

# Machine learning as a tool for analysis of cultural ecosystem services in historic urban environments:

## Case of Jaffa, Israel

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## Abstract

Sustainable urban design ideally describes a process generating environmental and sociocultural responsibility and promotes viable and liveable environments. To achieve this, it is essential to address how current environmental, economic, and social systems impact spatial configurations and to acknowledge concepts of urban landscapes as a cultural construct informed by a history of change. The UNESCO Historic Urban Landscape recommendations provide a promising tool and guidelines for significantly improving conservation practices and emphasize acknowledging the city as a dynamic entity for future interventions, design, and planning. Although the attributes of the historical cities also include the intangible aspects of spirit and feeling, the means and identification at local levels and specific settings and contexts require further elaboration. The digital turn of the 21st Century C.E. has witnessed emerging concepts of big data, smart cities, urban science, and data-driven cities that are merging with technological innovation and reshaping the urban environments and processes. Big data applications and machine learning tools provide us with enormous potential for analysis of user behavior useful for many disciplines. However, such explorations are largely unexplored in strategic assessments and spatial planning within historic urban environments along with the use of digital tools, machine learning, and big data. For this purpose, documenting the attributes and capacities of historic urban landscapes and their provisioning of cultural ecosystem services can present information beyond the traditional datasets to firstly visualize human behaviours and map the values associated with the elements of the landscape. The core spirit of this research is present in the concept of heritage as strongly related to the relationship between intangible values and products concerning tangible entities in which these values are materialized. The research also implies that an innovative method may be useful for addressing issues of spatial complexities and highlighting the need for sustainable solutions critical for heritage planning and tourism frameworks together. This article explores how visualizing pluralist datasets for cultural ecosystem

services can enhance the spatial analysis of historic urban landscapes and aid in strategic assessment for sustainability. The case study of the ancient port town of Jaffa, Israel, is studied for contextually embedding the tool to test the applicability. This case highlights the socio-spatial heterogeneity within the Tel Aviv-Yafo metropolis and the present-day gentrified historic area inflicted by neoliberal practices, resulting in shifting demographics, spatial conflicts, and environmental impacts. Using quantitative and qualitative assessment data combined with remote sensing and GIS, impacts on the landscape can be evaluated.

Around 3,800 images were obtained from the social media platform, Flickr was used in this study. After carefully studying 1000 randomly selected images, each was manually labeled to identify and visually map elements grouped in four major categories pertaining to the cultural ecosystem services (CES) values—elements include significance for social-cultural, economic, cultural, and ecological. Various machine learning tuning experiments were carried out with 850 (85%) of manually labeled images using algorithms belonging to the convolutional neural networks (CNNs) family, a subclass of artificial neural networks. The best candidate model is selected based on the F1 classification score using a held-out dataset of 150 (15%) images. The selected model is used to assign scores to all Flickr-extracted images under the elements and associated value categories mentioned above. Combined with georeferencing obtained along with the images from Flickr, model-determined scores are mapped to a two-dimensional location space, enabling the generation of geospatial heatmaps. Furthermore, this also enables the analysis of temporal variations in the CES-value distribution of the chosen geography. This approach can be easily extended to monitor Flickr images automatically and share CES value scores and insights with decision-makers, requiring minimal human intervention. The research acknowledges the limitation of volunteered geographic information (VGI) and crowd-sourcing, however, extends the experiment as a significant exploration for analysis of the behaviors of certain sections of the communities and user groups.

The proposed approach thus delivers useful integrative information for environmental management and landscape planning, especially for marginalized and spatially fragmented historic urban environments, aiming at sustainable use of services provided by nature and culture. The multiplicity of information and datasets can be better managed with innovative frameworks of indicators, and assessment matrices, with new emerging digital tools for visual representations such as datascaping. This methodological development applied to the capacities of historic urban landscapes providing ecosystem services is presented in this paper to foster critical discussions. Such a study can provide an innovative and useful analysis of VGI when coupled and layered with other datasets and visualizations such as data from vacation rentals and hotels, reviews in different languages for restaurants to visualize the cognitive boundaries of users specific to religion, activism site and protests and the co-relation to elements of the analysis to name a few. Innovative processes have the potential to augment the capacity of data analytics through integration with the use of datascapes methods. These digital representations can provide an alternative to mainstream spatial representations. This can be achieved by re-visioning urban heritage management and designing data collection, analysis, and visualization of attributes to bridge the gap between policymakers and citizens and break silos of information within institutions. This exercise of mapping and visualization through the use of digital tools and data analytics will be used to assess the developed method for its relevance toward new approaches for urban heritage planning and decision-making frameworks and inform professionals through a generative process to steer impact assessment and future planning and interventions.

This method may have a high potential to contribute to the ontologies and discourse of heritage and spatial planning for sustainability.



Fig. 1. The classification was carried out as per cultural ecosystem services highlighting a) social elements b) economic elements of VGI pictures from Flickr.com for Jaffa and its environs, Tel Aviv-Yafo.

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## Conflict of Interests Disclosure

There is no conflict of interest.

## Author Contributions

**Conceptualization:** Komal Potdar

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**Formal Analysis:** Kedar Dabhadkar, Komal Potdar

**Validation:** Kedar Dabhadkar

**Visualization:** Kedar Dabhadkar

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