Can we use waste generation as a smart indicator?

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Abstract

Improving environmental quality is one of the prominent purposes of the governments in developing countries where additional international pressures with an increasing level of environmental awareness exist. Environmental quality models are predicted by using generally its components such as air pollution, emissions, demand and awareness to protect it, but by somehow lack of municipal solid waste generation and municipal solid waste management expenditures. ***Objectives*** *This study aims at exploring the effects of municipal solid waste generation per capita, municipal solid waste expenditures per capita, and waste expenditures rate on environmental quality.* ***Prior work*** *A range of assessment tools have been designed to provide holistic picture of smart cities and many common prospects of the system. Focusing on the specific domains of the smart city concept, some scholars propose four smart environment indicators, including attractiveness of natural conditions, pollution, environmental protection and sustainable resource management.* ***Approach*** *The current study constructed a national dataset from Turkish provinces, including environmental indicators, running a causal relationship model. Hierarchical regression analysis was conducted to explore the relationship between environmental quality and municipal solid waste management.* ***Results*** *The mean of environmental quality index level in 81 cities. The mean of annual municipal solid waste generation in 81 cities was 429 (± 100.25) kg per capita in Turkey in 2016. Municipal solid waste expenditures per capita was a predictor of environmental quality level.* ***Implications*** *The findings of this study signal that we can estimate the*

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level of environmental quality by using municipal solid waste management in the next years. Our results showed that municipalities' solid waste management expenditures clearly had an impact on environmental quality level in Turkey. This type of convergence of interests might get municipalities to adopt municipal solid waste management programs adopting IT towards better environmental quality level. ***Value*** *Environmental quality level turned out to be reflecting environmental inequality in the provinces of Turkey.*

Keywords: *Municipal solid waste management, multivariate statistical analysis, environmental quality.*

1. Introduction

Improving environmental quality is one of the prominent purposes of the governments in developing countries where additional international pressures with an increasing level of environmental awareness exist. Environmental quality refers to a source of well-being (Streimikiene 2015), and previous research has explored the influences of macro factors on environmental quality, including economic, social and demographic factors (Cropper and Griffiths 1994; Arbulu et al. 2015). In the last two decades, those factors have inspired much attention due to their policy implications over time, such as urbanization, economic growth, and sustainable development. Particularly, municipal solid wastes are still among the prominent problems in urban society, and many studies have emphasized that wastes if managed not properly, may be harmful to human, plants, animals and environment, steadily deteriorate the health status of individuals, and gradually reduce the environmental quality (Pierzynski et al. 2005; Keleş et al. 2012). For example, landfilling, as a conventional waste disposal technique, may increase health expenditures due to increased congenital abnormality, cancer incidence, and mortality rate, especially under-five (Jerrett et al. 2003; Ruston 2003). The possible way to cope with this emerging problem is to assess the level of waste generation, its management performance, to identify the mismanagement conduct, and to follow up the expenditures to protect environmental quality (Adeoye et al. 2016).

Recently, studies examining many aspects of smart cities have emerged, but there have been also research gaps. Overall those studies have been much related to defining assessment methods on multiple smart city dimensions to provide holistic picture of smart cities and many common prospects of the system, specifically embedding information technologies in each dimension. In this scope, a variety of system/subsystem assessment indicators have been proposed to follow-up the relevant characteristics of the smart cities. Consequently, using the relevant indicators, many studies have focused on ranking of the smart cities and its components, common prospects, and its determinants, economically, politically, and culturally. For example, Shafik (1994) have examined the effects of economic growth on smart environment while Adeoye et al (2016) have revealed that rural deveopment are related with integrating many technological tools. Many other studies have argued that income is associated with environmental quality, implying that as income grows environmental quality increases because of income elasticity of demand for environmental quality (OECD 2008; Giovanis 2015). Nevertheless, few studies discuss the effects of municipal solid waste generation quantity and municipal solid waste management expenditures on environmental quality. Environmental quality models are predicted by using generally its components such as air pollution, emissions, demand and awareness to protect it, but by somehow lack of municipal solid waste generation and municipal solid waste management expenditures.

Against this background, the current study constructed a national dataset from Turkish provinces, including the environmental indicators, running a causal relationship model. It aims at exploring the effects of municipal solid waste generation per capita, municipal solid waste expenditures per capita, and waste expenditures rate on environmental quality levels in 81 provinces of Turkey. It provides new evidence about the inductive environmental impact of waste management. This study contributes to the public administration and environmental economics literature by uncovering the effects of annual municipal waste generation and expenditures on environmental quality.

2. Literature review

One of the major problems encountered in city life is the environmental problems emerging from inappropriate municipal solid waste management. Approximately 32 million tons of municipal waste generated in Turkish provinces in 2016, according to Official Statistics Bureau. Examining the effects of municipal solid waste on smart environment is a vital research topic in environmental economics and public administration.

Smartness is specially denoted as exploring innovative solutions to the needs of people in a society, and defined with six domains: (i) economy, (ii) people, (iii) governance, (iv) mobility, (v) environment, and (vi) living (Centre of Regional Science Vienna University of Technology 2019; Giffinger and Gudrun 2010). Those domains are related to the characteristics of the cities where they should aspire to achieve better in terms of competitiveness, social and human capital, active participation, transport and ICT, natural resources, and quality of life [13].

In Turkey many local governments utilize IT applications regarding smart environment, such as infrastructure automation, water and sewage systems monitoring (e.g. using smart meters, detection of leakage, water quality monitoring, vigilance systems), municipal solid waste collection/sorting systems (e.g. pay as you throw, recycling systems), environmental quality measurement (e.g. air quality measurement and monitoring with sensors, noise pollution measurement), energy consumption reduction (e.g. using smart meters and networks, distribution and intermediate station automation, building energy management, street lighting) applications (Varol 2017).

A range of assessment tools have been designed to provide holistic picture of smart cities and many common prospects of the system. Most of the assessment methods focus on multiple smart city dimensions with an overall system perspective, specifically embedding information technologies in each dimension and process. For example, European smart cities ranking system have been put forward to provide a more comprehensive understanding of the concept, sustainable urban model (Lazaroiu and Roscia 2012; European Commission 2012). It includes a set of metrics, standards, or indicators regarding smart city objectives that are related to all actors affected by proper implementation of effective and innovative solutions.

The same methodological approach may particularly tackle the subsystems, where the task is much more effective and producing new indicators to provide new insights. Therefore, due to the difficulty in accurately measuring environmental quality, many researchers have developed a novel approach to quantify the environmental quality level by aggregating a range of indicators. Focusing on the specific domains of the smart city concept, some scholars propose four smart environment indicators, including attractiveness of natural conditions, pollution, environmental protection and sustainable resource management (Lazaroiu and Roscia 2012; European Commission 2012; Batty et al. 2012). This approach considers environmental quality to be a function of air pollution, green space area, waste management, individuals' awareness and demand for protecting nature, and energy efficiency.

In general, it assumes that income per capita positively related to environmental quality while illiteracy and infant mortality rate, as meaningful social standard and economic inequality indicators, are negatively related to it due to decreasing environmental awareness and demand (Beigl et al. 2014). Many studies report that economy, urban development, and human attitude are prominent factors influencing municipal solid waste generation (Liu and Wu 2010). For example, high economic level and adopting advanced technology in developed countries increase costs but reduce the risks, because of the trade-off between economic growth, technological infrastructure, costs and risk of diseases, and environmental degradation (Ikhlayel 2018). That is relevant for the early stage of economic development, but when the economic growth reaches a sustainable level, municipal solid waste generation begin to decline substantially (Arbulu et al. 2015). Thus, reducing the amount of waste is the main objective of developed countries' waste policies.

Municipal solid waste management in most countries differ due to national regulations, including source reduction, material recovery transfer, incineration, sterilization, anaerobic digestion, composting, and landfilling (Özeler et al. 2006; Ezechi et al. 2017). There have been many attempts to pursue the municipal solid waste management practices and expenditures. For example, The World Bank (2001) proposed a software tool for urban cleaning services municipality solid waste management (COSEPRE) to assist Lima Municipal Cleaning Services Company to follow up the costs, excessive expenditures, relevant corrective actions, and waste prediction (The World Bank 2001).

Despite the extensive literature, Turkish scholars have paid little attention to the subject. So, this study attends to fill the gap suggesting an evidence to explore the linkage between the variables. Moreover, the findings gathered from this study will provide further insights for public policy makers and researchers. We also expect that local governments will follow up their process and activities on environmental quality, and municipal solid waste management by using the indicators suggested in this study.

3. Methodology

3.1. Materials/ Data

Environmental quality for 81 provinces in Turkey were recorded based on a dataset of Turkish Statistical Institute (TurkStat). Linearities between environmental quality and selected municipal waste management indices of each urban society were examined using correlation analysis. Specifically, in this study we used twelve indices which are explained below. Air pollution, forest area, population provided controlled municipal solid waste services, noise level and satisfaction level were included in the environmental quality index by TurkStat (Türkiye İstatistik Kurumu 2016). Also, income per capita, literacy rate, under-five mortality rate, population, amount of municipal solid wastes, municipal solid waste expenditures, and municipal solid waste expenditure rate was obtained from TurkStat province-level database (Türkiye İstatistik Kurumu 2017).

Income (TL/capita): This indicator is the gross domestic product. Data was based on 2016 calendar year.

Literacy (%): This indicator refers to the rate of people who are graduated from a formal school and able to read and write in national formal language. Data was based on 2016 calendar year.

Under-five mortality rate: This indicator refers to the number of deaths of infants and children under five years old per one thousand live birth. Data was based on 2016 calendar year.

Population: This indicator refers to the urban residents in a province. Data was based on 2016 calendar year.

Air pollution (mg/m3): This indicator refers to the average of PM10 values of the stations in a city. Data was based on 2015 calendar year.

Forest area per km^2: This indicator refers to the forest area per km^2 in a city. Data was based on 2015 calendar year.

Population provided controlled municipal solid waste services: This indicator refers to the percentage of urban population receiving regulated waste management services provided by local governments in a city. Data was based on 2015 calendar year.

Noise level: This indicator refers to the percentage of households having noise problems from the streets. Data was based on 2015 calendar year.

Satisfaction level: This indicator refers to the satisfaction rate of urban residents from sanitation services provided by local governments in a city. Data was based on 2015 calendar year.

Annual municipal solid waste generation (thousand tonne/capita): Generated amount of municipal solid waste in a city. Data was based on 2016 calendar year.

Annual municipal solid waste expenditure (TL/capita): Total expenses for municipal solid waste management, including collection, transportation, storage, treatment, and disposal. Data was based on 2016 calendar year.

Waste expenditure rate: This indicator refers to the percentage of the expenditures for municipal solid waste management by local governments in total environmental protection expenditures in a city. Data was based on 2016 calendar year.

3.2. Method

The dependent variable in this study was environmental quality, while annual municipal solid waste generation per capita, annual municipal solid waste expenditure per capita, and proportion of municipal solid waste management expenditures in total environmental protection expenditures in a city were treated as independent variables. Hierarchical regression analysis was conducted to explore the relationship between environmental quality and municipal solid waste management. We controlled income per capita, illiteracy rate, population, and under-five mortality rate. We used the SPSS 21.0 (SPSS Inc) and the R programming language (R-Studio) for all data modeling.

4. Results

In this section, descriptive findings of environmental quality, annual municipal solid waste generation per capita, annual municipal solid waste expenditures per capita, and the percentage of the expenditures for municipal solid waste management by local governments in total environmental protection expenditures are provided. Also, the regression models are presented.

4.1. Descriptive findings

The mean and standard deviation values are presented in Table 1.

Table 1. Descriptive statistics

Abbreviation	Variables	Mean	SD
EQ	Environmental quality	0.5906222	0.1203727
GDP	Income per capita	24854.5101546	8432.04505
LITR	Literacy	95.5275309	2.1563265
MORT	Under five mortality rate	11.7975	3.77353
POP	Population	985368.7778	1786221.06536
MWG	Municipal solid waste generation	429.0987654	100.2536290
MWE	Municipal solid waste expenditure	71.8868	31.19251
MWER	Municipal solid waste expenditure rate	44.6960494	14.3658487

The mean of environmental quality index level in 81 cities was 0.59 (± 0.12). First five cities which had greater environmental quality were Kastamonu (0.81), Karabük (0.80), Bilecik (0.76), Kırklareli (0.74), and Yalova (0.74). Last five cities which had smaller environmental quality were Iğdır (0.20), Muş (0.25), Hakkari (0.31), Kars (0.37), and Ağrı (0.37).

The mean of income per capita in 81 cities was 24854 (± 8432) TL in Turkey. While, the first five wealthy cities were İstanbul (54,933), Kocaeli (53,267), Ankara (45,247), Tekirdağ (40,083), and Bilecik (38,274), having approximately 12% of the total annual national income, the most poverty-stricken cities were Ağrı (11,125), Şanlıurfa (12,161), Van (12,378), Batman (14,015), and Bitlis (14,145), having approximately 3% of the total annual national income. Data on annual income per capita reveals that there apparently exists an economic inequality among Turkish provinces in 2016.

The mean of literacy level in 81 cities was 95.53% (± 2.16) in Turkey. While, the most literate five cities were Antalya (98.68%), Çanakkale (98.35%), Tekirdağ (98.34%), İzmir (98.34%), and Denizli (98.34%) in 2016, the least literate five cities were Mardin (90.64%), Şanlıurfa (90.7%), Şırnak (91.24%), Siirt (91.33%), and Muş (91.53%).

According to the Table 1, the average level of under-five mortality rate was approximately 12‰ in 81 provinces in Turkey in 2016. While, the city which was most suffering from the mortality rate under five years old was Şırnak (22‰), the least one was Tunceli (4‰). Data on the average level of under-five mortality rate reveals that there apparently exists social inequality among Turkish cities in 2016. While the most crowded city was İstanbul (14.8 million), the least one was Tunceli (83 thousand). The mean of annual municipal solid waste generation in 81 cities was 429 (± 100.25) kg per capita in Turkey in 2016. While, the most municipal solid waste producer cities were Muğla (719 kg/per capita), Bartın (657 kg/per capita), Kars (639 kg/per capita), Ardahan (620 kg/per capita), and Kilis (620 kg/per capita), having approximately 10% of the total municipal solid waste generated, the least one was Kahramanmaraş (259 kg/per capita).

The mean of municipal solid waste expenditure per capita in 81 cities was 72 (± 31) TL in Turkey. First five cities which had greater municipal solid waste expenditure per capita were İstanbul (148), Muğla (145), Antalya (135), Ordu (131), and Van (129). Last five cities which had smaller municipal solid waste expenditure per capita were Osmaniye (12), Niğde (14), Gümüşhane (18), Kars (28), and Muş (30). The mean of municipal solid waste expenditure rate in 81 cities was 45% (± 14) in Turkey. First five cities which had greater municipal solid waste expenditure rate in total expenditures for environmental protection were Konya (84%), Denizli (84%), Niğde (83%), Bursa (82%), and Kocaeli (81%). Last five cities which had smaller municipal solid waste expenditure rate in total expenditures for environmental protection were Bingöl (21%), Adıyaman (24%), Bolu (25%), Bilecik (28%), and Düzce (35%).

4.2. Multiple regression results

To explore the causality between independent and dependent variables, regression analysis was adopted. The proposed regression equity was as follows:

$$Ln(EQ)= \alpha i+ \beta 1ln(GDP)+ \beta 2ln(LITR) + \beta 3ln(MORT) + \beta 4ln(POP) + \beta 5ln(MWG) + \beta 6Ln(MWE) + \beta 7Ln(MWER)+ \varepsilon \quad (1)$$

Where:

EQ – environmental quality;

GDP – gross domestic product per capita;

LITR – literacy rate;

MORT – under-five mortality rate;

POP – population;

MWG – municipal solid waste generation quantity;

MWE – municipal solid waste expenditure;

MWER – municipal solid waste expenditure rate.

We checked the variables in terms of being highly correlated with environmental quality. Correlation values between the independent and dependent variables are presented in Table 2.

Table 2. Correlation between exploratory variables

	EQ	GDP	LITR	MORT	POP	MWG	MWE
GDP	0.526 (0.000)						
LITR	0.629 (0.000)	0.733 (0.000)					
MORT	-0.597 (0.000)	-0.615 (0.000)	-0.636 (0.000)				
POP	0.74 (0.257)	0.533 (0.000)	0.242 (0.015)	-0.085 (0.225)			
MWG	0.061 (0.053)	0.187 (0.036)	0.196 (0.040)	-0.139 (0.108)	-0.007 (0.474)		
MWE	0.418 (0.294)	0.448 (0.001)	0.407 (0.059)	-0.228 (0.020)	0.421 (0.000)	0.172 (0.114)	
MWER	-0.075 (0.254)	-0.267 (0.003)	-0.371 (0.000)	0.252 (0.012)	-0.182 (0.052)	0.051 (0.326)	0.095 (0.131)

p-Values in brackets.

Two step hierarchical regression analysis was adopted to determine the predictors of environmental quality controlling for the effects of income per capita, literacy rate, under-five mortality rate, and population. In regression analysis further assumptions, such as linearity between dependent and independent variables, normal distribution of residuals, absence of auto-correlation, homoscedasticity (constant variance of error terms), and absence of multicollinearity problem between residuals are required to meet. Hence, we used correlation analysis, histogram visualization and Shapiro-wilk test, Durbin-Watson coefficient, Breusch-Pagan modified studentised test, and variance inflation factor accompanied with tolerance value to validate the assumptions of interest. The hierarchical multiple regression statistics are reported in Table 3.

Table 3. Hierarchical Multiple Regression Statistics

Model	Variable	Std. coefficient	Std. error	t-statistic	Significancy	Variance inflation factor
1	Constant	-	0.694	-1.937	0.056	-
	GDP	0.140	0.000	0.882	0.380	3.613
	LIT	0.375	0.007	2.831	0.006	2.510
	MORT	-0.282	0.004	-2.378	0.020	2.012
	POP	-0.116	0.000	-1.080	0.284	1.649
2	Constant	-	0.722	-1.857	0.067	-
	GDP	0.123	0.000	0.807	0.423	3.691
	LIT	0.368	0.008	2.692	0.009	2.977
	MORT	-0.297	0.004	-2.629	0.010	2.023
	POP	-0.183	0.000	-1.672	0.099	1.909
	MWG	-0.123	0.000	-1.486	0.142	1.083
	MWE	0.232	0.000	2.318	0.023	1.595
	MWER	0.120	0.001	1.301	0.197	1.358

According to the Table 3, the regression coefficient for the GDP was 0.123 (t= 807, p= 0.423), for the literacy rate was 0.368 (t= 2.692, p= 0.009), for the infant mortality rate was -0.297 (t= -2.629, p= 0.010), for the population was -0.183 (t= -1.672, p= 0.099), municipality solid waste generation per capita was -0.123 (t= -1.486, p= 0.142), for the municipality solid waste expenditures per capita was 0.232 (t= 2.318, p= 0.023), for the percentage of municipality solid waste expenditures in total environmental protection expenditures was 0.120 (t= 1.301, p= 0.197). Municipal solid waste expenditures per capita was a predictor of environmental quality level in 81 cities ($p<0.05$). Also, literacy rate and infant mortality rate were other predictors of environmental quality level.

In regression models, independent variables should not have strong relationship with one another. Otherwise highly related variables may manipulate the regression equation which symbolizes the apparent causal relationship between the independent variables and dependent variable. To diagnose the availability of multi-collinearity between the independent variables variance inflation factor (VIF) and tolerance have been used. VIF value exceeding 4.0, or tolerance value less than 0.2 indicate the multi-collinearity problem (Hair et al. 2010). With this background, VIF values in the second regression model ranged from 1.358 to 3.691, indicating that there was no multi-collinearity between the independent variables, as they were below the cut-off values.

Moreover, the assumption of homoscedasticity requires the constant variance of error terms, which can be measured by many specific tests such as plot and histogram visualization techniques, Breusch-Pagan test, Breusch-Pagan modified studentised test, Goldfels and Quandt test, Szroeter test, and White's asymptotic test (Evans 1989).

We applied Breusch-Pagan modified studentised test to validate the assumption of homoscedasticity, and found that p value was greater than 0.05 (BP= 0.023), indicating that there was no heteroscedasticity. To diagnose the auto-correlation which is one of the assumptions of linear regression, we checked Durbin-Watson coefficient, and found that it (1.8) was less than the reference level (1.5-2.5)

(Norusis 1999). Moreover, we diagnosed the normal distribution of residuals with histogram visualization and Shapiro-wilk test (p> 0.05), which indicated that the residuals were normally distributed. The regression models are presented in Table 4. While model 1 included controlled variables, the independent variables were subsequently added to the following model (model 2).

Table 4. Regression models

Model	R	R square	Adjusted R square	Std. error of the estimate	Change statistics					Durbin-Watson
					R square change	F change	df1	df2	Sig. F change	
1	.685	.469	.441	.0899796	.469	16.793	4	76	.000	
2	.735	.541	.496	.0854140	.071	3.781	3	73	.014	1.8

In model 1 with controlled variables predicted environmental quality, R-square value was 0.47. In model 2 the R-square value was 0.54. This finding implies that the second model has more predictive power, explaining 54% of the total variance. ANOVA test was applied to compare the regression models. ANOVA test has extensively been used to detect mean differences among groups on a single dependent variable are likely to have occurred by chance (Tabachnick and Fidell 2014). In ANOVA test p and F values are the critical factors for determining the significant difference between the models. The ANOVA test results validated the existence of significant group difference between hierarchical regression models for the dependent variables.

Table 5. ANOVA test results of the regression models

Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	0.544	4	0.136	16.793	0.000
	Residual	0.615	76	0.008		
	Total	1.159	80			
2	Regression	0.627	7	0.090	12.270	0.000
	Residual	0.533	73	0.007		
	Total	1.159	80			

According to the Table 5, hierarchical regression models for environmental quality level were significantly different from each other (p=0.000). The assessments for the model performance indicate that the fitting accuracy of the model.

5. Discussion

This study focuses on the environmental aspect of the smart city concept by uncovering the effect of municipal solid waste generation quantity and municipal solid waste expenditures on environmental quality in Turkish cities. Furthermore, in addition to income level per capita, many other factors were analyzed in this study, with the aid of multivariate statistical methods. Overall results indicated that social development factors and waste management development play a great deal of important roles in environmental quality level. Moreover, the findings of this study signal that we can estimate the level of environmental quality by using municipal solid waste management in the next years.

The results imply that municipal solid waste expenditure per capita is a predictive factor for smart environment. This can be explained by adopting expensive disposal methods which adopt new technology rather than conventional and cheap municipal solid waste treatment methods such as dumping into landfill sites and burning in incinerations. According to Turkish Statistical Institute, 28.80% of what urban residents thought that was garbage is dumped in municipality's landfill site, 61.23% is dumped in controlled landfill site, 9.79% is send to recovery facilities, and 0.19% is disposed with unregulated methods (Türkiye İstatistik Kurumu 2017). This is in line with previous studies indicating the trade-off between smartness and costs of risks and quality assuring measures (Ikhlayel 2018). Although Nicolli et al (2010) found out that municipal solid waste production quantity has negative impacts over environmental quality in Italy, our result was not in line with this finding. Annual municipal solid waste generation quantity per capita and municipal solid waste expenditures rate in total environmental protection expenditures were not found to be predictor variables of environmental quality.

Municipalities are one of the local governments, and their number has reached 1397 in 81 provinces in 2016 (TC İçişleri Bakanlığı Mahalli İdareler Genel Müdürlüğü 2018). Our results showed that municipalities' solid waste management expenditures clearly had an impact on environmental quality level in Turkey. Municipalities have high level of responsibility to effectively manage municipal solid wastes, which are by-product of daily life. An integrated solid waste management requires a significant financial resource, approximately 2-3 billion TL depending on the choice of technology (TC Çevre ve Şehircilik Bakanlığı 2017). Those forecasting mean that municipalities need a larger investment resource than they can handle alone. This type of convergence of interests might get municipalities to adopt municipal solid waste management programs adopting IT towards better environmental quality level. Furthermore, the concept of partnerships should be a more inclusive option with a range of policy actors, and policy makers should enable public-private initiatives for municipal solid waste management to compensate the physical infrastructural gaps of municipalities.

In addition, environmental quality level turned out to be reflecting environmental inequality in the provinces. Existing environmental inequality in Turkish provinces is a major threat to public health and health status. Hence, the results imply that some further policy measures should be adopted and implemented to decrease the environmental inequality, controlling the effects of efficient municipal solid waste management.

The results show that municipal solid waste generation quantity (429 kg/per capita) in Turkish provinces is relatively higher than that in European countries. Beigl et al found that annual municipal solid waste amount of production in major EU cities with higher prosperity level is 415 kg/per capita (Beigl et al. 2014). This result can be explained by environmental awareness level and demand for environmental quality in European countries. According to a national project report, annual municipal solid waste generation quantity is 420 kg/per capita in 2008 (TC Çevre ve Orman Bakanlığı 2010). Our results implied that annual municipal solid waste generation quantity had increased by 2% from 420 to 429 kg/per capita in last eight years.

6. Conclusion

This study analyzes the impact foctors on environmental quality. The empirical restls show that the major influencing factor of environmental quality is municipal solid waste expenditures of municipalities in provinces of Turkey. Municipal solid waste expenditures and the literacy rate appear to increase environmental quality, while the under-five mortality rate influences negatively on environmental quality.

The results have some policy and administrative implications. First, local governments should efficiently operate their primer task of municipal solid waste management. Hence, some further financial and economic analyses are required. Second, performance of municipal solid waste management is undoubtedly prominent concern which should be focused on.

This study can provide insightful references for planning and the future environmental protection policy measures. Ascertaining the effect of municipal solid waste generation on environmental quality provides useful evidence and understanding for the policy making process regarding the urban environmental quality and its determinants. Municipal solid waste management policies should be seriously taken into consideration with the active involvement of actors for the sake of smart environment which is a key factor for critical health issues in a community, especially developing countries.

However, this study has some limitations. First, it is based on a cross-sectional data which is published by TUIK for just one year. Second, data extracted from indirect data source. Third, the explanatory power of the regression coefficient is not so high as it stems from one-year data. Some further research using a panel data on the relevant topic would provide clear and strong evidence. Although those limitations we expect that the results will induce many of the local governments to follow some efficiency guidelines to enhance the performance of municipal solid waste management.

References

[1] Adeoye PA, Sadeeq MA, Musa JJ, Adebayo SE (2016) Solid waste management in Minna, North Central Nigeria: Present practices and future challanges. In Rada EC (ed) *Solid waste management: Policy and planning for a sustainable society*, Apple-Academic Press, Oakville- Canada, pp 103-116.

[2] Arbulu I, Lozano J, Rey-Maquieira J (2015) Tourism and solid waste generation in Europe: A panel data assessment of the Environmental Kuznets Curve. *Waste Management* 46:628-636.

[3] Batty M, Axhausen KW, Giannotti F, Pozdnoukhov A, Bazzani A (2012) Smart cities of the future. *The European Physical Journal 214*:481-518.

[4] Beigl P, Wassermann G, Schneider F, Salhofer S (2014) Forecasting municipal solid waste generation in major european cities. *http://former.iemss.org/sites/iemss2004//pdf/regional/ beigfore.pdf. Accessed 28 October 2019*.

[5] Centre of Regional Science Vienna University of Technology (2019) *European smart cities.* http://www.smart-cities.eu/press-ressources.html. *Accessed 28 October 2019*.

[6] Cropper M, Griffiths C (1994) The interaction of population growth and environmental quality. *Population Economics 84*(2):250-254.

[7] European Commission (2012). *European Smart Cities*. http://www.smart-cities.eu/model.html. *Accessed 28 October 2019*.

[8] Evans M (1989) *Robustness and size of tests of autocorrelation and heteroscedasticity to non-normality.* Monash University.

[9] Ezechi EH, Nwabuko CG, Enyinnaya OC, Bobington CJ (2017) Municipal solid waste management in Aba, Nigeria: Challanges and prospects. *Environmental Engineering Research 22*(3):231-236.

[10] Giffinger R, Gudrun H (2010) Smart cities ranking: An effective instrument for the positioning of cities? *Architecture, City and Environment IV*(12):7-25.

[11] Giovanis E (2015) Relationship between recycling rate and air pollution: Waste management in the state of Massachusetts. *Waste Management 40*:192-203.

[12] Hair JF, Black WC, Babin BJ, Anderson RE, Tatham RL (2010) *Multivariate Data Analysis.* Pearson, New York.

[13] Ikhlayel M (2018) Indicators for establishing and assessing waste management systems in developing countries: A holistic approach to sustainability and business opportunities. *Business Strategy and Development* 1:31-42.

[14] Jerrett M, Eyles J, Dufournaud C, Birch S (2003) Environmental influences on healthcare expenditures: An exploratory analysis from Ontorio, Canada. *Journal of Epidemiology and Community Health* 57:334-338.

[15] Keleş R, Hamamcı C, Çoban A (2012) *Çevre Politikası.* İmge, Ankara.

[16] Lazaroiu GC, Roscia M (2012) Definition methodology for the smart cities model. *Energy* 47:326-332.

[17] Liu C, Wu X.-W (2010) Factors influencing municipal solid waste generation in China: A multiple statistical analysis study. *Waste Management & Research 29*(4):371-378.

[18] Nicolli F, Mazzanti M, Montini A (2010) Waste generation and lanfill diversion dynamics: Decentralized management and spatial effects. In Carraro C (ed), *Sustainable Develeopment Series*, Italy: Ferrara, pp 1-38.

[19] Norusis MJ (1999) *Guide to data analysis.* Prentice Hall, New Jersey.

[20] OECD (2008) *Household behaviour and the environment reviewing the evidence.* OECD Publications, Paris.

[21] Özeler D, Yetis Ü, Demirer, GN (2006) Life cycle assessment of municipal solid waste management methods: Ankara case study. *Environment International* 32:405-411.

[22] Pierzynski GM, Sims JT, Vance GF (2005) *Soils and environmental quality.* Taylor & Francis, Boca Raton.
[23] Ruston L (2003) Health hazards and waste management. *British Medical Bulletin 68*(1):183-197.
[24] Shafik N (1994) Economic development and environmental quality: An econometric analysis. *Oxford Economic Papers* 46:757-773.
[25] Streimikiene D (2015) Environmental indicators for the assessment of quality of life. *Intellectual Economics 9*:67-79.
[26] TC Çevre ve Orman Bakanlığı (2010) *Türkiye'nin iklim değişikliği ulusal eylem planı'nın geliştirilmesi projesi atık sektörü mevcut durum değerlendirmesi raporu.* Ankara.
[27] TC Çevre ve Şehircilik Bakanlığı (2017) *Ulusal atık yönetimi ve eylem planı (2016-2023).* Ankara.
[28] TC İçişleri Bakanlığı Mahalli İdareler Genel Müdürlüğü (2018). *2017 yılı mahalli idareler genel faaliyet raporu.* Ankara.
[29] Türkiye İstatistik Kurumu (2016) *İllerde yaşam endeksi.* http://www.tuik.gov.tr/ PreHaberBultenleri.do?id=24561. Accessed 28 October 2019.
[30] Türkiye İstatistik Kurumu (2017) Belediye atık istatistikleri, 2016: http://www.tuik.gov.tr/ PreHaberBultenleri.do?id=24876. Accessed 28 October 2019.
[31] Türkiye İstatistik Kurumu (2017) *Bölgesel istatistikler*. https://biruni.tuik.gov.tr/ bolgeselistatistik/tabloOlustur.do. Accessed 28 October 2019.
[32] Türkiye İstatistik Kurumu (2017) *İstatistiklerle çevre, 2016*. http://www.tuik.gov.tr/ PreHaberBultenleri.do?id=27685. Accessed 28 October 2019.
[33] Tabachnick BG, Fidell LS (2014) *Using Multivariate Statistics.* Pearcon, Essex.
[34] The World Bank (2001) *COSEPRE- Costs of urban cleasning services - technical documentation.* The International Bank for Reconstruction and Development, Washington, USA.
[35] Varol Ç (2017) Smart city approach for sustainable development: Practices of municipalities in Ankara. *Çağdaş Yerel Yönetimler 26*(1):43-58.