

# Green Space and Happiness of Developed Countries

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**Abstract**—Previous research has reported a connection between urban green space and public health that ultimately contributes to happiness. Existing studies have mainly investigated green space over small areas. This paper revisits this significant correlation by examining the relationship between country-level happiness and the amount of urban green space as measured systematically from satellite images. Based on 2018 and 2013 data from 30 developed countries, we found that there is a correlation between urban green space and happiness, and this relationship becomes stronger among countries with higher GDP. We also found that the relationship between happiness and green space has grown stronger over time.

**Index Terms**—Happiness, Green space, Satellite images

## I. INTRODUCTION & BACKGROUND

Investigating the effects of green space and air pollution on public health has often been an exciting research topic. Scholars have found that air pollution can lead to a wide range of health problems and that green space can have a positive effect on the removal of air pollution [3]. In addition to the impact of green space on air pollution and public health, its impact on stress is also significant. As noted by Grahn and Stigsdotter, the realized sensory dimensions of urban green space help people to recover from stress [4]. Urban green space can encourage more recreation and physical activity and enhance social interaction [11], [13]. Other research has suggested that mental health improves for those surrounded by green space: Kaplan found that being in green environments can be of great help to mental health [8].

According to the annual World Happiness Report, social interactions and health are both influential factors of happiness [5], [6]. As one might imagine, mental health, stress reduction, increased social interactions, and air pollution removal all contribute to the health and, therefore, exploring the link between happiness and green space will be useful. MacKerron and Mourato present research with a new approach by delving into the correlation between momentary subjective well-being (SWB) and individuals' immediate environment. By developing a smartphone app, in a random location, they asked participants to answer a brief questionnaire about SWB [10]. They found that participants are happier in green environments than in urban environments.

For exploring the link between happiness and green space at the country-level, it is necessary to consider other factors that happiness depends on. Growth in GDP is known to be

associated with happiness [2]. However, a curved relationship emerges between income and happiness rather than a straight-line relationship. This trend indicates, beyond a certain level of income, additional life satiation gain will not follow [7].

Unlike previous studies on the relationship between green space and well-being [1], [9], this paper studies the effects of green space on happiness at the country-level. Moreover, we investigate this relationship over time to show that the impact of green space on happiness increases over time. Every year the World Happiness Report has been published and used a score to describe the life satisfaction in each country. We use these indexes as a criterion of life satisfaction. Only countries with the highest Human Development Index (HDI) are considered because it is not possible to compare many countries due to their special circumstances (e.g., civil war, sanctions, etc.). By considering countries with the highest HDI as an essential criterion in measuring the richness of human life, the comparison of nations would be achievable.

For green space, we used satellite images to calculate the percentage of green space in a country. Official statistics only include official parks and open space in calculating green space.<sup>1</sup> In contrast, we take two different approaches to measurement. The first approach takes in the images of the target cities and its green space (e.g., official park, forest, grassland, trees, etc.). We find that the boundary of municipal towns could lead to noise in data. Hence the second approach takes an arbitrary three-kilometer radius from the target city hall and its green space. We test two main hypotheses:

H1: Urban green space will be positively correlated to happiness.

H2: The above relationship will become stronger over time.

## II. DATA AND METHODOLOGY

### A. Happiness Score

The world happiness report covers 156 countries and measures how happy their citizens realize themselves to be. This report hence annually produces the rank of countries in terms of *happiness score*, which is the average response of the survey on how happy participants are in life in the range between 0 and 10. While many factors may affect happiness, not

<sup>1</sup>For example, see [www.worldcitiescultureforum.com](http://www.worldcitiescultureforum.com)

all of them appear in the report because of the lack of comparable data across the 156 countries (e.g., unemployment, inequality, etc.). Therefore, the report describes happiness by six primary agents — GDP per capita, social support, healthy expectancy, freedom to make life choices, generosity, and perceptions of corruption — and also one extra element to characterize residuals, disappeared factors, that are effective on happiness [5], [6].

### B. Satellite Images

The USGS website (earthexplorer.usgs.gov) offers a 30m-resolution Landsat 8 satellite images for summer 2018. A total of 68 images tiles are used in this research, where each tile covers approximately 37,000km<sup>2</sup> and 41,581,593 cells. The Normalized Difference Vegetation Index (NDVI) is a well-known remote sensing indicator to assess the green vegetation area in satellite images. Areas with high NDVI scores include official parks, backyards, street trees, mountains, riverbanks, golf fields, and urban farmlands.<sup>2</sup> The examples in Fig. 2 shows urban green space is highlighted based on this score. The NDVI is calculated from two spectral bands of Landsat 8, RED (Band 4) and Near Infrared (NIR, Band 5), as follows:

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

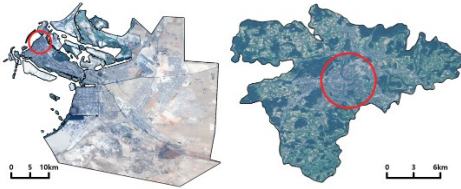


Fig. 1: Examples Landsat 8 satellite images. Red circles show 3-km radius zones from city halls. (Left: Abu Dhabi in UAE, Right: Bern in Switzerland)

### C. Data Selection Criteria

We consider two criteria. One is the gross domestic product (GDP), which evaluates the monetary value of final services and loading that produced over a year. Even though this measure alone cannot capture the overall living standard, GDP per capita is considered a compelling factor that describes people’s well-being.

Another is the Human Development Index (HDI), which focuses on people, their choices, and opportunities to look for expanding the richness of human life. The Human Development Reports (HDRs) has introduced this index as a measure of attainment [12]. Thenceforth, country-wise ranking by HDI has been popularly used. Many agents are considered to increase the enrichment of human life, where the most significant factors are known to be the gross national income per capita, life expectancy index, and education index. Unlike GDP that considers the income of anyone within a country, the

<sup>2</sup>The threshold to determine green space varies from continent to continent. An average score of 0.3 is used based on guidelines.



Fig. 2: Examples areas with high NDVI scores. (Top-left: Park Guell in Barcelona, Spain. Top-right: River banks in Yeouido in Seoul, Korea. Bottom-left: Urban farmlands in Abu Dhabi in UAE. Bottom-right: Trees in Vancouver, Canada)

gross national income includes all the income of a country’s residents as well as that of businesses. The life expectancy index and education index reflect the current standing of health and education in a country, respectively.

### D. Analysis Methodology

To understand the statistical relationship between happiness and green space, one needs to control for factors that are related to happiness. This paper hence limits observations to developed countries with high HDI [12]. Because this metric encompasses life expectancy and education, which are critical to happiness, limiting countries to high HDI can effectively control for these factors. Therefore, the top 40 countries in HDRs 2018 has considered and then sorted in terms of GDP [6], to control for financial considerations. Afterward, the top-30 countries were selected.

Most countries have green space (e.g., forest) where no one lives, so exploring the percentage of green space in the country-level would not be a fair comparison between countries since some countries are larger. The idea to solve this problem is to consider cities’ satellite images to calculate green space to avoid considering forests. But according to the World Happiness Report, the happiness score is a measure in the country-level. If city-level data are to be regarded as country-level data, the selected cities must be a good representation of the country’s population distribution.

For proper representation of the country, the sum population of the chosen cities should be large enough, so we consider 10% of the country’s population as a threshold with at most ten cities. Also, the percentage of green space for each country is calculated as the ratio of the sum of cities green areas to the sum of total cities area. Due to the previous explanation, some countries with high HDI were not reviewed (e.g., United States, France) because their dispersal of the population is high, and taking ten cities with the highest population would not be enough to pass the threshold. In some cases, a single city already covered over 10% of the country’s population. For

	Country	GDP <sup>†</sup>	Happiness	Cities <sup>‡</sup>	Satellite <sup>§</sup>
1	Qatar	11.693	6.374	2 (22%)	1
2	Luxembourg	11.459	6.910	2 (17%)	1
3	Singapore	11.309	6.343	1 (61%)	1
4	UAE	11.109	6.774	3 (23%)	1
5	Norway	11072	7.594	4 (20%)	4
6	Ireland	11.046	6.977	1 (21%)	1
7	Switzerland	10.957	7.487	7 (13%)	3
8	Netherlands	10.768	7.441	5 (14%)	2
9	Sweden	10.750	7.314	3 (23%)	3
10	Denmark	10.736	7.555	2 (24%)	1
11	Iceland	10.711	7.495	2 (44%)	1
12	Austria	10.705	7.139	3 (21%)	3
13	Australia	10.700	7.272	3 (44%)	3
14	Germany	10.699	6.965	7 (11%)	6
15	Canada	10.670	7.328	3 (30%)	3
16	Belgium	10.648	6.927	4 (16%)	1
17	Finland	10.588	7.632	3 (18%)	2
18	U.K.	10.576	6.814	4 (15%)	2
19	Japan	10.554	5.915	6 (16%)	4
20	Malta	10.476	6.627	4 (17%)	1
21	New Zealand	10.469	7.324	2 (17%)	2
22	South Korea	10.464	5.875	1 (19%)	1
23	Italy	10.457	6.000	7 (12%)	6
24	Spain	10.414	6.310	5 (15%)	5
25	Israel	10.392	7.190	3 (19%)	1
26	Czechia	10.359	6.711	2 (14%)	2
27	Slovenia	10.312	5.948	3 (19%)	1
28	Slovakia	10.283	6.173	2 (12%)	2
29	Estonia	10.251	5.739	1 (30%)	1
30	Lithuania	10.241	5.952	1 (20%)	1

<sup>†</sup>Natural logarithm of GDP at purchasing power parity per capita

<sup>‡</sup>Number of cities and the aggregate population of total observed

<sup>§</sup>Number of satellite images used to examine the selected major cities.

TABLE I: Data Statistics

example, Tallinn alone captured 30% of the people of Estonia, which is included in our analysis. Countries like Cyprus could not be studied easily, due to unclear administrative boundaries. The countries listed in Table I are grouped into the top-10, 15, 20, and 30 lists based on their GDP, which will be used in later analysis. All statistics and satellite data are based on the 2018 reports. We also gathered the happiness report and satellite data for 2013, which we compare.

### III. RESULTS

We use three measures to investigate the relationship between happiness and green space: (1) Pearson’s correlation, (2) Spearman’s correlation, and (3) linear regression. Two measurement approaches are used: the entire cities and 3-km radius zone from city halls. We utilize the percent of the regions that are greenery determined by the NDVI values from the 30m-by-30m pixel satellite images.

#### A. Findings from the 2018 Data

Fig. 3a shows the correlation between happiness and the average green space of major cities. The trend lines are shown separately for the top 30, 20, 15, and 10 countries. The top left figure shows there is no correlation for top-30 countries (Pearson’s  $r=-0.035$ ,  $P=0.857$ ). Although these are developed

countries, they vary enormously in terms of economy and social infrastructure (e.g., freedom, health).

The top right figure is for top-20 countries, which now shows a more visible linear relationship. However, statistical significance is not guaranteed ( $r=0.316$ ,  $P=0.174$ ). The slope of the fitted line ( $\alpha$ ) is 0.845, with the R-squared value of the linear model of 0.1. Although several outlier countries are apparent, green space is starting to show some relationship with happiness at this level.

The bottom left figure for top-15 countries shows a more pronounced result. Several outlier countries are removed, and a linear correlation is meaningful given the small sample size ( $r=0.466$  and  $P=0.079$ ). The slope  $\alpha$  has increased slightly to 0.943, with an R-squared value of 0.217.

The bottom right figure of the top-10 countries shows the most robust trend. Pearson’s correlation,  $r$ , is 0.626 ( $P=0.052$ ) even for this small sample, reinforcing a prominent relationship between happiness and green space measured at major cities. The linear regression also has the most significant slope of 1.265, and the R-squared value is 0.392, confirming a steady trend. It is interesting to note the stronger correlation for countries with higher GDP and HDI scales.

Another perspective to inspect the relationship is Spearman’s correlation, which examines Pearson’s correlation between the ranks of items rather than the actual values. Forasmuch as countries are ranked in the World Happiness Report, comparing the country ranks of happiness and green space can be an appropriate measure for the task. We, however, find that Spearman’s correlation is not significant for the top-30, top-20, and top-15 countries ( $P>0.128$ ). Top-10 countries, nonetheless, show a reliable and robust rank correlation of 0.673 at a significant level ( $P<0.05$ ).

Measuring the level of green space around city halls could indicate a robust pattern because this method is oblivious to the size of each city. Since now we are looking at a much smaller area, none of the Pearson’s correlation appears as significant ( $P>0.101$ ). Despite failing the significance test, the reported correlation  $r$  is again the highest for the top-10 countries and is lower for top-15 and 20 countries, respectively. The correlation was close to zero for top-30 countries similarly. Nonetheless, happiness and green space measured from city hall areas indicated a significant trend under Spearman’s rank correlation. This  $r_s$  value for top-10 countries is 0.648 ( $P<0.05$ ). The values obtained for this group indicate a significant relationship between happiness and green space.

#### B. Findings from the 2013 Data

The results from the 2013 data are similar to those of the 2018 data, where the relationship between happiness and green space is stronger among the more affluent countries. Top-30 countries did not show any trend, whereas top-20 and 15 countries showed a linear trend with some outliers. However, it was the top-10 countries that indicated prominent Pearson’s correlation  $r$  of 0.594 ( $P=0.07$ ). When it comes to the Spearman’s rank correlation, the top-20, 15, and 10 all indicated a significant trend, again with a stronger rank correlation

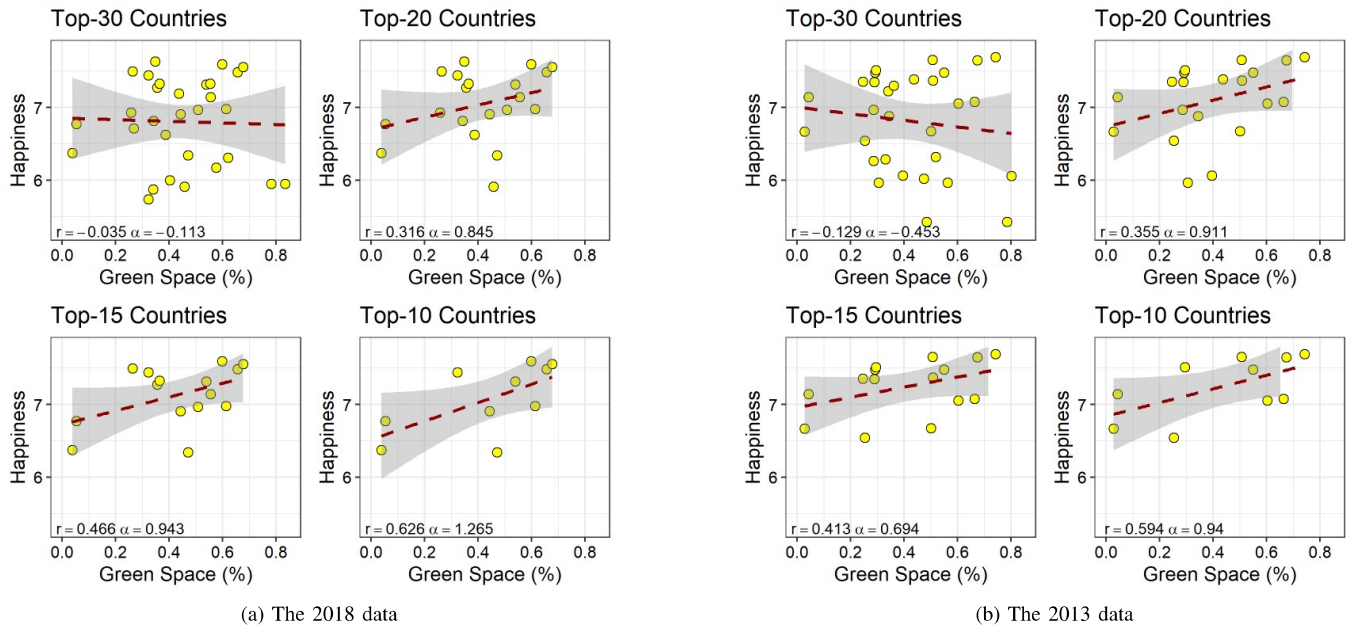


Fig. 3: Comparison of the World Happiness Index and green space measured from satellite images of the major cities taken in 2018 and 2013, respectively.  $r$  represents the Pearson correlation, and,  $\alpha$ , the slope of the fitted line.

showing for the wealthiest countries. We emphasize that both the association and the slope of the linear relationship has increased in the 2018 data compared to the 2013 data. These findings are robust and reinforce the growing importance of urban environments in people’s happiness.

#### IV. DISCUSSION & CONCLUSION

The link between wellbeing and environmental factors are of growing interest in psychology, health, economics, and environmental conservation [10]. Asking what promotes happiness has attracted much attention. The first to be considered was income. While disputable, there is evidence that income affects happiness in developing countries [2]. However, this effect becomes weaker for developed countries, and shows a truncated trend rather than a straight-line; i.e., income is essential to happiness until some point but has a habitual effect for the wealthier countries [7]. Thus, non-material variables such as family life, health, or work utility must be examined comprehensively for developed countries.

This paper verified the extent to which green space correlates with happiness in developed countries by analyzing satellite images that match the year of happiness reports. The relationship is the strongest among top-10 countries rather than top-15 or 20 countries. The result is consistent with the previous finding that non-material variables represented by green space plays a role for rich countries [7]. Moreover, the significance of green space has increased over the years.

The result has policy implications. It affirmed the need for developed countries to increase green space to promote the happiness of citizens above a certain level of richness. The green area does not have to be in the form of official parks, but

it can be street trees, riverbanks, or even golf fields. Although the quality of the green space may matter more, the quantity still does in some countries.

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