

Investigating the Relationship Between Storage Strategy Choice and Urbanization

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Abstract

This study examined the potential relationship between urbanization and the preferred method of solid waste storage. Urbanization index images were produced for 4 provinces in Türkiye. The possibility of urbanization as a factor in storage preferences was examined using the thematic map produced for these neighbouring provinces. It has been demonstrated that higher urbanization and sanitary landfill coexist in two of the provinces. However, the fact that one province opted for sanitary landfills, despite its low urbanization rate, demonstrated the need to consider external factors. In this context, a comprehensive assessment was conducted, considering parameters such as the province's urban and rural populations and daily waste volumes. Despite low urbanization, high industrial activity was considered a contributing factor in the choice of sanitary landfills. In addition to low urbanization, a higher rural population was an indicator of open dumping sites.

Keywords: Landfill, Open Dumping Site, Remote Sensing, Urbanization, Waste.

Introduction

Solid waste management (SWM) has become a popular topic in recent years due to its environmental impact. The solid waste disposal process, carried out in developed countries at highly controlled sites, is also an energy recovery process (Ali et al., 2014). In developing countries, there is a gradual transition from open dumping sites (ODSs) to sanitary landfills (Osra et al., 2024). In Turkey, some provinces have multiple sanitary landfills, while others have only one site, depending on population density and the amount of waste collected per day. In some provinces, ODSs, which do not monitor methane gas accumulation or leachate, are preferred. This storage method has numerous proven negative environmental impacts (Chavan et al., 2022; Jakhar et al., 2023).

Due to the negative impacts of ODSs, the use of sanitary landfills has become a necessity rather than a choice (Singh et al., 2022). Activities are typically carried out under a union involving multiple district municipalities. The required permits are obtained from the ministries, environmental reports are prepared, the facility is constructed, and it operates for its designated lifespan. In some cases, district municipalities from different neighboring provinces may also become members of the same union. In addition to projects undertaken simultaneously, it is expected that provinces sharing a common border will have similar solid waste disposal strategies. However, characterizing provinces that still insist on open dumping, or that prefer sanitary landfilling but are insufficiently ambitious or committed to it, is crucial. This study investigated the urbanization of a province with open dumping and three neighboring provinces with sanitary landfills. It was investigated whether urbanization, as revealed by satellite imagery, is an indicator of solid waste storage preferences. In this context, data obtained from official institutions were also included in the data evaluation and discussion section.

Data and Method

Four neighboring provinces located in the Black Sea region of Türkiye were selected as the study area. These provinces were Zonguldak, Bartın, Karabük, and Kastamonu, as shown in Figure 1. Karabük shares a common border with the other three provinces. Provinces with bordering neighbours are likely to take similar actions through joint projects and collaborations. They are expected to develop policies by supporting or imitating each other. This is also expected for solid waste storage, but among these provinces, Bartın is the only province where open dumping is practiced. The other three provinces dispose of solid waste in sanitary landfills within their own provincial borders.

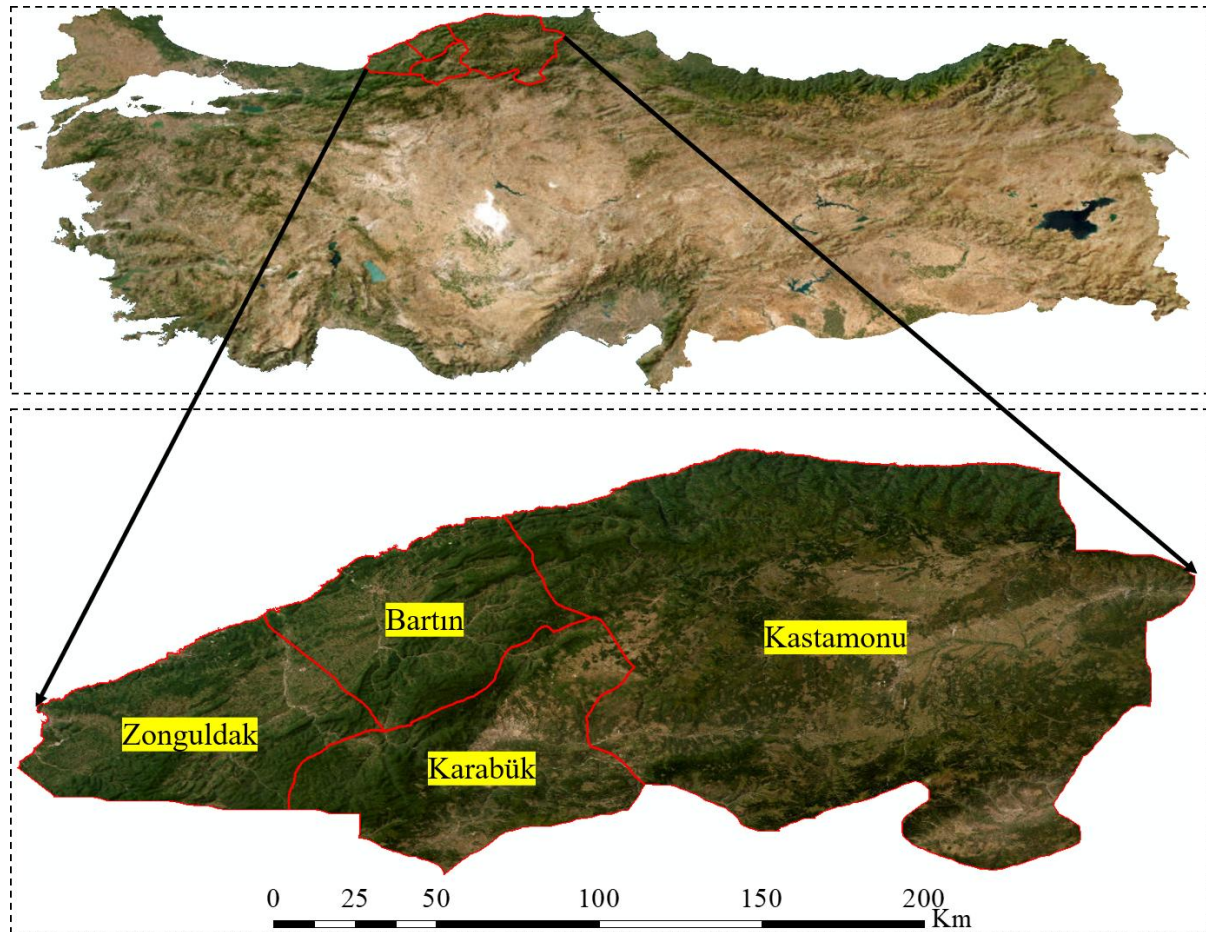


Fig. 1. Study area.

Landsat satellite imagery was used to assess urbanization in the cities. While Sentinel imagery offered much higher spatial resolution, Landsat was preferred for covering the provinces in a single frame. Zonguldak, Bartın, and Karabük are located in the same image, while Kastamonu is located in a separate image. This eliminates the need for mosaics for any province. Since the downloaded images are at the L2 level, they do not require any external radiometric calibration or atmospheric correction. The Normalized Difference Built-up Index (NDBI) (Zha et al., 2003) was used as the urbanization index. The NDBI, whose formulation is presented below, uses the SWIR and NIR bands. The fact that built-up areas have higher reflectance in the SWIR band and vegetation has higher reflectance in the NIR band leads to differences in the index values (Javed et al., 2021). Since no in-depth calculation was made, pixels greater than 0 were theoretically accepted as built-up areas, and pixels smaller than 0 were accepted as other areas.

$$NDBI = \frac{SWIR - NIR}{SWIR + NIR} \quad (1)$$

Results

The NDBI image is shown in Figure 2. The expected situation was that provinces where landfills were preferred would experience greater urbanization. In other words, Bartın, the province with open dumping, is expected to experience lower urbanization compared to other provinces.

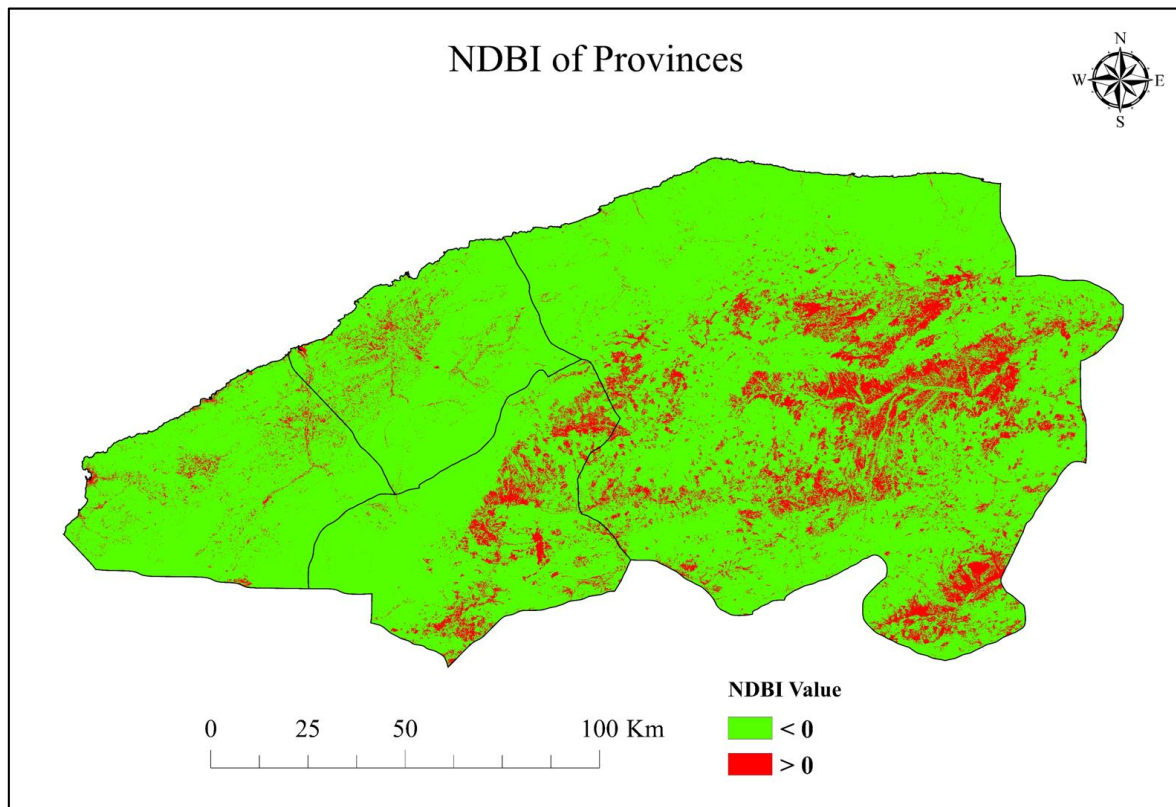


Fig. 2. NDBI for four provinces.

Images derived from NDBI values can be interpreted in different ways. The first is an assessment of the density of red zones representing built-up areas, derived directly from NDBI values. Examining Figure 2, it can be easily determined that urbanization is relatively higher in the provinces of Karabük and Kastamonu. Based on this information, it can be argued that the increasing amount of solid waste, which will increase with increasing urbanization, necessitates the need for sanitary landfills, and therefore these provinces utilize this method of storage. The low construction rate in Bartın also supports this situation. However, while Zonguldak, where the sanitary landfill is located, is similar to Bartın in total covered area, there is no significant difference in built-up area based on NDBI values. This prevents a direct correlation between urbanization and the choice of storage process based on NDBI values.

Two issues should be carefully considered for the contradiction between the provinces. The first is how realistically NDBI values represent urbanization. Because bare land and mountainous regions have reflectance values similar to those of built-up areas in the SWIR band, they are difficult to distinguish from one another. The greater similarity between Karabük and Kastamonu than between other provinces may have contributed to the greater presence of

built-up areas. Another issue that needs to be addressed is the impact of external factors beyond urbanization. Urbanization may be a factor in the preference for sanitary landfills, but specific circumstances may also influence that preference, given the high volume of waste generated despite relatively low urbanization. One of these specific cases applies to Zonguldak. Figure 3 presents a graph based on data obtained from provincial environmental status reports openly accessible from the Republic of Türkiye, Ministry of Environment, Urbanization, and Climate Change (Url-1). Figure 4 presents a graph showing the total, urban, and rural population values for each province. The data required for this graph were obtained from the Turkish Statistical Institute (Url-2).

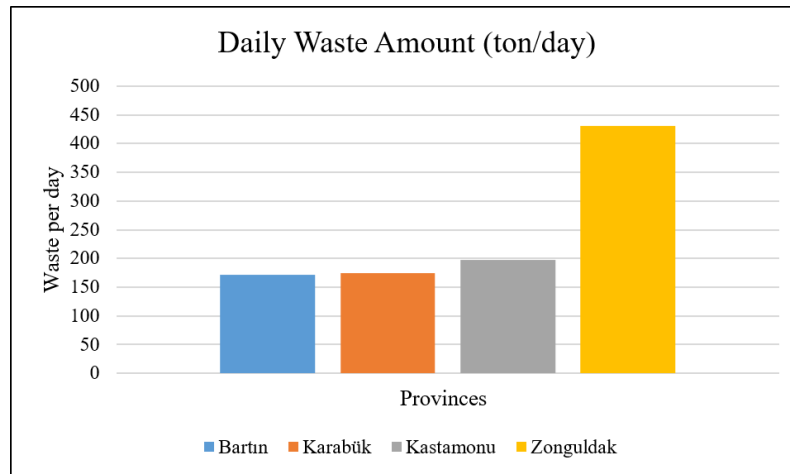


Fig. 3. Average daily amounts of solid waste collected in the provinces.

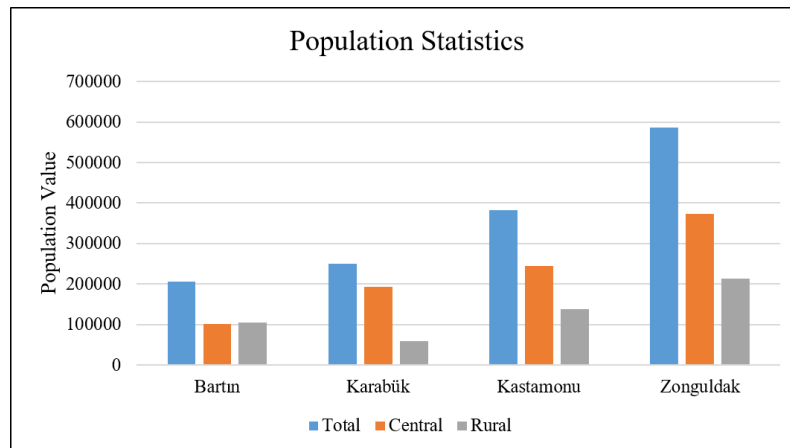


Fig. 4. Population statistics for the provinces.

The graph in Figure 3 shows daily waste collection across the four provinces covered in the study. The reports include average daily waste collections for both summer and winter. When evaluated on a 12-month basis, Zonguldak stands out significantly from other provinces. As stated in the environmental status report, the daily waste collection in the Ereğli district of Zonguldak, home to the coal basin, is 114 tons in summer and 109 tons in winter. These values are higher than those in the other provinces shown in the graph. In other words, despite being similar to Bartın in terms of urbanization based on NDBI values, activities in the Ereğli district of Zonguldak province significantly increase daily waste volumes, which may have increased the need for sanitary landfills and led to a trend in the disposal process. As shown in Figure 4,

Zonguldak has higher values than other provinces for both total and urban populations. This, in turn, increases the amount of daily waste collected. An examination of the graph in Figure 4 reveals that the urban population exceeds the rural population in all provinces that opt for sanitary landfills. In Bartın, where open dumping is used, the rural population is slightly higher than the urban population. In light of this information, it can be argued that there is a clearer relationship between the number of people living in densely urbanized areas and the storage process. The fact that Bartın and Karabük have similar daily waste volumes, despite the differences in urban populations, is likely due to Bartın's tourism activities. While the daily waste collection amounts in summer and winter are very similar in other provinces, in Bartın the difference between them is greater. This situation is highly likely to increase waste volume in addition to the existing population due to tourism activities.

Conclusion

The study examined the relationship between urbanization and solid waste storage preferences, assuming that neighboring provinces may follow similar SWM policies. In this context, provinces that prefer sanitary landfills and those that prefer ODS were evaluated together using NDBI values derived from Landsat imagery, which provide insights into urbanization. In practice, while NDBI was theoretically evaluated using threshold values, it was concluded that there may be a relationship between urbanization and storage strategy, but external factors were also influential. The inability to adequately distinguish among different land surfaces using NDBI in Landsat imagery was a significant drawback. Using higher-spatial-resolution imagery, the relationship under investigation could be more reliably demonstrated. Furthermore, the attribute data obtained from different institutions were found to be useful in addressing different approaches to solid waste storage.

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Url-2: Population statistics, retrieved from: <https://www.tuik.gov.tr>, retrieved date: 01.11.2025.