes are also promoting sustainability and digital inclusion through innovative projects (Bifulco et al., 2017; Moura & Silva, 2021). All cities with a smart city approach are using advanced technologies and data-driven methods to develop policies that improve sustainability, efficiency, inclusion, and the quality of life for their residents.

In theory, smart cities aim to improve economic development, sustainability, and quality of life by using digital data and technology to increase productivity with a technology-centric vision. In practice, however, the intended goal is not always achieved. The fact that smart cities are part of a neoliberal agenda that serves only the interests of investors and large corporations leads to limited citizen participation (Jiang et al., 2019). This has been criticized as deviating from the concept's goal of improving quality of life and being citizen-centered (Hollands, 2015; Webster et al., 2018; Halegoua, 2020). From this perspective, smart cities have become entrepreneurial cities focused on economic prosperity and competition. In addition, the data-driven production of urban decisions leads to the production of socially unjust decisions. Many academic studies show that current smart city practices are biased towards physical, technological, and economic development, while social rights, democratic values, and environmental development are largely neglected (Halegoua, 2020). Whilst the technology and digital infrastructure of smart cities are developing very rapidly in cities, progress on many issues, such as inequality, polarization, security, and ethical issues, is still very slow (Alizadeh & Sharifi, 2023). In this context, instead of assuming that information technology will automatically transform and improve cities, a more equitable approach which prioritizes social rights and focuses on human capital is needed. Participatory democracy is a prerequisite for the success of the smart city phenomenon (Van Waart et al., 2015; Van Geenhuizen, 2018).

Smart City Components

Smart city components are the elements that make up a smart city. These components include technologies, infrastructure, and services designed to enhance sustainability, efficiency, and quality of life. The smart city approach involves integrating the different infrastructure systems developed for various aspects of the city into a single composite system, both internally and as a whole (Samih, 2019). Smart city infrastructure integrates various technological and non-technological components such as a smart economy, smart mobility, smart environment, smart energy, smart buildings, smart water, smart waste management, smart governance, and smart citizens (Figure 1) (Bifulco et al., 2017; Kirimtat et al., 2020; Oke et al., 2020). These components work together to create a sustainable, efficient, livable, and inclusive smart city. However, a city does not need to possess all of these components to be defined as smart. The number of smart components can vary depending on different smart city priorities (such as cost and available technology) (Mohanty et al., 2016). City administrators can make any dimension of the city smart. For example, developing a signal application that focuses solely on the density of vehicles at traffic lights to address the problem of traffic congestion is a smart city component.

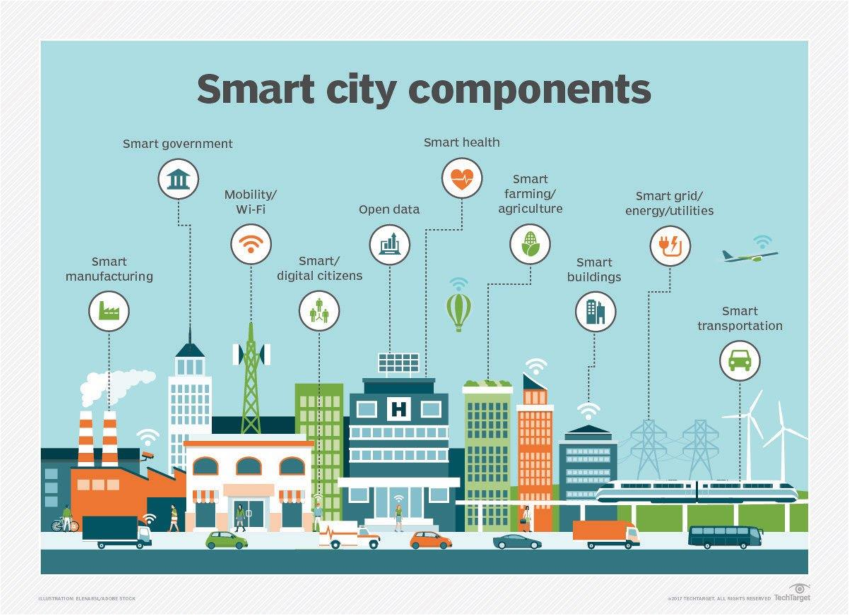

Figure1: Smart City Components (Shea & Burns, 2023)

A smart economy, one of the main components of a smart city, seeks to create high-tech production areas, develop the workforce, and increase productivity to improve the competitiveness of the city (Moura & Silva, 2021). Smart mobility includes innovative applications for public transportation, private vehicles, and pedestrian and bicycle infrastructure to improve the efficiency and safety of transportation systems. Examples of smart mobility include developing intelligent traffic management systems, collecting and analyzing real-time traffic information, smart parking solutions, and using autonomous vehicles (Ateş & Erinsel Önder, 2019). Applications that offer creative solutions to reduce the impact of urban growth on the environment and natural resources, waste management, and the use of renewable energy sources are part of the smart environment component. Smart energy includes using technology for electricity distribution, energy consumption, efficiency and sustainability of energy systems, and the development of smart grids. Smart buildings include using technologies to improve the efficiency and sustainability of buildings, including managing energy consumption and integrating renewable energy sources. Technologies to improve the management of water resources, such as clean water and wastewater, are part of the smart water component. Smart waste management includes innovative technologies for collecting, transporting, sorting and disposing of waste (Mohanty et al., 2016). These smart city components contribute to creating a more sustainable, livable and efficient city by using technology to improve the quality of life of its citizens.

On the other hand, smart governance is a collaborative management approach in which the stakeholders affected by urban decisions participate in city governance and are involved in the decision-making process regarding public policies and services (Lim & Yigitcanlar, 2022). All innovative technologies make the smart city citizen-centric and citizen-oriented, especially information and communication technologies (Ruhlandt, 2018). In the context of this study, smart governance in the following section is examined in detail, particularly urban living labs, which offer important opportunities for citizen participation in the management of smart cities.

Smart Governance

Smart governance, one of the components of smart cities, is based on the premise that public services should be delivered with a participatory approach based on democratic, egalitarian, transparent and accountable concepts. Smart governance emphasizes that not only the authorities or experts, but also all stakeholders, including marginalized communities, should participate in determining urban policies in an interactive and collaborative decision-making process (Foth, 2018). From this perspective, citizens are considered to be the main stakeholders in urban development, and the objective is to identify their needs and desires and produce technological solutions to urban problems using a participatory approach (Cortés-Cediel et al., 2021; Veeckman & Temmerman, 2021; Levend & Fischer, 2023).

To qualify as a smart city, stakeholders should have access to real-time data to understand and solve city-related problems and be governed by a citizen-centred participatory governance structure (Fernandez-Anez et al., 2018). Smart governance is an innovative, networked governance system that enables citizens to participate in decision-making actively and strengthens collaboration among stakeholders through the use of innovative technologies and data-driven approaches (Meijer, 2016). Smart governance enables the use of information and communication technologies to support economic growth, sustainability, efficiency, transparency, accountability and a high quality of life by engaging all segments of society in the governance process (Lopes, 2017). Citizen-centred city decisions with social innovation enable the development of social capital and social sustainability at the forefront, and stakeholders co-produce and learn throughout the process (Axelsson & Granath, 2018; Jiang et al., 2019). Technological tools for data collection and engagement in smart cities are central to a series of data flows emanating from big data processes. These offer significant opportunities for citizen engagement, social sustainability, and inclusion in smart cities.

Researchers have conceptualized four different types of smart city governance (Figure 2) (Praharaj et al., 2018; Lopes & Farooq, 2020). The first is a traditional governance structure that seeks to create a smart city. In this conceptualization, the government plays a leading role and supports smart city development through planning, policy, and financing support. Second, the government aims to improve decision-making by analyzing real-time data from sensors and other innovative technologies, leveraging information technologies such as open data policies and IoT to develop sustainable smart cities and tackle urban challenges. Administrators seek to improve efficiency by leveraging technology and data systems. Third, administrators aim to integrate ICT into the management process to enhance the quality of urban services, increase efficiency, and generate and implement decisions through a transparent process. This governance structure is efficient, transparent, and citizen-oriented, with fully digitalized service delivery, interconnected systems, and active citizen participation. In the final type, the governance structure involves the government, private sector, citizens, and other stakeholders collaborating to ensure that all stakeholders have a voice in governance. In this governance approach, no group in society is excluded, and all are collectively responsible for decisions made regarding the city.

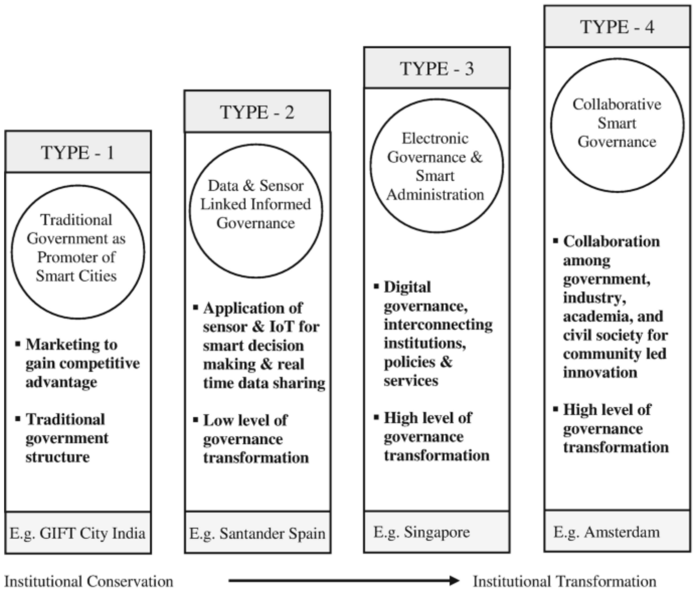

Figure 2: Various Conceptualizations of Smart Governance (Praharaj et al., 2018; Lopes & Farooq, 2020)

Administrators adopting a participatory approach to improving the quality of life of citizens are not only building the technological infrastructure for data collection but also implementing innovative systems to support citizen participation in the process (Granier & Kudo, 2016). Many digital participatory platforms and tools have been developed, including ICTs and real-world applications, to facilitate citizen or community participation in decision-making and improve collaboration between administrators and stakeholders (Praharaj et al., 2018). For example, the features of GIS technology, such as geographic data collection and visualization, help to increase citizens' awareness of the process. Currently, new ICT tools such as social media, websites, crowdsourcing and the Internet of Things are increasingly being used by planners and governments to engage the private sector and citizens in planning processes (Jiang et al., 2019). In ICT-enabled governance, providing citizens with various ICT tools allows stakeholders to access information and data efficiently and economically, participate whenever and wherever they want, and communicate with community members. As a result, decisions in smart cities are made with a collaborative and participatory management approach based on the values of interaction, dialogue, cooperation and relationship-building among stakeholders.

Smart City Technologies

Smart cities generally refer to the deep integration of information and communication technologies (ICT) into the urban fabric to promote economic development, ensure citizens' well-being, and enhance participatory governance (Sengers et al., 2018). The ICT infrastructure is the core smart component of the smart city, integrating all other components and acting as the nerve centre (Gil-Garcia et al., 2015; Mohanty et al., 2016). Within this infrastructure, smart cities use advanced ICT technologies such as the Internet, the Internet of Things (IoT), artificial intelligence (AI), autonomous vehicles (AV), virtual reality (VR), cyber-physical systems (CPS), robotics, blockchain, cloud computing, big data and digital public repositories, mobile applications, and geographic information systems (Halegoua, 2020; Kirimtat et al., 2020; Moura & Silva, 2021). In a smart city, real-time data collected from sensors, meters, devices and citizens is important for understanding city life and getting feedback from people. Smart cities use various software, user interfaces, and communication networks to monitor the urban infrastructure and services, improve service efficiency, enhance the quality of life for citizens, and promote sustainable development. Technology monitors and improves urban infrastructure through measures such as crime and public safety, education, health, transportation, energy, pollution, waste management, environmental monitoring, and emergency response. In addition, it is used to support and improve the efficiency of systems such as land use, planning, participation, transportation and security to interact with citizens in the management process and to facilitate citizen participation in decision-making (Gil-Garcia et al., 2015; Halegoua, 2020; Kirimtat et al., 2020). In summary, in a smart city, various technological tools integrate and analyze real-time and real-world data about the city into the computing infrastructure, enabling decisions to be made, activities to be coordinated, and actions to be implemented for city services.

The vision of creating a system that makes cities smarter and where everything is interconnected is based on the possibilities offered by information communication technologies. Systems created with ICT are the essential infrastructure for analyzing the current situation, decision-making, planning, development and management operations related to any phenomenon in smart cities. High bandwidth internet (World Wide Web) and multimedia applications have played an important role in developing the smart city approach. Internet-based e-government, e-governance and technologies enable urban services to be carried out efficiently and effectively (Yigitcanlar, 2016). The Internet of Things (IoT) is another technological component that forms the basis of smart cities. IoT enables establishing a network system between people and objects and between objects and other objects, enabling them to communicate and exchange information (Mohanty et al., 2016; Jonell & Meritähti, 2017). The objects in this system can include everything from computers and smartphones to smart homes, smart vehicles, household appliances and street sensors. With IoT, real-time data from objects and machines is collected. The collected data is analyzed to understand the process of the city's functioning. The analysis results are then evaluated within the smart governance structure, and practical solutions are produced to optimize city services and improve citizens' quality of life. IoT is used for many purposes, such as regulating energy consumption in smart buildings, reducing traffic congestion, helping to find parking spaces with smart parking applications, improving air quality by monitoring air quality, and optimizing the waste collection system with sensors (Shea & Burns, 2023). Another example of IoT use in smart cities is digital twin technology. The digital twin model involves creating a digital copy of a city to monitor changes that may occur in real life in a city. A bridge between the physical and virtual worlds is created to test a possible scenario or the suitability of a planned service in cities (Švelec et al., 2020). Thus, the future of cities can be shaped by simulations before problems occur and without investing in a service.

Another important component of smart city technology is artificial intelligence (AI). Artificial intelligence comprises machines or computers that mimic cognitive functions such as learning by collecting information about a case from their environment or different objects using various technologies, conceptualizing by analyzing this data and developing possible solutions, making and implementing decisions, and improving itself (Samih, 2019; Yigitcanlar et al., 2020). AI technologies help overcome various challenges by automating urban services and optimizing resource allocation (Yigitcanlar et al., 2024). In addition, AI-based data analytics techniques are used to manage, analyze, and draw meaningful conclusions from large and diverse datasets obtained in real-time from the urban area through information communication technologies (Bibri et al., 2023). For example, the data obtained from sensors, cameras, and autonomous vehicles in urban areas can be analyzed by artificial intelligence to identify potential threats such as security issues, natural disasters, and fire at a speed beyond human capability and take the necessary measures to mitigate them. Autonomous vehicles are an issue that needs to be emphasized in relation to AI as they are becoming more widespread and a part of the city transportation system to reduce service costs and provide safer transportation services (Yigitcanlar et al., 2020).

In smart cities, real-time or process-oriented data about the city is obtained from sources such as IoT devices, sensors, databases, cameras, websites, mobile applications, and social networks (Mohanty et al., 2016; Yigitcanlar, 2016; Kirimtat et al., 2020; Moura & Silva, 2021). This data is defined as Big Data. Since it is impossible to analyze the data obtained for all areas of the city with traditional methods, this data is analyzed using smart city technologies such as artificial intelligence, machine learning, and big data analytics to enhance the capacity to make informed decisions about the city (Gil-Garcia et al., 2015; Halegoua, 2020). Another technology that increases the ability of city managers to make the right decisions is Geographic Information Systems (GIS) technology. GIS is a system designed to collect, store, analyze, and visualize spatial data connected to an information system (Yigitcanlar, 2016). With web-based GIS technology and artificial intelligence add-ons, data processing, visualization, and 3D modelling, functions related to the urban area are presented in a format that citizens can easily access.

As a result, information and communication technologies are rapidly developing in all areas of urban life. As these technologies become more widespread in society, the opportunities for citizens to participate in the decision-making processes related to the city will increase. Implementing a participatory decision-making process in cities not only enhances society in terms of democracy, transparency, trust, and social capital but also increases the legitimacy of the decisions made. Integrating innovative participation mechanisms into the decision-making process results in a better understanding of the needs of citizens. It facilitates decision-making that encompasses all segments of society, including marginalized groups. In this regard, the following section examines urban living labs in which the participation of actors in smart cities results in more democratic and inclusive governance.

3. URBAN LIVING LABS

Living Labs

As part of the smart city approach, living labs, relying on ICT and data use, offer more democratic, inclusive, and innovative governance as a means of participation and co-creation (Ståhlbröst, 2008; Bergvall-Kåreborn et al., 2009; Bifulco et al., 2017; Memiş & Küçük Bayraktar, 2020). Living labs are open, inclusive, and collaborative innovation ecosystems that aim to develop new technologies, products, services, and systems through active user participation and co-creation in the early stages of the innovation process using different methods across a variety of fields, where multi-actor active user participation through public-private-public partnerships occurs in real-life communities and environments ekosistemleridir (Ståhlbröst, 2008; Ballon & Schuurman, 2015; Leminen, 2015; Schuurman, 2015; Lehmann et al., 2015; Anttiroiko, 2016; Leminen et al., 2017; Chronéer et al., 2019; Hossain et al., 2019; Mastelic, 2019; AMS Institute, 2023; The European Network of Living Labs, 2024). They use innovative methodologies to create, prototype, trial, manufacture, and test innovative technologies, solutions, and products in a real-life environment before implementing them on a larger scale (Bergvall-Kåreborn et al., 2009; Colobrans, 2019; Habibipour, 2022). Before a product or service is officially introduced into the market or society, prototypes or new versions are tested by real people in the real world. In this process, the Internet of Things enhances the communication capacity between stakeholders through information communication technologies such as artificial intelligence, sensors, and smart devices. It creates the technological infrastructure for co-creating innovative products.

Living lab is a human-centred approach, as it considers individuals to be the main source and developers of knowledge for research and development activities (Schuurman, 2014). The framework involves people at different stages of the innovation process. It is an open innovation network providing a physical or virtual participatory environment where people can interact and discuss knowledge, experiences, and mutual interests in decision-making (Schuurman et al., 2016). Many stakeholders from different sectors participate in the activities of living labs, adopting different roles in product development. The fact that the living lab allows users to interact with each other in their real-world environment distinguishes it from traditional engagement tools (Ståhlbröst, 2008).

The living labs process is driven by different actors, classified as utilizers, enablers, providers, and users (Leminen et al., 2012; Schuurman, 2014; Georges & Gilbert, 2017; CENTA, 2020). Utilizers ensure that projects are carried out in line with the goals they want to achieve. Utilizers are considered researchers throughout the innovation process and are involved in gathering information, processing information, designing, porting, developing, testing, and evaluating the product in a real-world environment (Mulder, 2012; Levenda, 2019). Enablers help to provide the environment and funding for stakeholders to participate in the living lab. These stakeholders provide resources or policy support for developing products or services in the private and public sectors. Providers, usually universities or other research and educational institutions, offer their human and technological resources, tools and methods to other stakeholders to create innovative products or services in living labs. Users can play the role of object and subject in the living lab process. In the role of object, users reveal their needs, desires and experiences, while in the role of subject, they take an active role in the production process (Schuurman, 2014; Georges & Gilbert, 2017; Hossain et al., 2019). City managers can use living labs as an innovation tool where users actively participate in the city's policy-making process.

The term living labs was first coined in the early 1990s by researchers at the University of Philadelphia in an attempt to solve real-world problems, and was further elaborated in the early 2000s by work done at the Massachusetts Institute of Technology (Ståhlbröst, 2008; Ballon & Schuurman, 2015; Puerari et al., 2018; Van Geenhuizen, 2018; Van Geenhuizen, 2019). The concept was popularized with the establishment of the European Network of Living Labs (ENoLL) in 2006 with the support of the European Commission, which aims to promote and develop the concept of living labs (Schuurman, 2014; Georges & Gilbert, 2017; Lehmann et al., 2015; Schuurman, 2015). More than 480 living labs are linked to ENoLL, mainly in Europe (The European Network of Living Labs, 2024). ENoLL provides information exchange, training, project development and promotion services to its members (Schuurman, 2015; Dekker et al., 2020).

Urban Living Labs

Smart governance places citizen participation at the heart of governance for the public good and the efficient delivery of public services. However, traditional engagement tools have not successfully generated innovative solutions to urban challenges, such as reducing traffic congestion, increasing public safety, and improving air quality. Therefore, with a smart governance approach, it is inevitable that technological solutions will evolve to enable residents to actively participate in shaping their urban environment and to translate their needs and aspirations into urban policies through consultation, deliberation, feedback, co-design, and planning in the decision-making process (Foth, 2018; Soeiro, 2021). New human-centred ideas, techniques, and practices with multiple interdisciplinary approaches to citizen participation, inclusion, equity, urban development, and new collaborative models will be developed in line with a governance approach consistent with the Smart City approach (Rizzo et al., 2021; Veeckman & Temmerman, 2021). Urban living labs are a dynamic and innovative model of urban governance that fosters community engagement in developing innovative solutions to address a range of complex urban challenges and opportunities created by urbanization, such as climate adaptation, resilience, sustainable urban development, quality of life, urban inequalities, mobility, and smart technologies (McCormick & Hartmann, 2017; Steen & van Bueren, 2017a; Menny et al., 2018; Bulkeley et al., 2019; Chronéer et al., 2019). Urban living labs are a form of experimental innovation that enables city managers, citizens, and researchers to work together and provide opportunities for communities to exchange ideas, explore, learn, design, test, develop, implement, and evaluate solutions/interventions to improve urban life and address challenges (Bulkeley et al., 2016; Van Geenhuizen, 2019; Cuomo et al., 2020; Ersoy & van Bueren, 2020). To summarise, innovative work in the Urban living lab is carried out in a real-life environment and in an open innovation ecosystem to generate solutions to specific social, economic, and environmental problems in a specific urban area.

Regarding general characteristics, design and operation, living labs and urban living labs are very similar. Urban living labs are living labs that operate in an urban environment that can be scaled from a street/neighbourhood level to an entire city, enabling the testing and development of new technologies, services, systems, practices, processes, and types of interventions for the city (Baccarne et al., 2014; Steen & van Bueren, 2017b; Puerari et al., 2018; Habibipour et al., 2020; JPI Urban Europe, 2024). They are created to understand people's real-life experiences, problems, needs, and aspirations, and to test and implement innovative ideas to improve sustainability, quality of life, and service efficiency in urban policy (Marvin et al., 2018; Bulkeley et al., 2019). They comprise innovation networks and co-creation ecosystems that allow stakeholders to explore, investigate, experiment, test, create, develop, and evaluate new ideas, scenarios, systems, and solutions for the city in the complex and real-world environment of the city before they are implemented across the city (Bulkeley et al., 2016; Memiş & Küçük Bayraktar, 2020). In this way, a safe environment for learning is provided, allowing products and services to be tested transparently and repeatably in a real-world environment, with learning and innovation occurring at the end of the process.

In order to address urban challenges, urban living labs are managed through a real-time interactive process between residents, private actors, managers, and knowledge institutions. Citizens are the key actors in this process and are actively involved from the early stages of innovation design and development (Steen & van Bueren, 2017a; Puerari et al., 2018; Veeckman & Temmerman, 202; Breed et al., 2022; JPI Urban Europe, 2024). Stakeholders generate new ideas and policy proposals for the city, develop new approaches, and help pilot and test solutions. The active participation of citizens in urban decision-making contributes to better solutions tailored to their needs and to the development of cities according to the priorities of the people. An open and two-way interaction between citizens and city authorities in the participation process fosters mutual trust (Menny et al., 2018; Ersoy & van Bueren, 2020). Citizens can decide on solutions that affect their lives while developing a sense of trust, belonging, ownership, and responsibility, leading to a more inclusive, sustainable, and livable urban ecosystem. Because real users develop services in a real-world environment, city residents are more likely to adopt them (Steen & van Bueren, 2017b).

Urban living labs reduce risk and costs by allowing decisions under discussion to be tested in a more gradual and controlled environment before implementing them across the city. City managers can see how urban policies work in practice and identify opportunities for improvement against potential challenges. In this process, the innovation activities are coordinated within an integrated bottom-up and top-down structure. The bottom-up approach identifies needs, problems and unanticipated ideas, whilst the top-down approach identifies actions to address these ideas in line with existing goals and procedures within a formal structure (Mulder & Marseille, 2020). The Helsinki, Amsterdam, and Barcelona Living Labs are exemplary, having achieved broad collaboration between residents, local businesses, research centres, and local government to solve environmental problems, improve public services, enhance urban mobility, address sustainability and governance, improve urban living, and promote the use of smart technologies (Anttiroiko, 2016; Bifulco et al., 2017; McCormick & Hartmann, 2017).

Using information and communication technologies to collect and analyze data in real time during the decision-making process for urban areas increases the ability to make the right decisions. Another distinctive feature of urban living labs is that it uses information and communication technologies (ICT) for technical testing and data collection (Veeckman & Temmerman, 2021). In the data collection and implementation process, information and communication technologies such as mobile applications, social networks, geographic information systems, cloud computing, and the Internet of Things are employed to gather data on citizens' genuine thoughts. Experts simultaneously analyze the collected data to improve urban services and address problems by making more accurate and faster decisions. As a result, the quality and success rate of city services can be enhanced, while costs and resource consumption can be reduced.

The Living Lab Phases

As mentioned above, Urban living labs are living labs. The possible phases of living labs may vary depending on the purpose, focus, local context, and innovation concept. Therefore, no fixed methodology describes their innovative activities as a process (Breed et al., 2022). Nevertheless, Steen & van Bueren (2017b) in "A living lab way of working", Ståhlbröst and Holst (2013) in "FormIT", and Mastelic (2019) in "Living Lab Integrative Process" describe their phases (Bergvall-Kåreborn et al., 2009; Bergvall-Kåreborn & Ståhlbröst, 2009; Bergvall-Kåreborn et al., 2010; Georges & Gilbert, 2017; Ståhlbröst & Holst, 2013; Steen & van Bueren, 2017b; Mastelic, 2019; Zimmermann et al., 2023; SCORE, 2024). Based on Steen & van Bueren's framework of a living lab way of working (Figure 3) (Steen & van Bueren, 2017b), and considering the points highlighted by other definitions, the phases of living labs are presented below. Because living labs aim for continuous innovation, the process is non-linear. Situations that require constant re-examination are encountered along the way. Accordingly, living lab phases involve a cycle or iterative cycles within a cycle (Ståhlbröst & Holst, 2013).

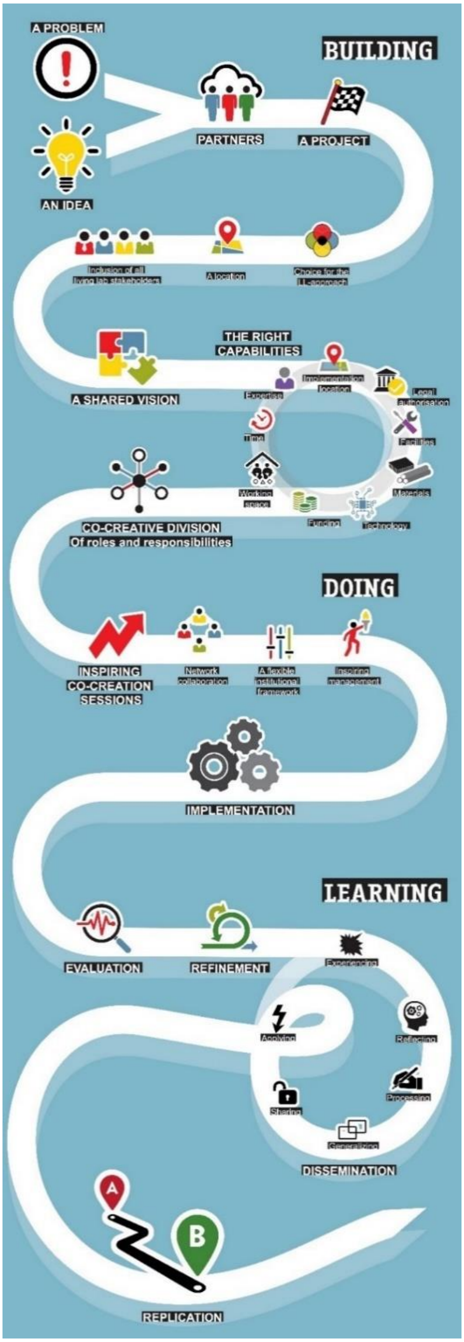

Figure 3: The Living Lab Phases (AMS Institute, 2023)

Step 1 – Initiation

Living labs aim to solve problems or develop innovative technologies, services, systems, and applications in response to specific cases (Ståhlbröst & Holst, 2013; Steen & van Bueren, 2017b; Menny et al., 2018; Habibipour et al., 2020). Towards this end, the scope of the process is defined. Stakeholders affected by the problem or interested in collaborating on the case are identified, and a communication infrastructure is established. To build trust among stakeholders, a communicative approach ensures that stakeholders work closely together. Next, the topic of the living laboratory is determined by establishing common goals. User needs and requirements are identified and continuously updated during this phase (Ståhlbröst, 2008; Mastelic, 2019). Formal and informal methods and techniques, such as observation, workshops, surveys, in-depth interviews, focus groups or multi-criteria analysis, are used to collect and generate data during the initiation process (CENTA, 2020). A public-public-private partnership is established with the participation of all stakeholders, and a concrete project idea that is in line with the established goals is expounded. In this process, three groups are formed: a leadership group to take ownership of the problem to be studied, an operational group to design and conduct the research, create content, conduct analysis, and prepare appropriate reports and documents and a user group to experience the solution model (Colobrans, 2019). All stakeholders are involved in living labs from the outset. The technological infrastructure created with ICT technology is actively used throughout the process.

Step 2 – Plan Development

At this phase, a shared vision for the innovation is established in line with the needs, wishes, and requirements of all stakeholders (Ståhlbröst, 2008). It is important to note that the shared vision should encompass the interests of all stakeholders (Steen & van Bueren, 2017b). Accordingly, all stakeholders should agree on the vision. Otherwise, the process must be repeated until a consensus is reached among the stakeholders (Ståhlbröst & Holst, 2013). The most important issue in the second phase is developing a process design that clearly outlines tasks, activities, and permissions. A location for the project is identified, and stakeholders should be open and honest about their roles and responsibilities in the process (Habibipour et al., 2020). In the plan development phase, the management structure must be established, and financial resources identified to ensure that the planned activities are carried out.

Step 3 – Co-creative Design

In this phase, stakeholders come together to develop a concept based on the previously identified vision and to identify key principles for new technologies, services, systems, or types of intervention. Stakeholders develop a prototype according to the key principles identified in the initial vision (Ståhlbröst & Holst, 2012; Georges & Gilbert, 2017). The designed prototype should be sufficiently detailed to allow users to perceive and experience the final service (Ståhlbröst, 2008; Ståhlbröst & Holst, 2013). This process creates an open environment where citizens can freely express their opinions, stakeholders can collaborate, and stakeholders feel secure (Menny et al., 2018; Habibipour et al., 2020). A flexible institutional structure is created to establish horizontal networks of relationships between actors in an open and transparent structure and to develop incentive practices. This institutional structure provides an uncomplicated, constructive, positive, transparent, and inspiring creative environment (Steen & van Bueren, 2017a; Steen & van Bueren, 2017b). Concrete results and products can be expected to emerge from this creative environment (Almirall et al., 2012).

Step 4 – Implementation

The basic approach in the living lab is to create, implement, and test the innovation in a real context and environment (Ståhlbröst, 2008). The stakeholders evaluate the innovations introduced through the implementation process in the short, medium, and long term, with the innovations being further developed (Almirall et al., 2012; Steen & van Bueren, 2017a; Mastelic, 2019; Habibipour et al., 2020). This phase ensures that the process remains straightforward and pragmatic, leaving behind the complex administrative structure of the current management approach. After testing the designed product, observing whether the solution meets the intended purpose and collecting data on the process is necessary (CENTA, 2020). Stakeholders' opinions on their experiences with the innovation are gathered, analyzed and evaluated in line with the criteria for innovation success. Based on this feedback, the innovation can be modified and redesigned (Ståhlbröst & Holst, 2013).

Step 5 – Evaluation

This stage is the experimentation process in which the performance of the innovative product is tested, evaluated, and redesigned in the real-world environment for which the product was designed (Ståhlbröst, 2008; CENTA, 2020). Feedback from the testing process is used to assess whether the living lab has met its objectives. Data are collected and analyzed through surveys and stakeholder interviews (Habibipour et al., 2020). The data collection process utilizes information and communication technologies in the context of smart cities, such as the Internet of Things (IoT), blockchain, cloud computing, big data, and digital public repositories, mobile applications, and geographic information systems. The evaluation is conducted on two levels: technical and conceptual. At the technical level, the evaluation determines whether the innovation works and, at the conceptual level, whether the innovation aligns with the initial goals and objectives (Steen & van Bueren, 2017a; Steen & van Bueren, 2017b; CENTA, 2020).

Step 6 – Refinement

The evaluation phase is followed by the refinement phase, where the product is distilled and optimized. The aim here is to repeat the process as much as possible to develop the most suitable product for the given objectives (Steen & van Bueren, 2017a; Steen & van Bueren, 2017b). This process continues until users are satisfied with and adopt the innovative product.

Step 7 – Dissemination

Dissemination is the reporting of findings and conclusions on innovative products, processes and experiences achieved through the living lab and, thereby, sharing them with the wider community. As a requirement of open innovation, sharing the results of experiments with the public allows others to be aware of the outcomes of the project (Mastelic, 2019). This enables everyone to gain insights into the process, whether it is successful or unsuccessful (Steen & van Bueren, 2017b).

Step 8 – Replication

The final phase replicates the developed innovation in other urban contexts. When the innovation is replicated, the development process is actually repeated to adapt the innovation to the new context (Steen & van Bueren, 2017b).

The fundamental modus operandi of the living lab is that there is co-creation, exploration, experimentation, and evaluation at each stage of the innovation process (Georges & Gilbert, 2017). After each stage, collaboration and evaluation of activities and goals may require feedback to learn more deeply and make necessary adjustments to the process. In this process, feedback continues until the desired goal for the innovation phase is achieved. Each living lab environment has its own specific conditions, and the organization and methods should be developed accordingly (Ståhlbröst, 2008).

4. DISCUSSION and CONCLUSION

In today's world, cities have become the focal point for achieving sustainable, equitable, efficient and economic development goals. The smart city concept and technological developments provide the necessary infrastructure to achieve these goals. While the first generation of smart city literature focused on technological innovation, it now focuses on creating social value centred on people and society. This study presents a theoretical framework for urban living labs developed according to the principles of smart governance, a component of the smart city concept incorporating technology, innovation, efficiency, transparency, collaboration, openness, accountability, and pluralism.

Urban living labs are a governance network of real contexts, real users and real use cases that strive to generate innovation in response to a problem or case. Taking into account the needs and aspirations of people living in cities, they provide an appropriate theoretical framework for urban governance and have the potential to improve the quality of life of citizens by creating sustainable and livable urban spaces.

Providing a platform for stakeholders to collaborate in urban areas, urban living labs are ecosystems. They ensure the active participation of all stakeholders in policy development, testing, and implementation. However, creating and organizing urban living labs requires significant effort. Firstly, collecting information and data from citizens in an environment that simulates the complexities of the real world, and, subsequently, developing policies for the city with the participation of all stakeholders is a big undertaking but, ultimately, one which contributes to improving the quality of life in cities. Information and communication technologies in the innovation generation process enable real-time data collection and analysis, facilitating user-oriented decisions. Stakeholders ensure that the innovative product aligns with the real needs of the community. Stakeholder validation of the innovative product assists in its rapid adoption by all, with the result being that the livability of the city is enhanced.

On the other hand, the innovative product obtained by testing urban living labs in a specific urban context may not be suitable for another city, or even for another community within the same city. The design of an experimentation process must be specific to each context. Similarly, the technology may be too pervasive, and the transparent sharing of data generated during the process with the public may be problematic for participants. Participants may not be tech-savvy, or the technological products used may adversely affect them throughout the process. Furthermore, the motivation of participants at the beginning of the process tends to diminish as it progresses. These situations can cause participants to drop out before the process is completed. Moreover, the complexity of the living labs process and the fact that each innovative product has a different context makes it necessary to continually revise the living labs phases. In this context, future research should focus on ensuring the continuity of citizen participation in the urban living labs and reducing the complexity of the experimentation process.

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CHAPTER 14

Examining the Concept of Therapeutic Landscape in terms of Human-Nature Relationship

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1.Introduction

Rapidly progressing unplanned urbanization threatens biodiversity by polluting the environment, while at the same time increasing the effects of extreme weather events and causing serious social and environmental problems. Today, the continuous expansion of cities has become an inevitable situation (Kahveci, Onur 2024; Onur, Gülpinar Sekban 2020; Onur, Gülpinar Sekban 2021; Tache et., al. 2024; Gülpınar Sekban 2022a; Gülpınar, Acar 2024). Coasts are changing, social areas are different (Onur, Gülpinar Sekban 2022). Problems such as dense construction, industrial uses, stressful work life, and staying away from nature arise due to population growth in urban areas. As a result, the negative effects it creates on urban spaces and people roaming in the city are the subject of many studies. The decrease in the relationship of people who switch from nomadic to settled life with nature is becoming a concept that needs to be filled for urban spaces. Therefore, the close relationship between humans and their immediate environment makes it important for the physical and mental health of individuals and makes it a priority issue in urban landscape designs (Kara and Oruç, 2020). While increasing highways, changing coastal balance, etc. affect global climate change, changes have always been the solution point (Steg, 2023; Gülpınar Sekban, 2022b).

This phenomenon not only disrupts environmental balances, but also leaves deep traces on human health and social structures. These traces emerge as health problems that negatively affect human health. In the simplest terms, health risks such as heat stroke, respiratory distress and heart diseases increase with the oppressive effect of increasing temperatures. At this point, many scientific studies such as green infrastructure applications, cittaslow applications, Nature Based Solution applications, and biophilic design approach can be suggested (Gülpınar Sekban at., al. 2019; Gülpinar Sekban, Düzgünes 2021; Onur, 2023; Fang et., al. 2023; Jezzini et., al. 2023). The healing power of natural effects such as clean air, sunlight, plants and exercise have been the treatment methods used in the field of health for centuries. However, it can be said that the period after World War II entered a period in which the industry gained momentum and relied more on treatment methods and technology that moved away from nature. In recent years, this trend has reversed. There are many literature reviews showing the benefits of contact with nature on human mental and physical health (Pirli, 2020). At this point, ecological approaches (Korkut et. al. 2017; Gülpınar, Acar 2021a, Hall et., al. 2024, Gülpınar, Acar 2024; Brück et., al. 2024) and the healing role of nature come into play.

2. Ecotherapy

Ecotherapy is an approach that seeks a solution to this problem. Ecotherapy, also known as nature therapy or green therapy, is a complementary and alternative therapy that uses the principles of ecological and psychological connection (Hinds and Sparks, 2018). In a different definition, ecotherapy is a field that aims to support mental and emotional health by using the healing power of nature with various methods ranging from simple nature activities to more planned interventions (Unsal, Korkmaz 2023).

The importance people give to their physical health is increasing day by day. But the important point is that; people now also give great importance to their mental health and try many alternative ways for this. Yoga hotels, spa-wellness centers and healthy living centers are just a few of them. But the common important point of each is "nature".

Ecotherapy can be easily integrated into regular mental health practice and has the potential to be a complementary tool for mental health professionals. Nature-based mindfulness approaches such as mindful walking and meditation in natural environments have been shown to significantly reduce anxiety and sadness. Ecotherapy appears to be a potential method for seeking solace in nature despite the pressures of contemporary existence. By embracing the healing potential of nature, individuals can revitalise their spirits, enhance their emotional well-being and reconnect with the age-old knowledge that lies in the vast beauty of natural life (Ünsal and Korkmaz, 2023). Natural areas, which ecopsychology and ecotherapy studies show as spaces that enable the re-establishment of the human-nature relationship, and urban green spaces are important because they contain natural elements within the city. The qualities of these spaces can contribute to urban design processes in terms of shaping the relationship between humans and their environment (Kara and Oruç, 2020).

Many scientific studies have proven that people who connect with nature have more positive mental, cognitive and physical health characteristics than other individuals. The most important of these is biophilic design (Kellert , Calabrese 2015; Onur, 2023)

In fact, it is an approach that aims to improve physical, mental and emotional health through interaction with nature. This therapy method may include methods such as forest therapy, gardening therapy, nature walks, connection with wildlife, meditation and mindfulness. Global climate change has profound effects on human psychology and emotional state, as well as environmental challenges. Rising temperatures, natural disasters and the degradation of ecosystems are creating new types of stress factors in individuals such as eco-anxiety and environmental mourning. In this context, ecotherapy has become an important method for both helping people reconnect with nature and reducing the psychological effects of climate change. Ecotherapy can increase environmental awareness and support sustainable living behaviors by enabling individuals to establish a deeper connection with nature. In addition, the positive effects of spending time in natural areas on mental health can make a useful contribution to alleviating the stress caused by climate change. There are various centers and programs around the world that offer ecotherapy.

- *Japan - Shinrin-Yoku*

Japan has developed one of the best-known forms of ecotherapy, Shinrin-yoku, which aims to reduce stress and strengthen the immune system by spending time consciously in the forest.

There is increasing interest in incorporating Nature Therapies into multidisciplinary treatment approaches for complex conditions such as depression. Shinrin-Yoku (Forest Bathing), which is based on spending time in forested areas and focusing on various sensory stimuli, stands out as one of these methods. (Doran-Sherlock et. al. 2023)

Figure 1. Japan - Shinrin-Yoku (URL-1)

- *Sweden - Friluftsliv*

In Sweden, a philosophy of outdoor living called "Friluftsliv" encourages people to connect more deeply with nature. These therapies include camping, hiking and practicing mindfulness.

Figure 2. Sweden – Friluftsliv (URL-2)

- *United States - Wilderness Therapy Programs*

Wilderness therapy programs for teens and adults are common in the United States. Participants tap into the healing power of nature through camping, hiking, and group therapy.

- *Switzerland - Alpine Therapy*

Ecotherapy is applied in Switzerland with activities such as hiking in the mountains, yoga and meditation. These methods are especially aimed at mental relaxation and stress management.

The peaceful atmosphere and fascinating beauties of nature play a fundamental role in the healing effect of ecotherapy. Moments spent in nature strengthen individuals' feelings of wonder and humility, helping them gain perspective and get away from their daily worries (Kaplan & Berman, 2010). Landscape design approaches are among the important components of this process (Gülpınar Sekban, Acar 2021a; Gülpınar Sekban, Acar 2023) (Figure 3).

Figure 3. Adler Lodge Retreats (URL-2)

- *Horticultural Therapy*

The Horticultural Therapy Garden is defined through elements such as the design of the outdoor environment, the adaptation of gardening tools, cultivation methods, and plant materials. This therapy program is outlined with objectives including mental recovery, recreation, social interaction, sensory stimulation, cognitive restructuring, and the training of sensory-motor functions. Additionally, the development of pre-vocational skills and the teaching of ergonomic body positions are considered key components of the program (Söderback et., al. 2004) (Figure 4).

Figure 4. Horticultural Therapy (URL 3).

3. Therapeutic landscaping

The concept of landscape is defined in its most current form in the European Landscape Convention as ‘an area whose characteristics are formed as perceived by humans as a result of the interaction and action of human and/or natural factors’ (Uzun, 2018). As it is understood from here, the fact that the landscape is shaped by the mutual interaction of human and natural elements and that this concept is evaluated as a whole emerges. The relations between human and nature are complex and have different characters. However, it is known for certain that the natural environment, which concerns people so much, has positive effects on the health and psychology of individuals. Since nature is also associated with the spiritual dimension of people, people can benefit from nature in different ways (Pouya et. al., 2015). At this point, it is possible to talk about the concept of therapeutic landscape.

Therapeutic landscape is referred to as the relationship between people and nature and the well-being of individuals after these relationships, the reduction of stress, and the concept of healing gardens dominated by natural elements. Şengür and Kepez (2023) stated in their study that the concept of ‘Therapeutic Landscape’ was first introduced by William Gesler in 1992. Although the concepts of therapeutic landscape and healing gardens are often used interchangeably, it is said that there are slight differences between them. In healing gardens, physical healing and spiritual psychological healing are provided, while in therapeutic gardens, people who are not sick spend time in therapeutic gardens and take a break from the fast cycle of the city (Şengür and Kepez, 2023). It can be said that the post-World War II period has passed into a period of greater reliance on treatment methods and technology, moving away from nature with the acceleration of industry. In recent years, this trend has reversed. There are many literature reviews showing the benefits of contact with nature on human mental and physical health (Pirli, 2020).

The belief in the therapeutic value of plants and gardens has continued into the modern times of medical treatment institutions and various support organisations serving individuals. The pioneer of horticultural therapy in medical institutions was psychiatrist F. C. Menninger, who founded the Menninger Foundation in Kansas in 1919. This psychiatric institution approved the healing properties of nature and implemented horticultural therapy programmes for patients. Today, therapeutic practices related to horticulture are included in horticultural therapy and can have a rehabilitative function in individual and group intervention processes (Barut and Kara, 2019).

Gardens and healing gardens

Throughout the ages, gardens have been a kind of shelter where people can be together with the beings of nature, where they can be relieved from the troubles caused by the ordinaryness of their daily lives. On the other hand, in the holy books and religious teachings, the place where people will be rewarded and where they will spend their second lives is generally defined as "heaven", an extremely attractive garden. In this context, the ideals of people to have a small "Paradise Place" in their lives on earth have introduced us to this branch of art (Kartal, 2009). Gardening has been a concept that all societies have given importance to since the existence of people. Gardens are designs that surround architectural structures, embrace and define them as an aesthetic and functional outdoor space, undergoing major changes in the process, and emerge as a structural and vegetal composition in every era. Gardens are human products that respond to human desires and needs based on natural foundations and generally have a limited environment (Ekşioğlu, 2001). They are places where fruits, vegetables, flowers, ornamental plants and medicinal herbs are grown and the beauty of nature is created by human hands (Kuş Şahin and Erol, 2009).

Healing garden

The healing effect of gardens is proven by manuscripts from the period. It is seen that human beings have always been intertwined with nature throughout history. It is known that the Chinese built healing temples so that their gods could help the sick, and that people later came to these temples to worship, stay as guests, revive and recover. The definition of heaven as a garden in Christian, Jewish and Islamic religions, the deep respect for trees in the Buddhist faith or the respect of atheists for the power of nature show that people's religious choices are a way to communicate with nature. The role and function of gardens in human history have varied since the past. While culture established the values of that region, the values created the architectural form of the period (Keçecioğlu, 2014).

When looking at prehistoric paintings, miniatures, reliefs and frescoes, information about gardens has been obtained. As the gardens of the first ages, Egyptian and Mesopotamian, Iranian, Greek and Roman gardens left their mark on the period. In addition to the understanding of intervention in nature that changed according to the periods and nations, the source of the purpose of arrangement was basically religious beliefs since the early ages. It has been determined that in 4000-5000 BC, there were houses with large gardens with regular roads in Egypt and that dates, figs, pomegranates, lemon palms, maples and acacias were grown in these gardens. Mostly, there were pools in the middle or at both ends of all gardens, and in addition to irrigation purposes, they were used for bathing, boating, and raising fish and ducks. Later, garden culture became widespread with the Medieval and Islamic Gardens (Ekşioğlu, 2001) (Figure 5).

Figure 5. Pictorial representation of ancient gardens (rectangular fish pond with ducks and lotuses, surrounded by palm trees and fruit trees, in a fresco from the Tomb of Nebamun at Thebes, 18th dynasty) (URL 4, 2024)

Today, it is observed that the knowledge and awareness of how a good design can affect people's quality of life is increasing among design disciplines. Especially in Landscape Architecture studies, designs for people's physical and mental health have begun to come to the fore, and as in the past, the healing feature of gardens has been brought to the agenda. In this context, the concept of healing (therapy) gardens has gained importance and many projects have been put forward for the design of healing gardens.

In general, healing gardens are an important type of garden where occupational therapy applications are carried out, have a high level of spatial organization and living comfort, contain functional and aesthetic landscaping, have active and passive use areas, provide people with social, cultural and physical comfort, and reduce the intense stress and pressure experienced by many patient groups, especially psychological patients (Akpınar Külekçi and Sezen, 2020).

As a part of nature, gardens have become spaces specially designed by people for the purpose of finding health. In particular, it has been determined that natural environments and designed spaces play an important role in accelerating the healing process. Healing gardens are designed spaces that emerged as a result of these developments. Healing gardens can be defined as gardens designed to strengthen patients with physical or psychological problems physically, mentally and spiritually and to reduce the pain, suffering and stress they experience (Arslan and Ekren, 2017).

Healing gardens are open areas where passive or semi-passive activities are carried out, which provide effects such as physical relaxation, stress reduction, increasing the sense of well-being, refreshing their memories, increasing their physical mobility and motivation (Sakıcı and Var, 2014). These gardens, also called open area therapy units, provide the concept of peace and healing by communicating with people through the five senses (Figure 6).

Figure 6. Healing gardens (URL 5, 2024)

CONCLUSIONS AND RECOMMENDATIONS

Although people have used nature for different purposes since their existence, it is known that they are especially in search of health in nature. Especially when they experience sad things, when they want to feel better, they tend to leave themselves to nature for healing, resting and protection. In this direction, it shows that being together with nature has positive effects on human psychology, they can benefit from nature in different ways and whenever they want, and nature acts as a balancing organ in people's lives. The healing power of natural effects such as fresh air, sunlight, plants and exercise have helped reduce stress levels by activating the senses. Ecotherapy and therapeutic landscape recognizes the deep connection between humans and the nature. In this study, the concepts of ecotherapy, therapeutic landscape and the healing feature of gardens are emphasized within the scope of landscape design discipline. It has been concluded that gardens, which are one of the basic elements of landscape design, are important activity areas that appeal to people's feelings and emotions. In the light of all these studies, we can list our suggestions as follows;

• Quality landscape areas should be designed to benefit from the healing power of nature.

• Existing green areas in urban areas should be developed.

• Gardens of public institutions and organizations should be designed to benefit from the healing properties of nature.

• Care should be taken to ensure that the elements used in therapeutic landscape studies are natural, and structural and plant materials should be in harmony.

• Water elements should be included in urban spaces.

• Holistic approaches involving architects, interior designers, landscape architects, city and regional planners, psychologists, psychiatrists, therapists, etc. experts should be adopted in the design of urban spaces.

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CHAPTER 15

Landscape Character Types Determination on A National Scale

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1.Introductıon

Landscape character assessment is the identification of landscape character areas and types through systematic analysis of natural and cultural landscape features. Landscape character assessment, aims to support the development of spatial planning objectives specific to the particular needs of character areas and types. It is also recognized as a tool that contributes to environmental protection and rational use of resources to achieve sustainable development goals. (Kim & Pauleit, 2007).

The definition and classification of landscapes, is important for the creation of sustainable landscapes. For this reason, a good definition of landscapes and ecological land classification are important in the creation of sustainable landscapes. (Uzun, 2003). Vize district of Kırklareli province, which is under pressure due to intensive land use in Thrace, was selected as the study area. The sustainability of landscape areas depends not only on the current use type but also on the type of use of other areas around it. Ecological factors should be taken into account in determining the types of use. Plans prepared at different scales may be incompatible with each other at the stages of making land use decisions. As a result, the characteristics of areas at different levels such as regions, provinces, villages and neighborhoods may adversely affect the sustainability of the areas if a holistic approach is not provided at the planning stage. When Vize district, which was selected as the study area, is examined, it is seen that there are a wide variety of land use types. In the study; it was aimed to determine the rural and urban landscape character types of Vize District and to evaluate the current situation. At the same time, it is also aimed to process the data and to create the data of the areas in the following stages for the Landscape Atlas to be created throughout the country by combining the areas in the following process. Thus, the “European Landscape Convention”, will contribute to the objectives of planning, conservation and management of European landscapes within its scope. (APS, 2000, Atik ve ark., 2016; Atik ve ark., 2017).

In the study; it was aimed to determine the rural and urban landscape character types of Vize District and to evaluate the current situation. The landscape character types to be created in the context of the Vize district, which is selected as an example within the scope of Determination of Landscape Types in the Thrace Region, will form the basis for the landscape atlas.

2. Research Area

The study area is approximately 1036 km² and is located in Vize district of Kırklareli province in the Thrace part of the Marmara Region. It is located between 41 degrees 36 minutes, 52 seconds (41.6143) north latitude and 27 degrees 50 minutes, 52 seconds (27.8478) east longitude. Vize is located at the southern foot of the Yıldız (Istıranca) Mountains, in an important basin connecting Anatolia to the Balkans and Europe. The district is surrounded by the Black Sea in the east, Tekirdağ province in the south, Lüleburgaz in the southwest, Pınarhisar in the west and Demirköy in the north. (Şekil 1) (Anonim, 2020a).

The primary material of the study consists of literature from written domestic and foreign sources such as publications, research projects and theses etc. on the concepts related to the subject and verbal data obtained from interviews with experts and academics.

The secondary material of the study consists of raw data obtained from relevant institutions and organizations regarding the natural characteristics (topographic structure, climate structure, soil structure, geological structure, flora and fauna) and cultural characteristics (historical development, demographic structure, socio-economic structure, accessibility, historical and cultural texture) of Vize district of Kırklareli province and raw dataobtained from relevant institutions; 1/100.000 and 1/25.000 scale environmental plans, observations made in the field, field studies.

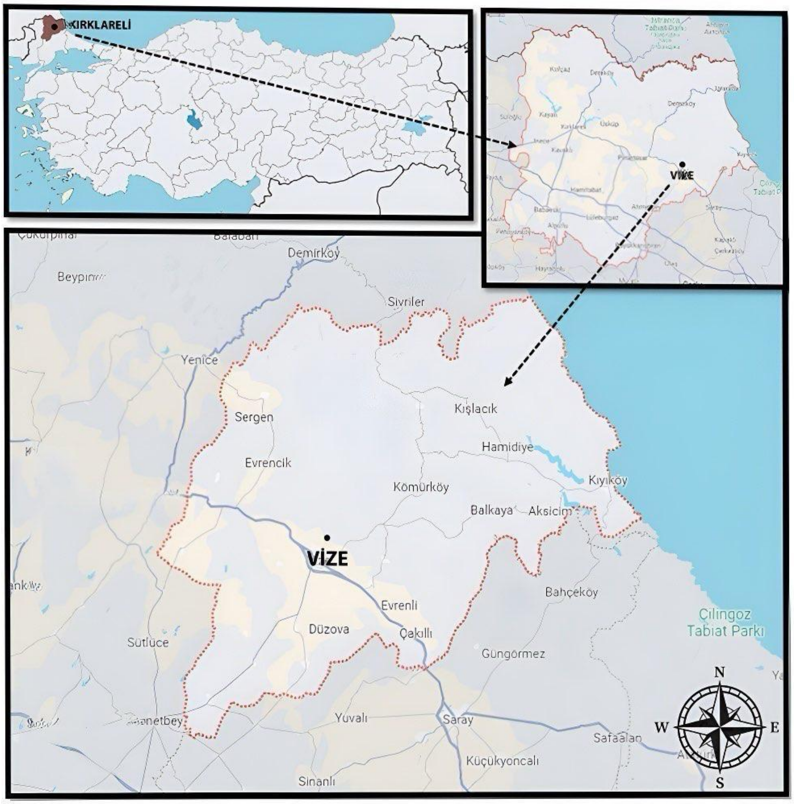


Figure 1. Location of the research area

3. **Method**

The research method consists of 4 stages: data collection, preparation of data sets, data analysis, and development of conclusions and recommendations.

The data were digitized using ArcMAP software and national (Table 1) level datasets were prepared for the types of landscape characters. The national level datasets and landscape character analysis maps prepared are given in the findings. National level maps of landscape inventories prepared in 1/25.000 scale detail were overlaid and classified, and landscape character types were defined according to the formulas below:

Landscape character type at national level

Climate + Geomorphography + Geology + Landscape Pattern

With the help of the codes given according to the classes in Table 1; landscape character types were determined at national level. For example, the landscape type defined as "B1.P.KST.DP" at the national level is plateaus with a humid climate, chemical sediments sedimentary rock structure and agricultural landscape pattern. (Şahin ve ark., 2014).

Table 1. Climate, geomorphography, geology, geology, landscape pattern codes and classes at national level (Şahin et al., 2014).

Climate	**B1.** Humid **B2.** Humid **B3.** Humid **B4.** Humid **C1.** Semi-arid Less Humid **C2.** Semi Humid
Geomorphography	**E.** Sloping Land **OT.** Lowland and Bottom Land **P.** Plateaus
Geology	**KST.** Chemical Sedimentary Sediments **MAG.** Igneous Rocks **MET.** Metamorphic Rocks **PKT.** Plio Quaternary Sediments **ST.** Sedimentary Sediments
Landscape Pattern	**YP.** Settlement Landscape **TP.** Agricultural Landscape **D.** Natural and Semi-Natural Landscaping **SY.** Water surfaces

4. Findings

Landscape Character Types and Analysis at National Level

In the study area, 70.87% of the meso and 29.13% of the meso and micro climate types are meso climate type and micro climate type, respectively. The areas with meso climate type were calculated as 73,445.12 ha and the areas with micro climate type as 30,194.16 ha. (Figure 2).

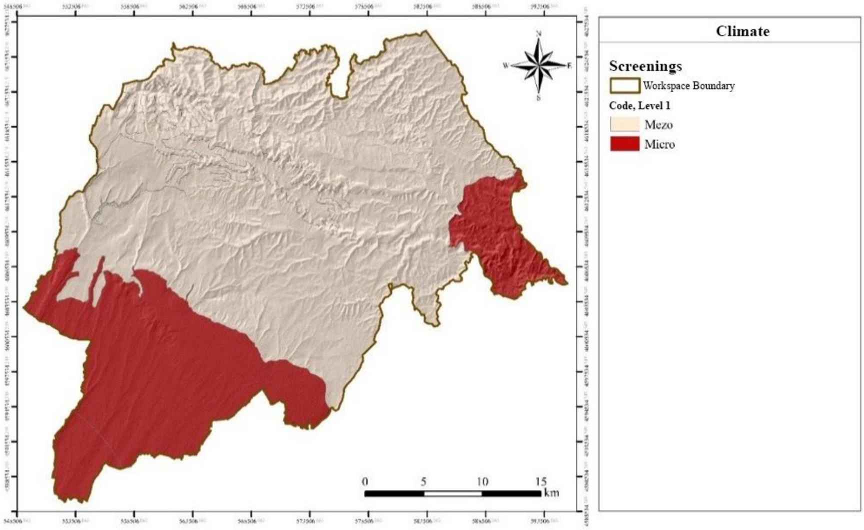
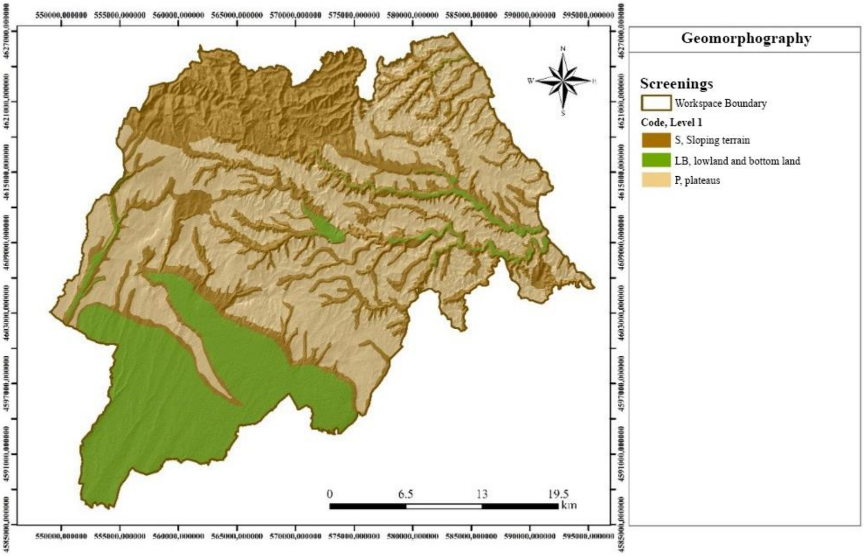


Figure 2. National level climate map of the research area

The national level geomorphography map of the study area is given in Figure 3. In the study area, 42.12% of the area is plateaus, 35.64% is sloping land, 22.23% is lowland and grassland. Plateaus were calculated as 43,658.89 ha, sloping land as 36,943.49 ha and lowland and grassland as 23,046.07 ha.

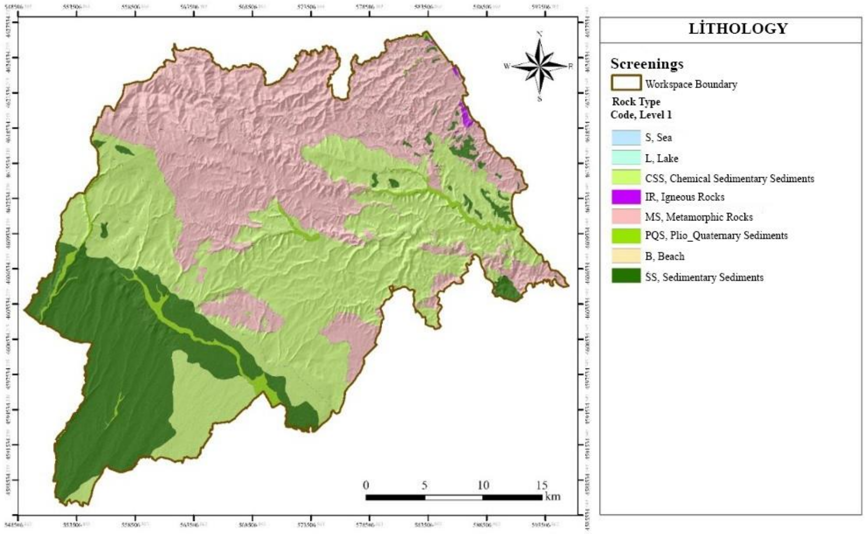
The national level geology (rock type) map of the study area is given in Figure 4. When the lithological structure of the study area is examined, 39.88% chemical sedimentary sediments, 37.60% metamorphic rocks, 20.13% sedimentary sediments, 2.04% plio *quaternary sediments, 0.17% igneous rock types are observed.*

Figure 3. National level geomorphography map of the research area



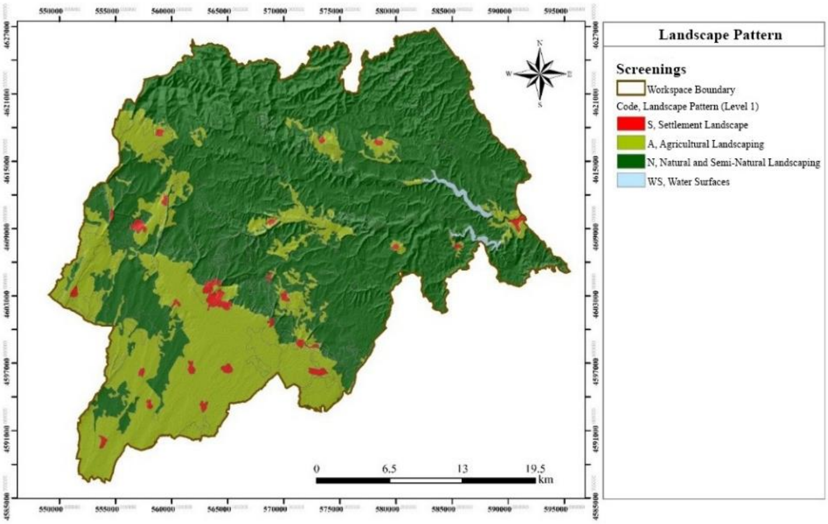
The national level geology (rock type) map of the study area is given in Figure 4. When the lithological structure of the study area is examined, 39.88% chemical sedimentary sediments, 37.60% metamorphic rocks, 20.13% sedimentary sediments, 2.04% plio quaternary sediments, 0.17% igneous rock types are observed.

Figure 4. National level geology (rock type) map of the study area



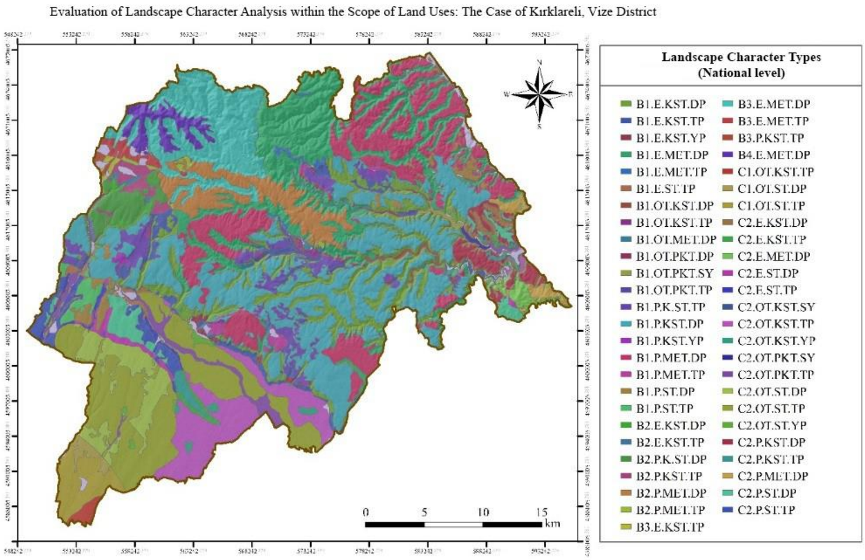
The national level landscape pattern map of the study area is given in Figure 5. When the landscape pattern of the study area is analyzed; 69.54% natural and semi-natural landscape pattern, 28.57% agricultural landscape, 1.35% settlement landscape and 0.54% water surfaces are observed. In the study area, the areas with natural and semi-natural landscape pattern were calculated as 72,068.93 ha and the areas with agricultural landscape pattern as 29,613.28 ha. (Figure 5).

Figure 5. National level landscape pattern map of the research area



The landscape character type map of the research area at national level is given in Figure 6. 51 landscape types were defined at national level in the research. The landscape character type with the largest surface area (163,03 km²) in the area is "B1.P.KST.DP", which is characterized by humid climate, chemical sedimentary sedimentary rock structure, agricultural landscape pattern and plateaus. This landscape type is located in the center and northwest regions of the study area (Figure 6). Of the study area; 369,43 km² is composed of sloping lands, 230,46 km² is composed of lowland and bottom lands and the remaining 436,58 km² is composed of plateaus. Plains are located in the southwest and south of the area, while plateaus are located in the center and north of the area. "B1.E.MET.DP" landscape character type with an area of 125,04 km², 'B1.P.MET.DP' character type with an area of 106,81 km², 'C2.OT.ST.TP' character type with an area of 93,76 km², 'B1.E.K.ST.DP' character type with an area of 74,25 km² were identified in the area.

Figure 6. National level landscape character type map of the research area



5. Discussion / Conclusion

In this study, landscape character types were determined by analyzing the current situation of natural and cultural landscapes and preparing digital maps by using geographical information systems. Thus, data for the determination of landscape character areas were created.

When the plans made in the region until today are examined; according to the decisions of the 1/100.000 scale Thrace Subregion Ergene Basin Environmental Plan Revision, sports, agro-eco and nature tourism areas will be developed in Demirköy and Vize districts of Kırklareli Province and İğneada- Kıyıköy towns are planned as “eco-tourism” towns (Anonymous, 2011). These uses are considered appropriate for the protection of the identified national landscape types. In Vize District; Ancient Bizye Amphitheater and other archaeological remains will be evaluated as an area for developing archaeological tourism (Anonymous, 2009- 2011).

According to the Plan Explanation Report of the Amendment to the Thrace Subregion Ergene Basin 1/100.000 Scale Revision Environmental Plan and the Plan Explanation Report of the Amendment to the 1/25.000 Scale Environmental Plan of Kırklareli Province, the area located in Çakıllı Town, Vize District, Kırklareli Province, which was declared as a Reserve Building Area by the Ministry on 25.03.2020, has been regulated as an “Urban Service Area” in the

“Thrace Subregion Ergene Basin 1/100.000 Scale Revision Environmental Plan” (Anonymous, 2021).

The classification and mapping of the landscape is carried out to provide a basis for spatial planning studies (Hepcan Coşkun et al., 2015). For this reason, it is of great importance to determine landscape character types and areas by mapping. Although there are many studies on this subject, there is not enough research. Akbana (2018) determined 229 landscape character types in Uluabat Lake and its surroundings. Erdoğan (2014) identified 854 landscape character types in 135 Şavşat district of Artvin province and Atik et al (2015) identified 22 landscape character types in Side district of Antalya province as a result of their study.

This study covers the part of the research “Evaluation of Landscape Character Analysis within the Scope of Land Uses: Kırklareli Province, Vize District” research on the definition of landscape types at national scale. Vize district was evaluated in terms of the definition of landscape types on a national scale. This study aims to define landscape character types on a national scale in the slow city Vize district for the definition of landscapes (Anonymous, 2020b) In line with this purpose, as a result of the evaluations made in the research; 51 landscape character types were defined on a national scale. The largest area of the 51 landscape types identified at the national level is 163,03 km² and the land use character type is plateaus in agricultural landscape pattern. This landscape type is located in the center and northwest regions of the study area. 369,43 km² of the study area consists of sloping lands, 230,46 km² of the study area consists of lowland and bottom lands and the remaining 436,58 km² of the study area consists of plateaus. Plains are located in the southwest and south of the area, while plateaus are located in the center and north of the area. As a result, there are rich landscape types in the area.

There is a very intensive land use in the Thrace Region due to reasons such as agriculture, industrialization and rapid population growth. As a result of this misuse of land, natural and cultural resources in the region are rapidly being damaged. Areas with natural features that are under pressure for the future of the region are even more important. In the 'Anonymous, 2021' reports, it is revealed that the research area is one of the important areas. In the slow city Vize district, it is necessary to make lower and upper scale planning according to national landscape types for sustainable planning and to make necessary changes in the plans according to these landscape types.

The study revealed that landscape character analysis studies should be encouraged in the Thrace Region to ensure national planning, conservation and management of landscapes. It is also suggested that different professional disciplines should work together to determine landscape character in landscape planning studies (Yılmaz and others, 2022).

ACKNOWLEDGEMENTS

This book chapter was produced from a part of the research project numbered NKUBAP.08. DRGA.20.254 supported by Tekirdağ Namık Kemal University Scientific Research Projects Coordination Unit (NKÜBAP).

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CHAPTER 16

Current Problems in Building Economy

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Introduction

Construction economics covers the economic dynamics, financial management, pricing strategies, and cost analyses of the const-ruction industry. The construction sector plays an important role in the growth and development of economies. It operates in a wide range of industries, from infrastructure projects to residential construction, from industrial facilities to commercial buildings, which has a major impact on the economic value of construction. The construction sector is not only provides employment but also stimulates economic growth (Myers, 2022). Within this scope, the sector's contribution to the economy should be considered together with its relationship with other economic factors.

Economic recessions are among the factors that can directly affect the activities of the construction sector. Global financial crises may increase labor costs, cause demand contraction, and make it difficult to finance construction projects. This implies that cost calculations and pricing tactics in the sector request to be reconsidered. Ruegg and Marshall (2013), while discussing the impacts of economic fluctuations on the construction industry, point out that cost management and flexibility strategies should be developed in order for stakeholders in the industry to be more resilient to such crises. From this perspective, the resilience of the construction sector against economic fluctuations is directly proportional to the cost optimization strategies and risk management of the stakeholders in the sector.

It is also important to examine the role of government policies and regulations in the development of these strategies. Economic stability is a crucial factor for the construction industry to achieve sustainable growth (Bon & Hutchinson, 2000). Government policies and regulations play a fundamental role in regulating the construction sector. Public policies can guide the timing and implementation of projects in the construction industry, affecting costs and pricing. In addition to the impact of government policies, how global economic dynamics shape the industry also needs to be evaluated. New regulations such as sustainability targets and environmentally friendly construction standards may also change the way of doing business in the sector and require innovative solutions. Hillebrandt (2000) elaborates on the impact of economic theories and government regulation on the construction industry on long-term strategies and sustainable development in the sector. In addition, the applicability of cost calculations and optimisation strategies are directly related to these regulations. The global economy has a direct impact on the construction industry. Factors such as difficulties in material procurement increased international trade, and fluctuations in exchange rates can affect the costs and financing of projects. The fragility of global supply chains and changing economic conditions pose a major challenge for the successful completion of construction projects (Ruegg & Marshall, 2013). At this point, it is important to understand how the industry is shaping up in response to the challenges that pricing strategies face.

Cost calculations and optimization are critical to the success of construction projects. High costs can lead to longer project times and lower profit margins. Myers (2022) states that ensuring cost optimization from the beginning to the end of construction projects helps increase the financial sustainability of projects. In this context, it is also necessary to examine how pricing strategies differ according to customer demands and market segmentation in the sector. Therefore, advanced techniques must be used to ensure cost control and optimization in the construction industry. Pricing strategies are critically important in ensuring the economic success of construction projects by balancing cost and profit targets determined by market conditions (Bon & Hutchinson, 2000). In summary, how risk management strategies and project financing support economic sustainability in the construction industry is also an important issue.

Taking market segmentation and customer preferences into account are other important factors for tailoring construction projects to the target audience. A proper understanding of consumer demands and expectations is necessary for projects to be competitive in the market and for investors to make better decisions. (Myers, 2022). In this context, market segmentation and customer preferences play an important role in determining strategic decisions in the sector, along with risk management and project financing.

Risk management and project finance come to the forefront to ensure the sustainability of construction projects. Effective utilisation of financing resources is essential to ensure the successful completion of projects. In addition, the uncertainties and risks encountered in project management require proper financial planning. Hillebrandt (2000) states that managing risks and financial uncertainties in the construction industry is a factor that directly affects the success of projects. Therefore, the development of risk management strategies is one of the most important measures against the challenges faced by the construction industry. In this context, how all these factors work together and influence each other has a significant impact on the overall economic sustainability of the construction sector.

As a result, the construction sector is affected by many factors such as economic developments, government policies, global economic fluctuations and financial management. This article aims to examine how the dynamics in the sector are shaped and how solutions can be found to the challenges faced by addressing current issues in construction economics.

Role of the Construction Sector in the Economy

The construction sector is the field of activity in which all kinds of building construction such as schools, factories, workplaces, hospitals, especially housing, all kinds of infrastructure activities such as road, bridge, dam construction and all structural and equipment works such as electricity, water, plumbing, heating, air conditioning are carried out. This sector is known to have a positive impact on national economies by stimulating economic growth through the demand for goods and services produced directly or indirectly by the related sub-sectors.

The construction sector is one of the main sectors that directly contributes to GDP. The share of the sector in total GDP is an important indicator of its contribution to economic development, especially in developing countries. Empirical studies reveal that this share typically ranges between 3% and 5% for developing countries and between 5% and 8% for more developed countries (Giang & Sui Pheng, 2011) and is strongly linearly correlated with GDP per capita (Saka & Adegbembo T. F, 2022). As economies progress through different stages of development, the share of construction in GDP increases initially, peaks and declines in more mature economies (Lopes et al., 2002; Gi-ang & Sui Pheng, 2011). Lopes et al. (2002) pointed out that there is a critical level of construction value added (CVA) as a percentage of GDP in developing countries. This critical threshold was found to be between 4% and 5%. Below this threshold, a relative decline in construction volume corresponds directly to a decline in GDP per capita growth. In contrast, above this band, sustained or increasing growth in GDP per capita is not necessarily associated with a relative increase in construction volume. (Saka & Adegbembo T. F, 2022).

In developing countries, investments in infrastructure projects both support economic growth and accelerate the growth of the construction sector. International organisations such as the World Bank and the Asian Development Bank encourage such investments through low-cost financing options. Growth in the construction sector is closely related to the overall economic development of the country. However, it is inevitable that the sector will face economic fluctuations in accordance with the inverted U-shaped development model. Therefore, strategies such as promoting infrastructure investments, adopting technological innovations, supporting sustainable policies and increasing global co-operation are important tools to ensure stable growth in the sector. Countries can secure the future sustainability of the sector by adapting these methods to their own economic and social conditions.

Global Economy and the Construction Sector

The prosperity of a country is possible only if all sectors stabilise the economy. The construction sector, which is one of these sectors, is of primary importance for the citizens of the country, affecting welfare, health and quality of life (Alaloul, et al, 2021). The construction sector, which contributes greatly to the economies of not only countries but also supply chains and worldwide economies by creating employment and income, has a hybrid structure that includes the use of both manufactured goods and basic resources such as raw materials and energy (Shishehgarkhaneh, et al, 2024).

A supply chain is a network of firms and organisations involved in processes and activities that create value in products and services for consumers. It is designed to maximise value for all members, from suppliers to customers, through material, information and financial flows (Noche & Elhasia, 2013). Global supply chains are riskier than local ones due to the large number of links connecting companies and are susceptible to disruptions, bankruptcies, failures, macroeconomic and political changes, and disasters. These risks can have a significant, albeit rare, impact on the performance of a global supply chain (Pham et al., 2023). Commodity prices are interdependent due to substitution and supply-demand relationships. A small change in a commodity can trigger a chain reaction in the supply chain system known as price fluctuations. This principle is particularly relevant in the construction industry, where different commodities and materials can transmit price fluctuations. Understanding the price transmission between these commodities is crucial for better control and market regulation. Identifying key price indices and the transmission path of price changes helps to design effective policies to manage price volatility and support vulnerable producers and consumers. Investigating the price transmission path between different commodities and materials provides a better understanding of price transmission mechanisms (Abdul Nabi et al., 2024).

Iron and steel are key products of the construction sector, which drives global economic development and provides key inputs for industrial companies. However, constant price fluctuations negatively affect countries and companies due to high cost levels (Akinci et al., 2023). The global steel industry is heavily dependent on maritime transport, which creates uncertainty and potential risks for the economy. To ensure stable supply and safe transport of iron ore, countries that are heavily dependent on imports should avoid trading with individual countries, establish a reserve mechanism, develop iron ore and steel futures markets, and use financial instruments to avoid price risks. Increased investment in external resources and technological innovation can stabilise supply sources (Song et al., 2019).

Cement, another key commodity of the construction industry, has significant capital and transport costs due to its low value-to-weight ratio. The efficiency and effectiveness of the supply chain has a direct impact on production and distribution costs and thus on cement prices. By integrating supply chain management (SCM) and reducing costs, cement supply chain processes can be optimised and thus influence prices by reducing costs (Noche & Elhasia, 2013). In the study by AssaadAbdul Nabi et al. (2024), materials with high price transmission capacity include fabricated metal products, construction sand, gravel, crushed stone and plastic construction products. Significant price changes can signal escalation in the supply chain. Concrete products and asphalt felts have high transmission capacity, suggesting that price increases may spread gradually through the construction materials network.

At the global level, a series of recent disasters and natural disasters, such as the Gujarat earthquake (2001), the Indian Ocean earthquake and tsunami (2004), the earthquake, tsunami and subsequent nuclear crisis in Japan (2011), the 9/11 terrorist attacks (2011), Hurricane Irma in the Atlantic (2017), strong economic forces changing the global trading environment, the US-China trade war, Brexit, etc., together with COVID-19, a pandemic that has recently emerged, are warnings that we are living in an unpredictable and increasingly volatile world (Pham et al., 2023). Together with strong economic forces changing the global trading environment, the US-China trade war, Brexit, etc., especially COVID-19, a recent pandemic, are warnings that we are living in an unpredictable and increasingly unstable world (Pham et al, 2023). According to the study by Bukhari et al. (2024), the COVID-19 pandemic has caused problems such as supply chain disruptions, difficulties in material procurement, overpricing and material shortages, labour restrictions, restriction of workers' freedom of movement, labour shortages in projects, financing problems, delayed payments and liquidity problems, reallocation of government budgets, health and safety protocols, social distancing requirements, changes in construction site operations, suspension of construction activities, especially in developing countries. In addition, the lack of a legal framework for the suspension and termination of construction contracts (Al-Mhdawi, et all, 2024) has led especially underdeveloped and developing countries into a chaotic environment.

In conclusion, an integrated approach is essential to strengthen the role of the construction sector in the global economy. Strategic public spending, innovative financing models, technological adaptation and international co-operation will not only make the sector resilient to economic fluctuations but also ensure that it continues to be a key driver of global growth.

Economic Recessions and Construction Sector

Economic recession is a process that refers to a marked decline in a country's economic activity, usually characterised by an increase in unemployment rates, a reduction in consumption expenditure and a slowdown in investment activity. The construction sector is fully linked to the national economy of countries and any change in the economic output of countries can have a direct impact on the construction sector (Al-Tobi & Manchiryal, 2020). Due to its strong link to the overall economy, it is difficult for the construction industry to survive economic downturns. Economic expansion and contraction cycles have a direct impact on construction demand. Growth periods increase cash flow and construction activity, while downturns reduce investment (Tummalapudi et al., 2021). Therefore, firms in the sector must adapt significantly to changes in the economic climate (Al-Tobi & Manchiryal, 2020). Contractors should adopt effective strategies to sustain growth during these fluctuations (Tummalapudi et al., 2021).

The global construction industry, especially in infrastructure, involves a complex network of contractors, technicians, craftsmen, labourers, industrialists and suppliers. These projects rely on advanced technology and often face unforeseen challenges that can change strategic objectives or material needs (Mahdi & Muhsin, 2024). The construction industry is particularly vulnerable to recessions due to high costs, competition and the project-based nature of the business. This can lead to project failures that affect profits and cash flow (Tummalapudi et al., 2021). Financial crises that halt projects, such as in Iraq, underline the complex and interdependent nature of the sector and its vulnerability to economic factors (Mahdi & Muhsin, 2024).

Construction sector starts to grow again in the recovery periods of countries after economic recession. Infrastructure projects, housing-road-bridge-tunnel etc. constructions increase economic activity and allow employment to recover. Therefore, it is important for governments to develop policies that support the construction sector during recession periods.

During the twentieth and twenty-first centuries, the countries of the world have been subjected to many economic recessions. The most recent one started in the United States of America in mid-2008 and later affected the rest of the economic world. Another economic recession was experienced in 2014. The financial recession in the US was reflected in most of the world economies and was called the global financial recession (Al-Tobi & Manchiryal, 2020). In this context, Mahdi & Muhsin (2024) defined a financial crisis as an imbalance between factors of production and consumption that leads to a deterioration in measures of economic balance in the region or group of regions affected by the crisis due to disruptions or problems in various systems. The crisis is caused by a total or partial imbalance in the economic sector, such as a significant fall in the price of the country's national currency against international and foreign currencies.

Mohammed (2021) argues that to effectively manage crises in the construction industry, construction companies should implement a crisis management system with robust procedures to control costs and risks. It is critical to record information and lessons learnt during the crisis. Companies can minimise losses by taking note of past mistakes, limiting expenditure and centralising management. Organisations need to take proactive and reactive measures to identify, plan, manage and resolve crises. They should explore new strategies for dealing with uncertainty and create a dedicated crisis team.

One of the methods used to support and revitalise the construction sector in times of economic recession around the world is investments in public infrastructure projects. Public spending on the construction of roads, bridges, hospitals and schools not only supports the sector, but also creates broad economic impacts and increases employment. Governments can also offer tax breaks and low-interest loan programmes to encourage private sector investment. Incentive packages for construction projects enable sector players to continue their investments even in times of recession. In addition, public-private partnership models are an effective way to finance large-scale projects and ensure their continuity in times of economic recession.

As a result, a combination of strategies such as public expenditures, incentive policies, urban regeneration projects and innovation should be used to reduce the effects of economic recessions on the construction sector and revitalise the sector. These methods can contribute to sustainable growth at both sectoral and macroeconomic levels by adapting them to the economic conditions of countries.

Government Policies and Regulations

Governments are under increasing pressure to transform poor areas into areas with adequate services, amenities, transport and infrastructure, and to address the social inequalities associated with poor neighbourhoods. In the process of seeking sustainable urban development for these areas, urban renewal policies have been identified as key strategies (Liu et al., 2017). As discussed by Ye et al. (2021), urban regeneration focuses on improving the physical, social, economic and environmental aspects of cities through actions such as redevelopment, rehabilitation and heritage conservation. Urban regeneration can be seen as an important priority to address the problem of urban decay by promoting land values and developing innovative industries as well as socio-economic development. Many countries have successfully implemented policies to facilitate the urban regeneration process. However, as urban regeneration involves multiple stakeholders, complex processes and unpredictable risks, each country has its own specific circumstances and unique economic and political contexts. As a result, urban regeneration policies in one country or region may not be appropriate in another country or region (Liu et al., 2017). The outcomes of urban regeneration projects are diverse and greatly influenced by the interactions between stakeholders and their willingness to co-operate. Effective urban regeneration requires innovative policies that encourage collaboration between governments, developers and communities while taking into account the complex dynamics of different actors in a changing environment (L. Ye et al., 2021). The complexities of urban regeneration policy, such as complex land use demands, protection of public interests and endemic social inequality, combined with a limited understanding of the policy itself, can slow down the development of the urban regeneration process. Therefore, a clearer understanding of the current situation and an assessment of mistakes and problems are needed (Liu et al., 2017). It is also important to prioritise the streamlining, consolidation and harmonisation of urban regeneration policies. This includes integrating the legal framework for urban regeneration activities into the overall urban planning system (Liu et al., 2017).

Fiscal incentives relate to monetary support such as property tax relief, grants and development fees. Structural incentives provide technical support such as marketing, technical assistance and expedited permits (Shazmin et al., 2016). Incentives can take various forms, such as direct or indirect, conditional or unconditional, explicit or implicit, in kind or in cash. Fiscal incentives are usually provided in the form of tax exemptions or deferrals. Tax incentives are the most common type of fiscal incentives in practice (Yılmaz & Yıldız, 2020). In their study on property tax incentives for green buildings, Shazmin et al. (2016) showed that fiscal incentives, especially property tax assessment incentives for green buildings, which have been widely adopted by many countries worldwide, including Spain, Romania, Italy, Bulgaria, the United States, Canada, Malaysia, and India, encourage the growth of green building practices at the local level. Fiscal incentives are used to develop economic activities in specific areas and to guide behaviour in this direction. Incentive policies also aim to reduce income and development differences between regions, increase employment, encourage investment, use advanced technologies and support economic stability and growth. Effective use of tax incentives in the right places and in the right amounts is of great importance in terms of achieving these objectives (Yılmaz & Yıldız, 2020).

Consequently, the harmonised development of government policies and regulations can lead to concrete steps towards solving the current problems in the construction economy. These approaches will make the sector more resilient and sustainable and will have positive effects on economic growth and social welfare. As a matter of fact, current problems in the construction economy necessitate the effective implementation of government policies and regulations. Issues such as fluctuating construction costs, financing difficulties, housing accessibility and environmental sustainability require a reassessment of the role of the construction sector in the economy. Firstly, the focus of government policies on strategic infrastructure projects can revitalise the sector during periods of economic recession. In this context, incentive packages and tax regulations are effective tools to attract investment in local construction projects and support sectoral growth. Simplification and transparency of regulations can increase the participation of both local and international entrepreneurs in the sector by reducing uncertainties in investment processes. Moreover, strengthening the legal framework for public-private partnership (PPP) projects plays an important role in the realisation of large-scale investments. Finally, governments' promotion of digital transformation in the construction sector can improve cost control and enable projects to be completed more efficiently. Making technologies such as BIM (Building Information Modelling) mandatory will contribute to the modernisation of the sector.

Cost Calculations and Optimisation

Money is always of special importance for those involved in construction projects. Therefore, the completion of any project within its estimated cost is the main criterion for the success of the project (Rahman et al., 2013). In many construction projects, project managers and contractors face challenges such as poor project planning, inadequate materials, labour shortages, increased material costs, delayed delivery, material wastage, budget overruns, unexpected weather changes, lack of management and control, material loss and poor communication. This leads to cost and time overruns and project conflicts. Therefore, it is necessary to examine the costs involved in projects and identify cost reduction or cost control techniques for the effective execution of construction projects (Mahadik, 2015). The success of any project largely depends on the adequate availability and effective management of various resources. Therefore, prior and adequate arrangements need to be made for the provision of construction related resources such as type and quantity of materials, manpower, machinery and finance at each stage of construction (Rahman et al., 2013).

Cost estimation is very important for construction contract award as it provides a basis for determining the likely cost of resource elements of the tender price for construction works (Akintoye, 2000). This is because among the most common reasons for resource management failure is that the importance of resource management is not properly recognised at the design and planning stage of a construction project, resulting in construction cost overruns. This results in the project having insufficient budget to fulfil its vital function (Rahman et al., 2013). Cost estimation is defined by Akintoye (2000) as the technical process or function undertaken to assess and estimate the total cost of executing an item(s) of work at a given time using all available project information and resources. The impact of inaccurate cost estimates on contracting work is significant. Overestimating costs can result in a high bid price being submitted by the contractor, which can make the bid unacceptable to the employer. On the other hand, underestimating costs can result in the contractor losing money on contracts awarded by clients.

According to Rahman et al. (2013), the construction industry is based on four types of factors: material, labor, money, and equipment. Money or finance is the first and foremost resource required for construction work, and proper financial management is essential for the completion of the project. Here, most decisions are based on economic criteria. Investments that are unlikely to be recovered with interest are not attractive. Economic decisions can be divided into two categories: Income growth is the goal of capitalism, and cost reduction is the basis of profitability (Suleiman & Nafea, 2021). Reducing construction costs is a constant goal for the construction industry. One way to reduce construction costs is to develop innovative technologies and methods that will increase efficiency, such as value engineering, material management, budget control, cost optimization techniques, and field cost reduction techniques. Through cost reduction techniques, the project cost is managed so that the contractor does not incur losses while carrying out various project activities (Mahadik, 2015).

Resource efficiency is the efficient use of energy, natural resources, and materials to produce products and services with reduced resource and environmental impacts. It is based on life cycle thinking and encompasses energy efficiency and material efficiency. While energy efficiency is about the economical use of energy, material efficiency is about the economical use of natural material resources, efficient management of by-products, waste reduction, and recycling (Ruuska & Häkkinen, 2014). Material efficiency means providing material services with less material production and processing. This definition can also be applied to building materials Tafazzoli (2016) states that efficient use of resources is fundamentally about making smart choices; smart choices involve choosing between alternatives. Therefore, efficient use of resources involves formulating, estimating, and evaluating economic consequences when alternatives are available to achieve a defined goal (Suleiman & Nafea, 2021). There are two main concerns regarding material consumption: the ability to meet market demand and the environmental impact of material production and processing (Tafazzoli, 2016). According to Ruuska & Häkkinen (2014), the building sector is one of the three key sectors where material efficiency needs to be improved. For example, in the European Union, better construction and use of buildings will affect 42% of final energy consumption, approximately 35% of our greenhouse gas emissions, and more than 50% of all extracted materials. It can also save up to 30% of water consumption. In general, material demand is expected to double in 40 years. Large increases in demand also bring large environmental impacts. One of the key factors in controlling the growth in material demand is controlling material waste. The construction sector is responsible for 35% of the world's solid waste (Tafazzoli, 2016). The production of materials can have a significant environmental impact. The extraction of raw materials and the production of materials can also be energy and/or labor intensive and very costly, and the extraction of materials can lead to changes in land use and related impacts (Ruuska & Häkkinen, 2014). Considering the large costs of extracting, processing, manufacturing and transporting materials to construction sites, material waste represents a large cost to the economy and harms the environment. Taking steps to minimize material waste in construction can help reduce the impact on non-renewable resources, energy, air pollution and ultimately global warming (Tafazzoli, 2016).

As a result, cost calculations and optimization-focused solutions ensure more efficient use of resources in the building economy. For example, it is important to conduct a life cycle cost analysis for cost optimization. This approach provides the most appropriate solutions by considering not only the construction process but also the maintenance and operating costs that will occur throughout the life of the building. In addition, sustainable material use and energy efficiency-focused designs provide both environmental and economic advantages. Similarly, innovative approaches can be adopted in project delivery methods. For example, the "Design-Build" model, where design and construction processes are managed in an integrated manner, provides time and cost savings. In addition, long-term supply agreements can be made against price fluctuations to reduce cost risks.

Conclusion and Recommendations

Construction economics is a multidimensional field of study that is shaped by both macroeconomic and microeconomic dynamics. In the context of macroeconomics, the contribution of the construction sector to the economic growth of a country, sectoral development processes and global market conditions are discussed; in the context of microeconomics, more specific elements such as project-based decision processes, cost management, pricing strategies and risk analysis are evaluated. The analyses conducted in this context reveal that the construction sector is not only an engine of economic development but also has a structure that is vulnerable to economic fluctuations.

At the macroeconomic level, the share of the construction sector in GDP varies between developed and developing countries, and these differences reflect the different needs and priorities of economic systems. While infrastructure projects and public investments are at the forefront in developing countries, sustainability and innovation become priorities in developed economies. In this context, public expenditures, infrastructure projects and incentive policies are of great importance to support the sector during economic recession periods. The state's contributions to the sector through regulations and policies play a critical role in ensuring economic stability. Models such as public-private partnerships, in particular, increase investments in the sector while also supporting macroeconomic growth.

In the context of the global economy, it is observed that the construction sector is directly affected by changes in international markets. Supply chain problems, fluctuations in material prices and the effects of economic crises require the sector to have a more integrated structure at the global level. Crises such as the pandemic period have further increased the importance of digitalization and innovative business models.

At the microeconomic level, issues such as cost calculations, optimization and risk management stand out as fundamental elements to ensure the sustainability of the sector. In project-based decision-making processes, approaches such as efficient use of resources and cost-benefit analyses directly affect the success of projects. In addition, analyzing customer demands and developing strategies for different income groups increase the marketing and sales performance of the construction sector.

In conclusion, construction economics is a complex and multidimensional field of study that needs to be addressed from a broad perspective, and suggestions that can be presented in this context can be listed as follows:

- Building a Bridge Between Macroeconomics and Microeconomics: While creating strategies for the construction economy, macroeconomic targets should be in harmony with microeconomic projects. For example, state incentive policies should be made applicable not only to large-scale infrastructure projects but also to small-scale innovative projects.
- International Collaborations: Encouraging international collaborations and partnerships to adapt to global supply chains and market conditions will provide a competitive advantage to the sector.
- Adoption of Technological Innovations: Building Information Modeling (BIM) and other digitalization tools need to be disseminated throughout the sector for both cost management and efficiency-enhancing processes..
- Increasing Risk Management Capacity: It is important to analyze the risks in construction projects and use tools such as insurance, financial hedging and long-term supply agreements against these risks..
- Sustainability and Green Growth: The use of sustainable materials and the promotion of energy efficient designs in the construction sector will make the sector more environmentally and economically resilient.
- Education and Human Resource Development: Training of human resources in the sector on topics such as cost management, project planning and sustainability will create positive effects at both macroeconomic and microeconomic levels.

In summary, for the sustainability and long-term success of the sector, it is critical to optimize both the macro dynamics that contribute to economic growth and micro processes such as project management. In this process, state policies, innovative approaches and international cooperation strategies will make the sector more resilient and competitive.

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CHAPTER 17

Re-Functionalisation of Immovable Cultural Heritage: The Case of Niğde City

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1. INTRODUCTION

Historical buildings, which help to establish a connection between the past, present and future (Kurak Açıcı & Konakoğlu, 2019), are documents and symbols that reflect the economic, social and cultural accumulation of societies and the urban and architectural style of the period in which they were built (Ahunbay, 2009). However, due to population growth and rapid urbanisation, many historical buildings are damaged and thus face the danger of extinction (Kurak Açıcı & Konakoğlu, 2019). For this reason, the concept of conservation comes to the agenda, especially in historical buildings. The foundations of conservation awareness were laid after the French Revolution in 1789, and the buildings destroyed during the revolution began to be repaired after 1830 (Ahunbay, 2009).

The main purpose of the conservation of historical buildings is to ensure that the original qualities of the building are preserved, and its value is preserved and transferred safely to the next generations (Örnek Özden, 2017). In the past, repairs were made to maintain the functionality of the buildings and to preserve their formal integrity by rebuilding the parts destroyed in natural disasters, fires and wars, while today, historical buildings can be repaired for conservation purposes because they are documents showing the cultural identity, social life and architectural techniques of society in a certain period (Ahunbay, 2009). The protection of historical buildings, which provide a cultural and historical reading of the history of the city by giving identity to cities (Bahar & Kurak Açıcı, 2021), means the protection of the identity of the city where it is located (Koçak & Can, 2018). Briefly, the main purpose of the conservation of historical buildings can be expressed as the safe transfer of the building to the next generations without deteriorating its original qualities and preserving its value (Örnek Özden, 2017; Yalçın & Kurak Açıcı, 2023).

One of the main problems in conservation work is the identification of buildings that need to be preserved. Original religious buildings, funerary monuments (pyramids, Seljuk tombs) and other functional buildings (coliseum, Roman baths) that have survived from the past are worthy of conservation as elements of the World architectural heritage. However, buildings of daily life, which are far from monumental and have purely functional purposes, are also considered as a component of the history of settlements and are evaluated within the scope of conservation studies (Ahunbay, 2022).

As historical and cultural heritage, the most preferred method of preserving historical buildings that connect the past and the future is the re-functionalisation of the building (Aydın & Şahin, 2018; Yalçın & Kurak Açıcı, 2023). Functional change is seen as a contemporary conservation approach in historical buildings (Ahunbay, 2009). In Turkey, the change of function in historical buildings was first started to be applied after the Tanzimat period. One of the first examples of change of function is Topkapı Palace, which was repaired in 1924 and started to be used as a museum (Uğursal, 2011; Gazi & Boduroğlu, 2015). When examined in terms of settlement history, Turkey is home to cities that have hosted different civilisations.

Turkey is a strategically and geographically important country in terms of connecting Asia and Europe. At the same time, it hosts many provinces with ten thousand years of historical and cultural accumulation, which have been the living space for different civilisations from past to present (Serçek, 2011).

The settlement history of Niğde, one of these provinces, covers 11 different periods, including Neolithic, Chalcolithic, Hittite and Assyrian, Persian and Hellenic, Roman and Byzantine, Seljuk, Eretnalılar, Karamanoğulları, Ottoman, National Struggle and Republican Periods (Yıldız, 2017). When the history of settlements in Anatolia is evaluated, it is possible to say that Niğde is a province that has hosted different civilisations and contains monumental and cultural structures of historical and cultural importance.

In this study, Niğde, which contains examples of monumental buildings and cultural heritage that are important in terms of historical development process, was selected as the research area. Within the scope of the study, the cultural heritage that are historically and culturally important in Niğde and have undergone changes in function within the scope of conservation studies have been evaluated and recommendations have been developed.

2. CULTURAL HERITIGES THAT HAVE UNDERGONE CHANGE OF FUNCTION IN NIĞDE

There are many important cultural heritage in Niğde that have undergone changes in function. Table 1 shows the architectural periods, construction dates, original use and new functions of the cultural heritage that have changed their functions. The old functions of these immovable cultural heritage are Niğde Castle, Greek Orthodox Church, Ak Madrasa, Sokullu Mehmet Pasha Bedesten, Kadıoğlu House, Göncü House, Resul Özkul House and Male Art School. The geographical location of the mentioned Houses and the study area are shown in Figure 1.

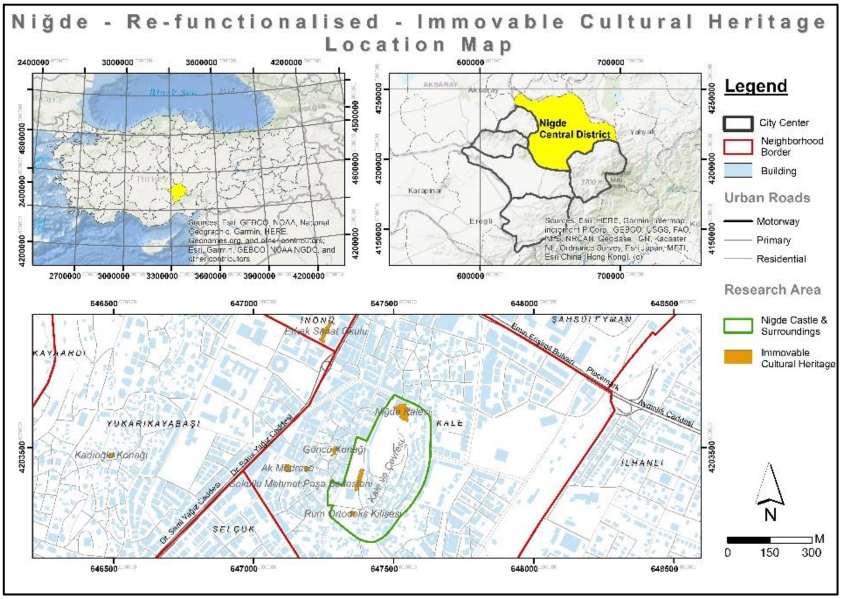

Figure 1. Geographical location of immovable cultural heritage that have undergone change of function

Table 1. Cultural heritage heritage that have undergone changes in function (Nigde Governorship, 2016)

Culture Presence	**Architecture Term**	**Construction History**	**Original Usage**	**New Function**
Nigde Castle	8th century BC		Castle	Kent Museum, garden, urban open and green space
Rum Orthodox Church	Late Ottoman Period	1861	Church	Library
Ak Medrese	Karamanoğlulları (Selçuklu Üslubu)	1409 (H. 812)	Medrese	Culture House
Sokullu Mehmet Pasha Bedesteni	Ottoman	16. Yy	Bedesten	Niğde City Museum
Kadıoğlu Konağı	Ottoman	1861	House	Museum
Göncü Konağı	Late Ottoman Period	1891	House	Guest House
Resul Özkul Konağı	Late Ottoman Period	1891	House	Restaurant (Tabal Gastronomy

Culture Presence	Architecture Term	Construction History	Original Usage	New Function
				House)
Erkek Sanat Okulu	Late Ottoman Period	1915-1917	School	Öğretmen Guest House

2.1. Niğde Castle

Built by the Hittite Civilisation in the IIXth century, Niğde Castle took its present form during the reigns of the Anatolian Seljuk State rulers Kılıç Aslan II, Rükneddin Süleyman Şah II and Alaaddin Keykubat I. It was registered with the decision of the Supreme Board of Antiquities and Monuments dated 15.07.1978 and numbered A1207 and the decision of the Kayseri Regional Board for the Protection of Cultural and Natural Heritage dated 31.07.1993 and numbered 1529 (Niğde Governorship, 2016). The castle, which is effective in the silhouette of Niğde, was built on Alâaddin Hill at an altitude of 1299 m. The structure consists of an inner castle and an outer castle surrounded by a north-south elongated fortification wall built with a masonry stone system surrounding it and enclosing the residential areas. Within the boundaries of Niğde Castle are the inner castle, Alâaddin and Rahmaniye Mosque, Hatiroglu Fountain, clock tower and residential buildings (Yıldız, 2017).

Since the castle was built in accordance with the slope of the land, it has a three-tiered appearance when viewed from the east and west facades, including the outer walls, the side bastions of the inner castle and the main bastions. The main bastion on the south side of the inner fortress was built higher than the side bastions. The thickness of the castle walls, which are made of fine yonu and rubble stone with lime mortar, varies between 1.30 m and 3.00 m (Özkarcı 2014). Today, Niğde Castle serves as a city museum, tea garden, urban open and green area (Figure 2).

Figure 2. Niğde Castle (Original, 2017)

2.2. Greek Orthodox Church

The Greek Church (Figure 3), located south of Niğde Castle in Sungurbey Neighbourhood, was built in 1861 during the last Ottoman Period (Yıldız, 2017). The church in the Eski Saray neighbourhood of the centre has a basilica plan. It was built with basalt building material and smooth cut stone. It has a narthex with six columns on the sides and in the centre (Nigde Governorship, 2016).

Figure 3. Greek Orthodox Church (Original, 2017)

The interior of the church consists of three sections with two columns and three arches. The building has a hipped roof using tile building materials (Niğde Governorship, 2016). The Greek Orthodox Church has been serving as Kale 100th Year Public Library since 2023.

2.3. Ak Medrese

The Ak Medrese (Figure 4); located in Saruhan Quarter; is a Karamanoğlulları Period building constructed in 1409. The madrasah was built with two storeys and a courtyard and yellow trachite stone was used as building material. The building was used as a hardware store during World War I. Since 1936, it served as the warehouse of the Istanbul Archaeological Museum, where movable cultural heritage were kept (Gabriel, 1962).

Between 1950-1957, it was used as the warehouse of the Niğde Museum, and between 1957-1977 it served as the Niğde Museum Directorate. After 1997, the museum was used for the preservation of stone artefacts, and today it serves as Niğde Culture House. The plan scheme of the building has a symmetrical structure and is the only example in Turkish Madrasa Architecture (Nigde Governorship, 2016).

Located in the north-south direction, the building has a water well in the centre of the interior space and is surrounded by nine arched porticoes to the east, west and north and the main iwan to the south (Yıldız, 2017).

Figure 4. Ak Medrese (Original, 2017)

2.4. Sokullu Mehmet Pasha Bedesteni

The bedesten built by Sokullu Mehmet Pasha in 1574 is an Ottoman Period building (Gabriel, 1962). The structure built as a bedesten (Figure 5) is located on the western slope of Niğde Castle on a slightly sloping land in the north-south direction (Yıldız, 2017).

Figure 5. Sokullu Mehmet Pasha Bedesteni (Original, 2017)

It was built with yellow trachyte rough hewn stone building material and arasta plan scheme. The Bedesten consists of a total of 48 shops and 4 cells placed opposite each other on both sides of the barrel vaulted road extending across the interior with a door on the north, south and east facades and a shop on the north and south facades (Niğde Governorship, 2016). Sokullu Mehmet Pasha Bedesteni has been serving as Niğde city museum since 2024.

2.5. Kadıoğlu House

Kadıoğlu House is a masonry building with a rectangular plan and consists of rooms opening to a hall (Figure 6). The ground floor of the masonry building was built as deaf walls with wooden beams between the rubble filling and a window opening was placed on each wall. The upper floor is covered with cut stone on rubble masonry. On the south and east facades, overhangs using stone building materials expanded the interior space. The facade facing east is divided by stylised columns. The columns consist of base, body and capitals. Stairs lead from the courtyard to the porticoed section in the east. In the interior, there are two rooms opposite each other opening to the hall (Governorship of Niğde, 2016). Today, restoration works are ongoing in Kadıoğlu House; when completed, it will start to serve as a city museum.

Figure 6. Kadıoğlu House (Ministry of Culture and Tourism, 2015)

2.6. Göncü House

Göncü House is a flat-roofed House building with a façade to Cullaz Street, built in masonry stone structural system using yellow trachyte tuff stone as building material (Figure 7). The landing in the courtyard is connected by a stone staircase. The pointed arched upper cover in the sa-hanlik section is connected to the floor with columns. The building was built adjacent to the Houses on neighbouring parcels (Governorship of Niğde, 2016). Göncü House and the other Houses around it have been serving as the guest house of Niğde Ömer Halisdemir University since 2015.

Figure 7. Göncü House (Original, 2017)

2.7. Resul Özkul House

It is a 1-storey masonry building built of cut stone. The ground floor entrance is located on the west façade of the building (Figure 8) (Niğde Governorship, 2016).

Figure 8. Resul Özkul House (Niğde Municipality, 2023)

The projections on the west façade are carried by consoles in the form of stylised lion heads and there are dragon-shaped gargoyles on this façade (Niğde Governorship, 2016). Resul Özkul House has been serving as Tabal Gastronomy House since 2023.

2.8. Male Art School

The Men's Art School has a rectangular plan orientated north-south and consists of basement, ground and first floor (Figure 9). The ground floor serves as a multi-purpose hall today. The historic teacher's house building was constructed of local fine masonry yellow trachyte stone. On the triangular pediment of the monumental entrance door, there is the Ottoman coat of arms, the frame surrounding the coat of arms and a total of 4 rosette cassettes, two of which correspond to the corners of the triangular pediment, and the inscription built of white marble. Local black andesite stone building materials were used for the stairs, columns and capitals, arch stones, brackets, as well as the floor stone flooring (Niğde Governorship, 2016).

Figure 9. Male Art School (Çoban, 2021)

There is a large garden on the eastern façade where the monumental entrance door of the building is located. The main entrance gate has two columns and three arches. The entrance is provided from three facades by 12-step stairs built with black andesite stone building materials. In order to increase the strength of the outer body walls of the building, plasters were placed on each facade and iron bars were mounted on the walls (Niğde Governorship, 2016). The building, which was built as a male art school, has been serving as a Teacher's House (guest house) since 1986.

3. CONCLUSION & RECOMMENDATIONS

Niğde is an important city with its historical and cultural values located in the Central Anatolia Region of Turkey and bears the traces of many civilisations. For this reason, Niğde is a city of great importance in terms of cultural heritage and immovable cultural heritage. Within the scope of this study, 8 immovable cultural heritage located in Niğde and re-functionalised after restoration works were investigated. The new functions of these buildings are, respectively, Niğde Castle City Museum, Castle 100th Year Public Library, Ak Madrasa Culture House, Niğde City Museum, Kadıoğlu Museum, Göncü Guest House, Tabal Gastronomy House and Niğde Teacher's House (Figure 10).

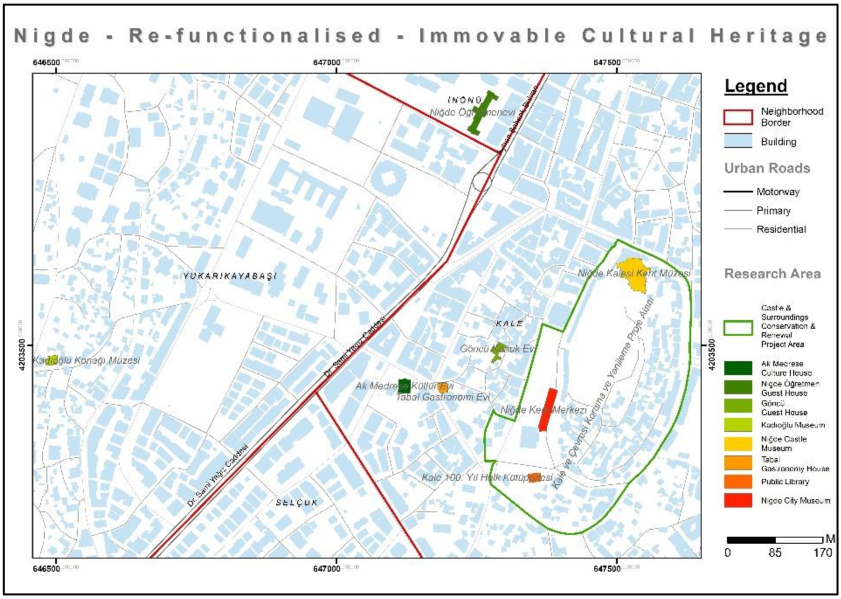

Figure 10. Re-functionalised immovable cultural heritage

However, there are still many dysfunctional immovable cultural heritage that are still idle and waiting to be restored. In the projects carried out for the renovation of conservation areas and immovable cultural heritage, it is generally necessary to strengthen the castle walls, repair the ramparts, design the visitor areas, and improve the infrastructure works around the castle and other immovable cultural heritage. Such projects are of great importance in terms of preserving the traditional texture of historical cities, transferring them to future generations and making them accessible to tourism.

Yıldız (2017), in order to preserve the natural and cultural character of the historical city centre of Niğde as well as to maintain its existence as an ecological settlement, suggestions were developed at the planning and design scale for the research area, taking into account the natural and cultural landscape features that have already been applied for centuries in the design of traditional settlement areas and the conservation zoning plan for Eskisaray and Kale neighbourhoods. These recommendations are;

"Traditional Niğde houses and monumental buildings in the historical city centre of Niğde should be identified by experts and repaired with appropriate restoration techniques; additions to the houses should be rearranged in accordance with the traditional texture. The buildings that have lost their functions within the traditional settlement texture should be re-functionalised in accordance with the socio-cultural structure of Niğde; for the buildings in the form of ruins, under the control of the Provincial Directorate of Culture and Tourism of the Governorship of Niğde, urgent reconstruction in accordance with their original form or consolidation of the foundations should be ensured to enable the buildings to exhibit themselves. In this context; Armenian and Greek Orthodox Churches, together with the traditional buildings and open spaces around them, should be functionalised as cultural and art centres. Sokullu Mehmet Pasha Bedesteni, located to the west of the Castle, should be organised as a covered bazaar where traditional Niğde handicrafts are offered for sale after the repair works are completed. Street fountains should be repaired and made functional."

It is expressed as follows.

In the following process, the renewal and protection of the area covering an area of 25,000 square metres within the borders of Niğde Province, Central District, in accordance with Article 2 of the Law No. 5366 dated 16.06.2005 on the Renewal, Protection and Preservation of Worn-out Historical and Cultural Immovable Heritage was approved by the Presidential Decree dated 4 March

2020. In this context, the Castle and its Surroundings Protection and Renovation Project was initiated by Niğde Municipality in 2022. Within the scope of the project initiated by Niğde Municipality, demolition works in the historical Niğde Castle and the surrounding area have been completed to a significant extent (Niğde Municipality, 2020).

Within the scope of the project, the objectives of the project planned to be realised by Niğde Municipality (2022) are as follows

- Protection of registered buildings
- Restitution, restoration and reconstruction of buildings in the region
- Commercial, residential and social facilities to be built in accordance with the traditional texture
- Transferring the historical and cultural richness of the city to future generations
- Restoration of castle walls, historical houses and other important structures to their original appearance
- Organisation of traditional streets and squares in the region
- Creating a promenade for visitors
- Protection and revitalisation of historical and cultural values
- Increasing the tourism potential of Niğde
- Mobilisation of hotels, restaurants and other tourism enterprises in the city

In summary, landscape design studies to be carried out for the purpose of conservation in Niğde Kale and Eskisaray neighbourhoods should emphasise the necessity of preserving and transferring a city centre that is not abandoned but integrated with its history to future generations together with its cultural heritage (Yıldız, 2017). For this purpose, the restoration works of the immovable cultural heritage that are still idle should be completed urgently and re-functionalised. In this process, in line with the support of relevant public institutions and organisations, Niğde City, which has qualified cultural heritage and immovable cultural heritage, will contribute to the tourism sector in Niğde City by increasing the quality of life in the Historic City Centre and raising public awareness. This situation will also bring about the development of the local and regional economy.

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