RESEARCH ARTICLE **(Open Access)**

Assessment of the green space of Tirana city and its impact on some public health indicators

ZYDI TEQJA[1]; ENKELEJD LEKAJ[1]; ZAMIR LIBOHOVA[2]; NIKOLLAQ BARDHI[3]

[1] Department of Horticulture and Landscape Architecture, Agricultural University of Tirana, Tirana, Albania

[2] USDA-NRCS-National Soil Survey Center, Lincoln, SHBA

[3]Department of Agronomic Sciences, Agricultural University of Tirana, Tirana, Albania

Abstract

The study of urban green space has become an important topic of research in the last decade. In this study the green area coverage of 11 administrative units of Tirana is evaluated based on the 2015 orthophoto. The total green area and the distribution for administrative units as well as relationships between the amount of green space, suicide, and noise and air pollution over different buffer distances from the monitoring points are evaluated. Over 27% of the area of the city of Tirana is covered by greenery but the distribution is heterogeneous among administrative units. The noise tended to decrease with increasing amount of greenery; however, the trends were not significant. On the other hand, the amount of air pollution decreased significantly with increasing amount of greenery and the strength of the relationship increased with increasing distance from the monitoring points. The relationship between greenery and suicidal rate overall was not significant, except for the most urbanized administrative units; however this based on a limited sample size. The data from this analysis shows trends between the amount of greenery and various health and environmental indicators that could be useful for better planning and management of green spaces in the future, however, more data is needed.

Keywords: Greenery, orthophoto, noise, air pollution, suicide

1. Introduction

The accurate estimation of green area size and distribution is important as it affects urban life and improves health conditions of urban population (6, 13). The definition of the term "green space" can be confusing and biased depending on the measurement or estimation method. This is especially critical for urban areas where the determination of the amount and distribution of green space is challenging due to its heterogeneity. Urban green space is often treated in a general way, but in order to reach accurate and comparable conclusions, a clear definition of green space must be given in each case and what is included in the study must be described. To increase the representation of the important qualities of green spaces, elaborate methods should be used to measure these qualities and green space data with the highest possible resolution are needed to demonstrate the characteristics of urban green space experienced by people. Such efforts can be seen in some studies that focus on measuring urban green space such as images of green space captured through the Google Street View or using a camera to measure the amount of urban green space visible from perspective of the user (25, 33, and 45). Liang et al, (34) also used the drone to measure the amount of 3D green space.

The choice of measurement method depends on the intent of the researcher and the possibilities for obtaining the data. We can distinguish three groups of methods:

(i) The first group is based on self-reporting (with surveys given to participants to measure the perceived availability of green space);

(ii) The second group is based on inventories of areas planted with different vegetation;

(iii) The third group is based on aerial imagery and geographical maps.

*Corresponding author: Zydi Teqja; E-mail: zteqja@ubt.edu.al

(Accepted for publication 22.12.2020)

***ISSN**: 2218-2020, © Agricultural University of Tirana*

There are advantages and limitations in determining the most accurate coverage of green space by each group of methods (43). The measurement of green space through questionnaires is based on the study of the population living in the study area. Questionnaires provided to the population in urban areas can be useful when assessing information about green space such as: proximity to home, accessibility, perceptions of quality and current use (28; 31). However, this method requires intensive resources and may not be possible in all studies. Also, the accuracy of the method is affected by the self-reporting of individuals that can result in a biased classification (19). Self-reporting of neighborhood characteristics could be affected by the health conditions of participating individuals. This may be especially true when the outcome includes psychological disorders such as depression (35, 37, and 42).

Measurement of green spaces based on inventories of land planted with vegetation often does not consider the trees and other greenery on the side of roads or urban squares thus removing a significant amount of urban greenery.

Measuring green space using mapping tools is based on Geographic Information Systems (GIS) technology. GIS is a powerful computer mapping technology and analysis that allows large amounts of information to be viewed and analyzed within a geographical context (53). Basically, the GIS program electronically defines large geographical areas to see the physical characteristics of a given land, using satellite imagery (Landsat, CORINE, etc. 30, 32, 50, and 51). GIS along with spatial analytical techniques are widely used to study public health issues (11, 41). Through various methods, GIS can be used to determine the area of land that is classified as green space. These methods include various geographic maps and existing data in the GIS program.

One index that is used to measure the amount of green space in urban areas is the Normalized Difference Vegetation Index (NDVI). NDVI provides objective measurements of healthy vegetation levels using Landsat images that can be applied to almost all land surfaces worldwide (15, 21, and 46). It is widely used in forest and agriculture research. In some researches, NDVI has been used in studies of the links between neighborhood greenery and health (4, 5, 13, 29, 52).

However, the use of NDVI for the definition of green space in urban environments may have some limitations. For example, spatial distribution of vegetation may be less concentrated and more difficult to detect at high levels of population density, compared to neighborhoods with lower densities (46). Also, an NDVI pixel in an urban setting rarely covers a single homogeneous region (as in the case of the agricultural environment) which makes it difficult to determine the vegetation within that pixel. Another limitation relates to the fact that there are many factors that affect the relationship between NDVI and geographical and physical attributes. These may include atmospheric conditions, image scale, vegetation moisture, soil moisture, general vegetation cover, and changes in soil type (1).

Finally, a major limitation to using NDVI to define green (or "open") spaces is its reliance on color reflection as a method of detection. This can greatly affect the determination of the amount of these areas considering the seasons. For example, during the seasons the leaves normally change color from green to red or yellow, which would result to lower NDVI score (22). This limitation can be addressed to a certain degree by applying the NDVI during late spring and early summer when the green coverage is likely at its peak.

An alternative method to NDVI is the classification of high resolution orthophotos, when available. ArcGIS offers flexibilities for more detailed spatial analysis of green space and pattern distribution.

For example, the high resolution orthoimage can be used to determine the area covered by the green space within a user specified buffer zone around any objects (streets, building, houses, etc.). However, this method depends on the definition of green space and on the manual characterization of land as "green space" and "other space". Based on the definition of green space used the method can be very subjective. Also, the method may require field validation in order to ensure accuracy.

In addition to amount and distribution an important indicator for green space is density. This would require an assessment of the strength of reflection in the case of satellite image or color in case of orthoimages. These are more challenging to quantify.

Albania was a rural country until beginning of the new century. The rapid changes that happened during last decade of twentieth century (49) were crowned in 2007 when for the first time the majority of Albanian population lives in urban areas. As developing countries like Albania move toward urban development the disconnectedness from nature is

increasing and it brings in scene the scientific interest in the potential health benefits of nature contact. Though there is evidence to suggest that contact with nature gives a range of health benefits and research recently has yielded substantial evidence on the role of urban green spaces, still there are large gaps in our understanding on this relationship (16, 20).

According to a WHO report (55), mental disorders contribute to many suicides around the world. Over 800 000 people die due to suicide every year and it is the second leading cause of death in 15-29-year-olds (WHO 2014). This is why the research on the benefits of mental health through reduced depression (3, 5, 10, 17, 27, 36, 40, 48, 54); Reduced anxiety (2, 5, 9, 41, 47) and Stress recovery and Suicide prevention (2, 8, 18, 24, 44, 55) seem to be more challenging.

The objective of this study was to: (i) determine the amount and distribution of greenery in the capital city of Tirana (Albania), and (ii) the relationships between the amount of greenery and health and environmental indicators.

2. Materials and Methods

2.1 Data sources

The geo-rectified orthophoto of 2015 for the city of Tirana provided by ASIG (The State Authority for Geospatial Information) was used for this study. The Projection of the ortho image was European Terrestrial Reference System 1989; GRS 1980 Ellipsoid, Lambert Equal Area Projection (ETRS_1989_LAEA) with an 8 cm pixel resolution.

The data on the level of noise and pollution for some monitoring points of the city of Tirana were provided through the National Environment Agency and data on the number and causes of death according to the administrative units of the city of Tirana were provided by the General Directorate of Civil Status.

2.2 Data Processing

The orthro image in RGB color space was classified in 5 classes using Iso Cluster Unsupervised Classification in ArcMap 10.5. The 11 polygons administrative units of Tirana were converted to raster using the same resolution and extend (snap) as that of classified image. Administrative units were used as mask to extract the classified image. The area of each class was calculated in m2 and km2 then zonal statistics was run to determine the percent green area for each administrative unit. After that, the distribution of green space for 11 units based on squares with 200m sides was estimated by calculating the standard deviation and the coefficient of variation. To assess the impact of greenery on noise and air pollution (particulate matter-PM10 in μg /m^3), the green space was calculated for buffer zones of 25m, 50m, 100m, 200m radius from the monitored points for noise level and PM10 in the municipality of Tirana. To better quantify the spatial distribution of green spaces within each administrative unit, the study area was divided into squares of 200x200m and the number of tiles with green spaces was calculated. The coefficient of variation of the distribution of greenery within each unit was determined. These squares were also used to test the accuracy of the green area measurement by means of orthophoto conversion. For this purpose, manual digital measurement was performed in 11 squares with a surface of 200x200m randomly selected (one for each administrative unit).

2.3 Data Analysis

Simple linear regression analysis was conducted to assess the relationships between the amount of greenery and health and environmental indicators. The analysis was performed in Excel for Microsoft Office 365.

3. Results and Discussions

3.1 Amount and distribution characteristics of green space

Figure 1 shows the general view of the orthophoto of the city of Tirana provided by ASIG, while Figure 2 shows the same image after the color classification with the administrative divisions of the urban area of Tirana. The third category of color values in Figure 2 represents the green space. After extracting the classified image it was possible to calculate the area of each class and then zonal statistics was run to determine the percent of green area for each administrative unit. The total area, green spaces and some spatial distribution characteristics for the 11 administrative units of the municipality of Tirana are given in Table 1.

Figure 1. Orthophoto of Tirana 2015 (Source ASIG Albania: https://geoportal.asig.gov.al/).

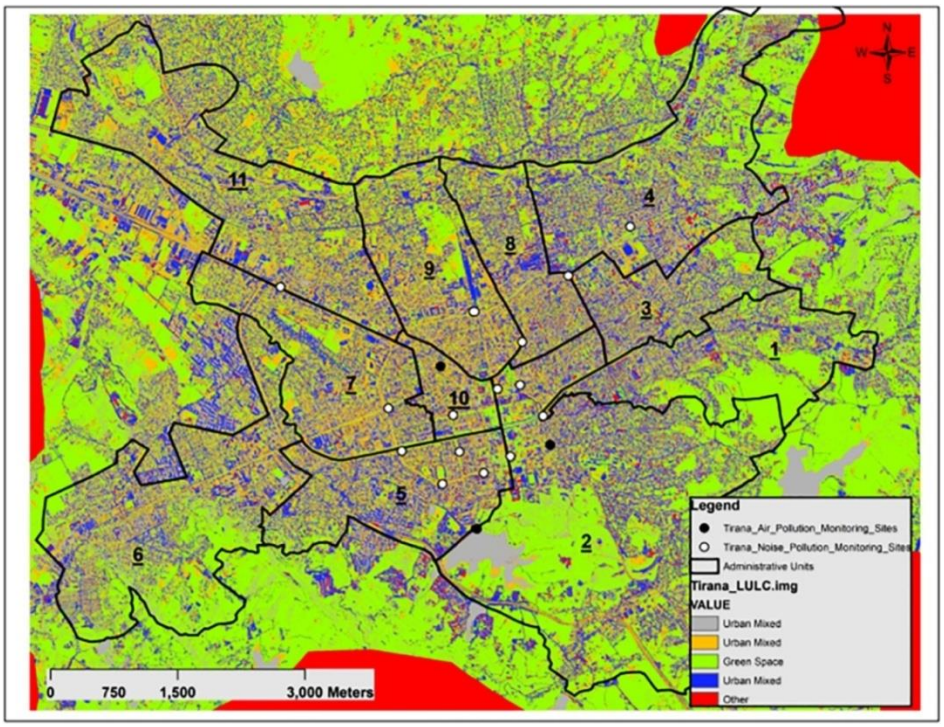

Figure 2. The classification of the ortho image for Tirana city; the borders of Administrative units and the locations of noise and PM10 pollution observations. The third category of color values represents the green space.

Table 1 Spatial distribution characteristics of Tirana green space, life span and suicidal cases by administrative units.

Administrative Unit	Total Area (km2)	Green Area (km2)	% of Green cover	Standard deviation	Variation coefficient	Life Span (years)	Average Suicidal cases	Suicidal Rate (/1000 deaths)
1	3.06	1.22	39.9	10307	65%	72.9	2.7	10.3
2	9.58	3.98	41.5	9174	56%	73.9	4.2	10.1
3	2.01	0.4	19.9	6000	78%	73.0	2.0	8.2
4	4.92	1.29	26.2	5850	56%	71.8	0.8	2.8
5	2.87	0.46	16.0	3940	65%	74.9	2.2	5.0
6	5.48	1.67	30.5	7894	71%	71.6	3.2	9.6
7	3.06	0.48	15.7	4176	70%	75.2	2.0	5.7

8	1.95	0.28	14.4	3311	58%	74.8	1.7	7.1
9	2.82	0.55	19.5	6094	72%	73.8	1.5	4.8
10	0.77	0.11	14.3	2567	48%	76.7	1.3	6.5
11	5.21	1.12	21.5	5253	60%	71.2	2.3	8.5

Figure 3 shows what percentage of the green area for each administrative unit. A significant part of the green area consists of greenery from trees along the streets, which is an important part of urban greenery. About 27.7% of the territory of the city of Tirana is covered by greenery with a somewhat heterogeneous distribution among the administrative units. Thus, the amount of green space varies from about 14.4% (administrative unit no. 8) to about 40% (administrative units 1 and 2). The administrative units 1 and 2 have only recently expanded to include former rural areas where the density of construction is still low.

To validate our model and to better understand, what the distribution of green spaces is in each administrative unit, the city territory was divided into squares with 200m sides. These squares were used to test the accuracy of the green area measurement by means of orthophoto conversion. For this purpose, manual digital measurement was performed in 11 squares with a surface of 200x200m randomly selected (one for each administrative unit). Figure 4 shows the relationship between the values measured through the orthophoto conversion model and the values measured manually. The strong correlation between these values is clear, which indicates the high accuracy of the measurement by our model. Note that all manual measurements are slightly lower than those by model. This may be due to the fact that by manual measurement it is difficult to include every green pixel in the measurement. This is evident in the fact that the measurements are almost equal when the green area is large and compact. It was therefore judged that there is no need to make correction to the model measurements.

This was followed by the analysis of the distribution of greenery within each unit by means of the coefficient of variation. These spatial distribution characteristics of the green space within each administrative unit are given in Table 1. The analysis shows that administrative units 3, 6 and 9 have the highest coefficient of variation, which means that they have the most heterogeneous distribution of green space. Units 2, 4 and 10, on the other hand, have a lower coefficient of variation, so they have a more uniform distribution of green space. Likely, the residents of these units have more equal opportunities to benefit from greenery.

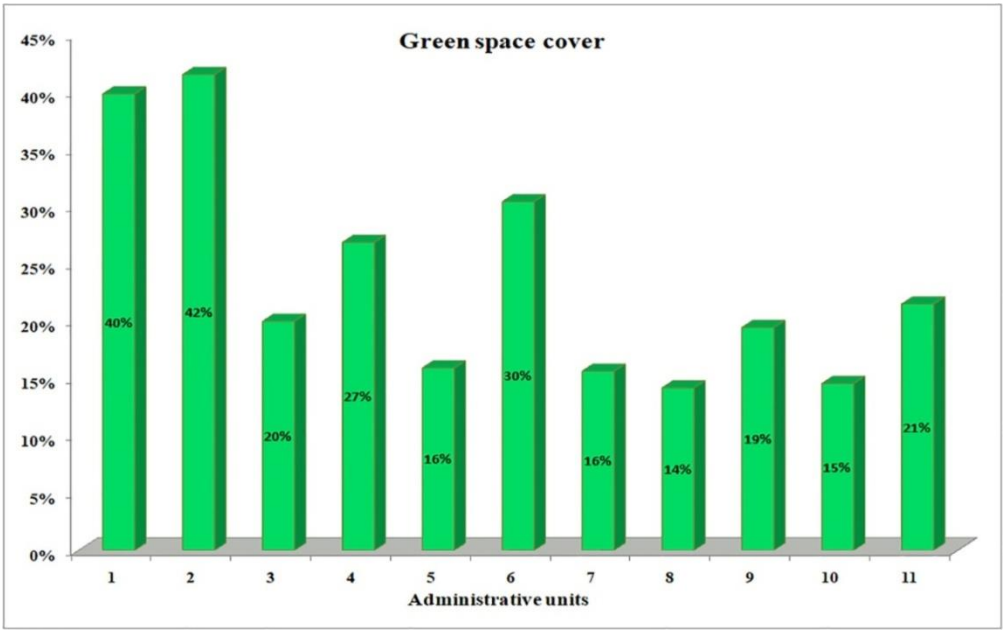

Figure 3. Green space in percentage of the total area by administrative units.

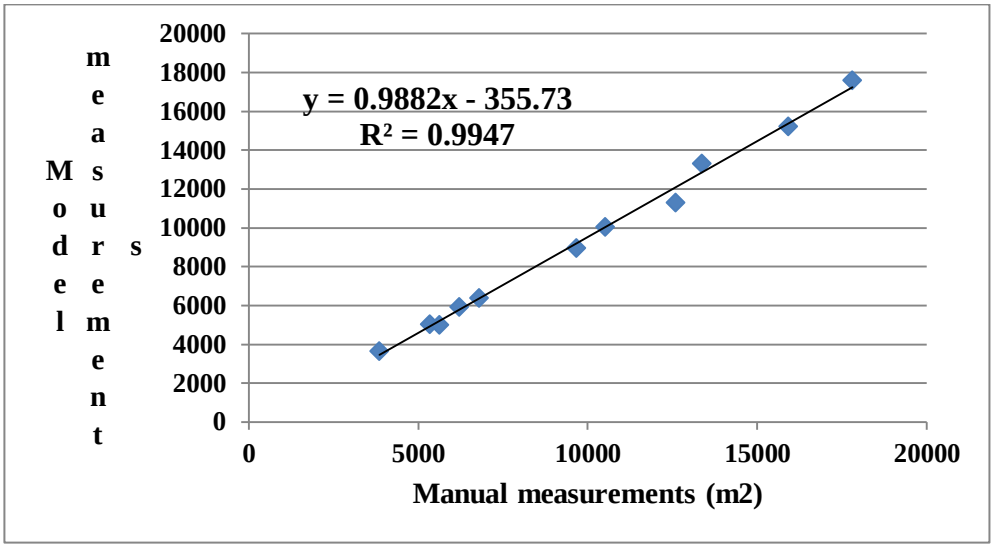

Figure 4. The relationship between manual and model measurements of green cover

3.2 Impact of green space on noise

To see the impact of greenery on noise levels we analyzed 15 monitored points for noise level (Figure 1) and calculated the green area in buffer zones with radiuses 25m, 50m, 100m, and 200m. The data are shown in Table 2.

Table 2. Green space amount in m2 for varying buffer distances from 15 Tirana city monitoring points. (Source of noise data: Reports of the National Environmental Agency of 2016).

No	Monitoring points	Green cover for different buffer zones				Year 2015	
		25m	50m	100m	200m	Day	Night
1	American Bank	25	258	2010	13202	63.47	62.83
2	Farmacia 10	85	664	3148	16995	67.63	53.44
3	21 Dhjetori	299	685	2663	11163	68.41	61.05
4	Vasil Shanto	422	1888	6672	19929	66.39	54.89
5	Police Directorate	501	1360	4239	14546	64.76	53.67
6	Selvia	39	221	2028	11199	65.39	58.72
7	Laprake	92	221	777	7698	67.69	60.03
8	Palace of Congresses	159	879	6721	33944	64.27	54.47
9	Unknown Partizan	258	777	3538	19096	67.35	57.34
10	Shkolla Bashkuar	117	1105	5591	19523	66.21	53.47
11	Dinamo Stadion	238	1088	4319	16273	59.45	58.54
12	Elbasani Street	226	1011	4350	17927	71.16	61.43
13	Skenderbeg	41	1031	10254	26707	74.25	62.49
14	Train Station	96	421	3331	13567	64.04	61.63
15	Edith Durham school	316	1500	3938	15644	61.69	58.07

The graphs in Figures 4 and 5 show the relationship between the green area and the noise level at night for 15 points at 25 and 50 m distance. These figures show a tendency to reduce noise with increasing greenery, but it should be noted that the relationship is weak and statistically unverified, so this issue needs more studies and perhaps better data quality.

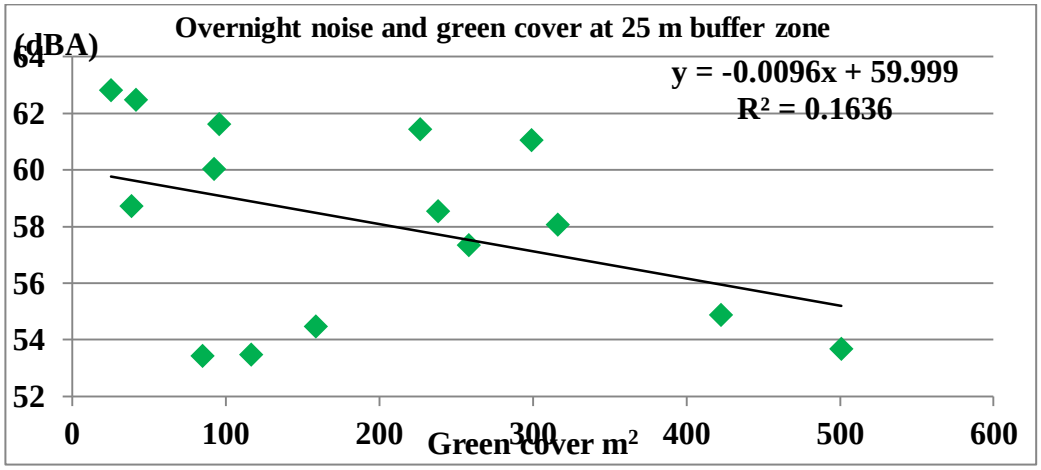

Figure 4. Relationship between overnight noise level and amount of greenery within a 25m radius of the monitoring point.

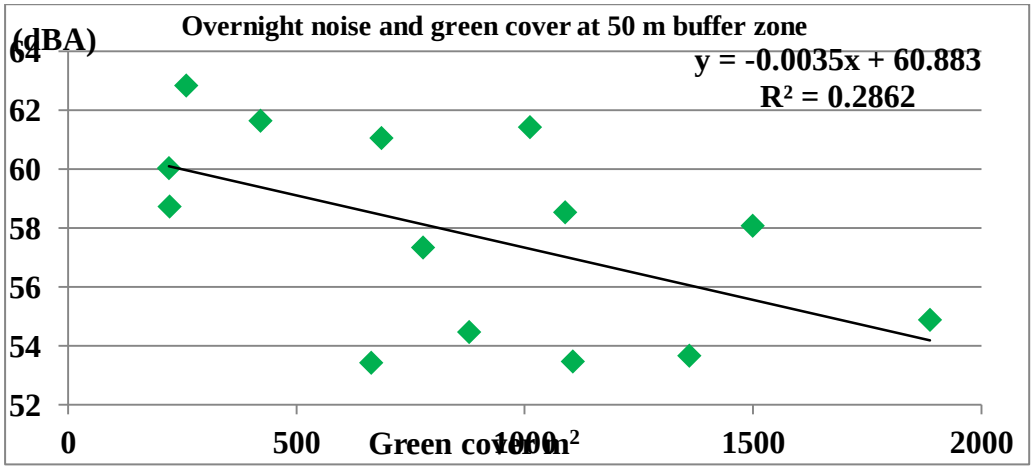

Figure 5 Relationship between overnight noise level and amount of greenery within a 50m radius of the monitoring point

3.3 Impact of green space on air pollution (PM10)

It was possible to find data on the level of pollution by PM10 particles for 11 monitoring points (Figure 1). Monitoring points for PM10 µg / m3 level and green area in buffer zones with radiuses 50m, 100m, 200m are given in table 3.

Table 3 Monitoring points for PM10 and green area for different buffer zones.

No	Monitoring points	Green cover for different buffer zones			PM10
		50m	100m	200m	µg/m3
1	**Farmacia 10**	631	2803	16576	40.62
2	**Iranian Clinic**	800	3197	17980	34.40
3	**Paris Commune**	90	720	8165	28.59
4	**21 Dhjetori**	196	2478	10743	73.65
5	**Koco Glozheni M**	1779	5501	16696	31.20
6	**Palace with arrows**	486	3871	16421	48.68
7	**Ali Demi St.**	1367	4723	16342	45.60
8	**Elbasani Street**	1602	5128	18337	37.55
9	**Dynamo Stadium**	902	3972	18242	36.72
10	**Train Station**	567	2374	13829	51.25
11	**Zogu Zi**	604	1506	6734	71.18

Source PM10 data: ISHP

Figure 6 shows the association of green spaces for different buffer zones from the monitoring point with the level of PM10 particles. It can be seen that the strength of the green area impact on PM10 increases with distance from the monitoring point represented by the buffer size. Increasing the green area leads to significant reductions in pollution.

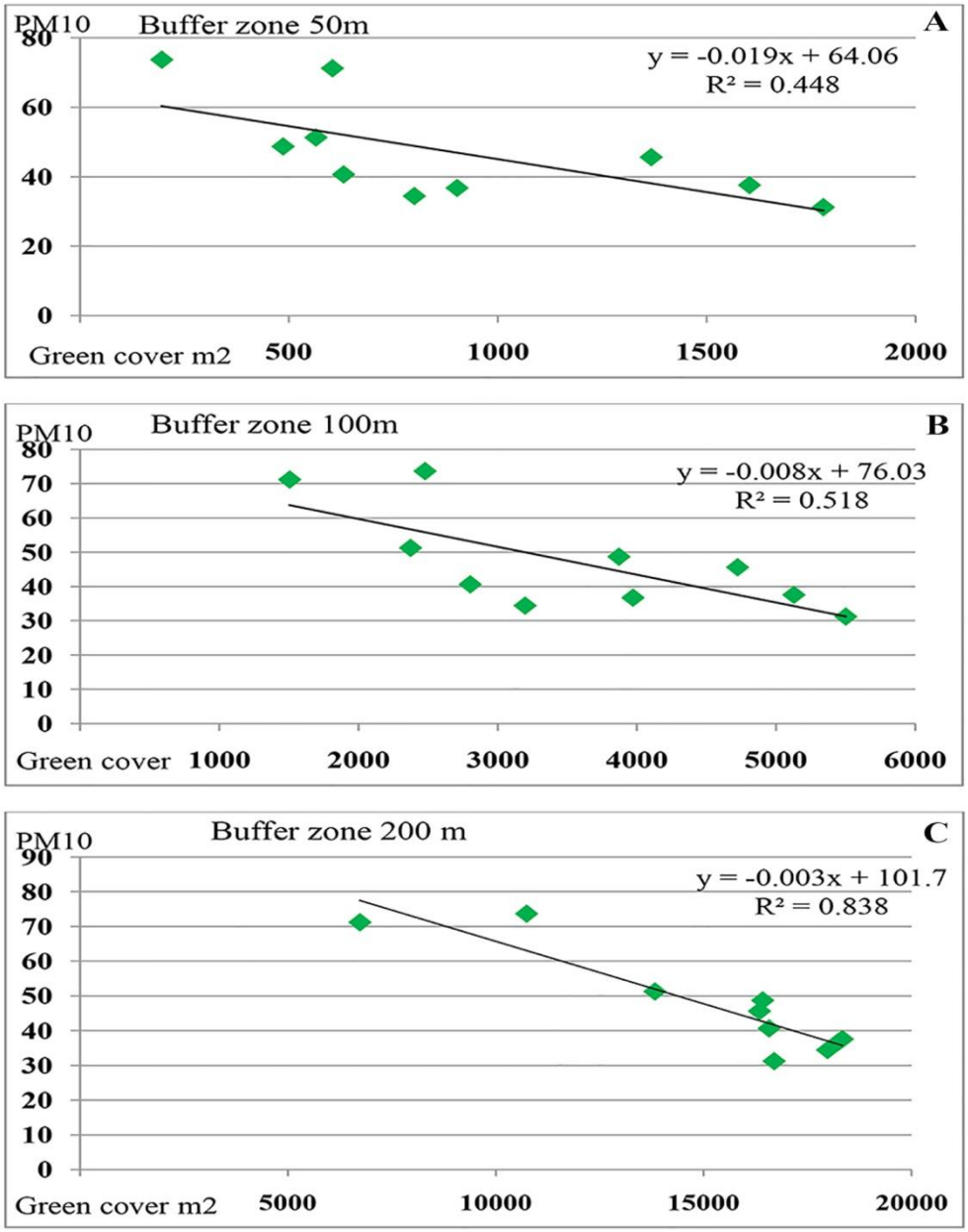

Figure 6. Impact of green space on PM10 for (A) 50m Buffer; (B) 100m Buffer; and (C) 200m Buffer.

Figures 6 a, b and c show that the strength of the green area impact on PM10 increases with distance from the monitoring point represented by the buffer size. Increasing the green area leads to significant reductions in pollution. The impact of greenery on air pollution has been discussed in different studies. Some of them consider the management of urban tree canopy cover as a viable strategy to improve air quality and help meet clean air standards (38, 39).

3.4 Greenery and suicides

The impact of greenery on mental health problems has been highlighted by several authors (references). In this study we analyzed the relationship between the number of suicides (as an extreme case of mental health) and the amount of greenery by administrative units (Figure 7).

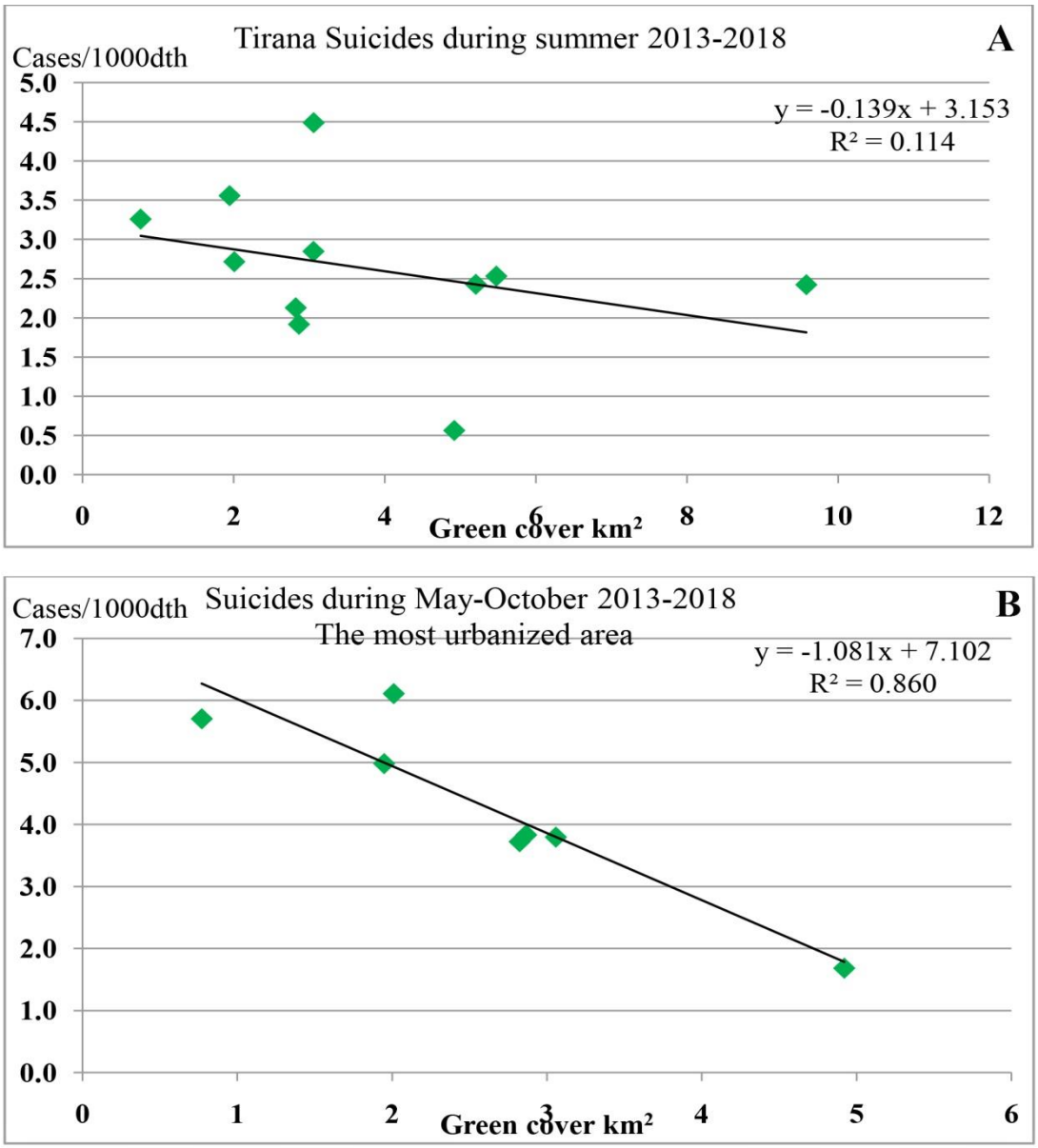

Figure 7 (A) Greenery and summer suicides for Tirana city; (B) Greenery and suicides for the May-October period for the most urbanized area of Tirana city.

If we perform a simple analysis for this relationship it seems that there is no relationship between these parameters. But if we focus only on the warm period of the year (in fact this is the period when the need for greenery is most felt) we see the emergence of a trend in this relationship (Figure 7 A). If we separate from this relationship the administrative units which in their territory have large rural areas and focus on the real urban area, so if we exclude the administrative units 1, 2, 6 and 11 then a clear connection is found between the green area and the number of suicides. So there seems to be a high and significant relationship between the amount of green and suicidal rates occurring during May-October period for the most urbanized administrative units (Figure 7B).

This situation could be explained as follows:

1. The administrative units 1, 2, 6 and 11 in recent years have included in their territories many areas that were previously outside the city and continue to have a pronounced rural character and it does not make sense to analyze the impact of greenery in rural areas where greenery is abundant.
2. In these areas there is a great change of population due to internal migration. So a large part of their population has not been there all their life but have come the last two decades.
3. As a consequence of the above two facts, these units also have important socio-economic differences with the most urbanized part of the city, differences

that make the studied connection much more complex and justify their separation.

According to different studies flora and fauna in urban green space can reduce blood pressure, depression and boost immune function. Vegetation in urban green space can also reduce health risks by mitigating air pollution and reducing the effect of hot islands in urban areas (28) as well as regulating other aspects of the microclimate.

Also natural views and sounds created by flora and fauna can increase parasympathetic activation, which can reduce metabolism and promote relaxed and calm feelings (23). Other structures in urban green space such as open space and playgrounds can encourage health behaviors through physical activity and social interactions, which have resulted in positive health indicators (12, 14).

It is very likely that the impact on depression and suicide is both from the effect that green space have on pollution reduction and from the direct effect of greenery. According to a recent study (7) exposure to air pollution is associated with an increased risk of depression and suicide. This analysis reviewed 25 studies published by the end of 2017 and found that someone living for at least six months in an area with twice the limit recommended by World Health Organization for fine particles, PM2.5, there would be approximately a 10 percent risk of increased depression. For suicides a link was found between short-term exposures to PM10 contamination. Thus exposure to 10 μg / m3 of PM10 over a three-day period was associated with a 2 percent higher risk of suicide (7).

Although the data shows a relationship between suicidal rate and the amount of green space especially for the May-October months, the results from this analysis need to be viewed critically. First, there is a very limited number of data. Second, there may be other underlying reasons for the observed suicidal rates and their relationship with the amount of green space. So, more studies and data are needed for reaching a definite conclusion.

4. Conclusions

Orthophotos provide very high resolution images making them very useful to measure and study green cover in urban areas where satellite resources like CORINE Land Cover cannot identify green spaces because of low resolution. In this study the orthophoto with 8cm resolution is used to measure and study the green cover of Tirana city. More than 27% of the area of the city of Tirana is covered by green vegetation. There is a heterogeneous distribution of green space between administrative units varying from 15% to 40%.

The relationships between environmental indicators (noise and air pollution) and the amount of green cover, though not all significant highlight in general the importance of green space for a healthy life. The relationship between suicidal rate and amount of green space, though intriguing should be interpreted with caution and merits further research.

The results from this study could potentially aide in better planning and management of green spaces in the future.

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