Journal of Environmental Management 346 (2023) 118984

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Measuring environmental awareness: An analysis using google search data☆

Amal Dabbous [a], Matthias Horn [b,*], Alexandre Croutzet [c]

[a] Saint-Joseph University of Beirut, Lebanon
[b] Bamberg University, Bamberg, Germany
[c] TELUQ University, Canada

ARTICLE INFO

Handling Editor: Raf Dewil

JEL classification:
Q01
Q50
C33

Keywords:
Environmental awareness
Google search
Pro-environmental behavior
Panel data

ABSTRACT

Environmental awareness is usually measured using surveys. This paper aims to offer an alternative measure: an Environmental Awareness Index (EAI) constructed using Google search data provided by Google Trends. The benefits of using Google search data over surveys are that (i) they are less costly to obtain, (ii) they are available at high frequency, and (iii) they cover countries where no surveys are available. To test the validity of the proposed EAI, this study empirically assesses the impact of the computed index on individuals' pro-environmental behaviors using the Special Eurobarometer: Attitudes of European citizens towards the Environment data. Results show that the EAI is positively related to pro-environmental behaviors with a statistical significance at the one percent level. This finding stays robust in pooled OLS as well as in panel regression analysis when GDP, mean years of schooling, and population are included as control variables and when time-fixed effects are introduced. Further, the results confirm that environmental awareness is not stable over time and underline the importance of having a timely measure of environmental awareness at hand. Finally, the findings offer several practical implications for managers and policymakers, who will be able to use a timely measure of environmental awareness, assess and measure the impact of their policies aiming to raise environmental awareness as well as depict the type of behavior influenced by their policies.

1. Introduction

The Conference of the Parties (COP) 27 on Climate Change and the COP15 on Biodiversity in the Fall of 2022 highlight some of the dire environmental challenges the world is facing, including but not limited to climate change, loss of biodiversity, and air and water pollution (United Nations Climate Change, 2022; United Nations Environment Program, 2022). The concern, interest, and knowledge of the population of environmental issues are crucially important to foster a commitment to address these challenges. Environmental awareness, which represents individuals' level of knowledge of the influence of their actions on the environment, is widely accepted as the first major step needed to assist people in solving environmental issues (Ramsey et al., 1992). Hence, depicting the environmental awareness gained by individuals is essential when trying to solve environmental issues and create a sustainable society (Sudarmadi et al., 2001). As argued by Bülbül et al. (2020) policies for encountering environmental degradation are designed and executed more easily in societies characterized by a high level of environmental awareness. Environmental awareness is a key factor to consider when developing a society that is well-informed about environmental problems and forming responsible citizens that care about their environment (Mkumbachi et al., 2020). It is considered an important component of environmental management and preservation of the living species (Hanisch et al., 2014). Authorities in many parts of the world attempt to measure environmental awareness through surveys (Ham et al., 2016).

This study offers an alternative measure of environmental awareness, it creates an Environmental Awareness Index (EAI) constructed using Google search data provided by Google Trends. The EAI is based on monthly search volumes on Google Trends for the period between January 2004 and July 2022. To identify search terms that may be used by environmentally aware individuals, this study combines two

☆ We would like to thank the editors and two anonymous reviewers and participants of the 28th European Association of Environmental and Resource Economists Conference (2023) in Limassol for helpful comments and suggestions. All remaining errors are our own.
* Corresponding author. Bamberg University, Department of Finance, Kaerntenstr. 7, D-96045, Bamberg, Germany.
E-mail addresses: amal.dabbous@usj.edu.lb (A. Dabbous), matthias.horn@uni-bamberg.de (M. Horn), alexandre.croutzet@teluq.ca (A. Croutzet).

https://doi.org/10.1016/j.jenvman.2023.118984
Received 9 May 2023; Received in revised form 23 August 2023; Accepted 9 September 2023

approaches. First, it selects keywords from the Sustainable Development Goals (SDGs) of the United Nations. Second, keywords from academic studies tackling environmental issues were selected. Later, it extracts the monthly Search Volume Index (SVI) of the keywords per country from Google Trends. The EAI per country is constructed as the sum of the SVI of all keywords per month for 20 EU countries and Great Britain.[1] In addition, a positive, a negative, and a neutral EAI is computed by summing up just the SVI of the keywords with a respective connotation. The reason to do that is that we believe that pro-environmental behaviors can either be induced by a willingness to do something good (e.g., reducing waste or carbon emissions), or worries about negative consequences of environmental issues (e.g., environmental disasters, global heating), or a combination of both.

As highlighted in Mellon (2014), the benefits of using Google search data over surveys are that (i) they are less costly to obtain, (ii) they are available at high frequency, and (iii) they cover countries where no surveys are available. Scheitle (2011) adds that the collection of Google search data is flexible enough to cover different research questions. Besides, whereas views and opinions are expressed when answering survey questions, Google searches aim simply at finding information. The interest is revealed through Google searches rather than declared in surveys.

Studies show that environmental awareness is essential to develop environmental behaviors (Conrad and Hilchey, 2011; Giudici et al., 2019) and can influence individuals' lifestyles to become more environmentally friendly (von Borgstede et al., 2013). According to Fu et al. (2020), environmental awareness is of great importance to adopt pro-environmental behavior. Clayton and Myers (2015) advocate that if individuals are aware of the environmental damage caused by their behavior, they will switch to an environmentally friendly one. Mkumbachi et al. (2020) consider that environmental awareness is the main factor driving pro-environmental behaviors. Our study builds on the assumed positive relationship between environmental awareness and environmental behavior to test the validity of the proposed environmental awareness index. Toward this end, it aims to test the correlation between these two factors and empirically assess the impact of the computed index on individuals' pro-environmental behaviors proxied by the answers to selected questions from the "Special Eurobarometer: Attitudes of European citizens towards the Environment".

The proposed relation also is tested by considering several control variables. Among the most important control variables is the degree of a country's urbanization. Urbanization is considered one of the major factors that affect carbon emissions and consequently environmental degradation (Alhassan, 2021). However, even though urbanization might alter the natural environment and is expected to raise the consumption of resources and energy due to economic growth and the development of economic activities (Alhassan, 2021), it might also promote environmental quality. As argued by Poumanyvong and Kaneko (2010), through enhancing public infrastructure such as improving the quality of public transport and generating more electricity as well as providing economies of scale, urbanization can foster environmental quality. To date, no empirical studies explored the link between urbanization and individuals' environmental behavior. This study, therefore, proposes to test if both environmental awareness and urbanization have a distinct influence on pro-environmental behavior.

The main objectives of this study are, therefore: (1) create an environmental awareness index that measures individuals' level of environmental awareness across time and fill the gap in the literature particularly since most indices use survey instruments offering static measures for environmental awareness, (2) to examine the validity of the proposed measure by showing its association with pro-environmental behaviors, and (3) to show that urbanization is a distinct measure from environmental awareness index capable of explaining certain types of pro-environmental behaviors.

This study offers several contributions. First, it constructs a timely, easy-to-observe index of environmental awareness that is more appropriate to measure environmental awareness than static measures compiled at a single point in time, e.g. surveys. By doing this it allows us to depict the variation in peoples' environmental awareness that is believed to change constantly. Hence, the EAI will provide important information to regulators that can use this index to plan and carry out attempts to enhance environmental awareness. Second, it proposes to validate the appropriateness of the environmental awareness index by showing its correlation with pro-environmental behavior and empirically assessing its impact on this behavior. These steps add to the robustness of the proposed index and help to clarify the debate in the literature regarding the environmental awareness and environmental behavior relationship. Third, by adding urbanization as a control variable in the equation relating environmental awareness and environmental behavior, it adds to the literature by exploring whether urbanization is a distinct factor that acts as a driver of environmental behavior, particularly since no prior works empirically tested this relationship.

The paper is organized as follows. Section 2 reviews the literature. Section 3 presents the methodology. Section 4 discloses the results and presents the discussion. Section 5 concludes and displays the implications and limitations of this study.

2. Literature review

2.1. Environmental awareness and its measures

Environmental awareness consists of understanding the various environmental problems and the measures that need to be adopted to generate good practices that help preserve the environment (Mkumbachi et al., 2020). It is a comprehensive measure that incorporates opinions, concerns, and different points of view regarding environmental problems, as well as thoughts and approaches on how to solve these issues and how to strengthen the relations between individuals and the environment to enhance environmental quality (Hopwood, et al., 2005; Wang et al., 2016). It represents an individual's general understanding of the various environmental problems and is considered a key factor to ensure the transition to a more environmentally friendly behavior (Daziano and Bolduc, 2013; Wang et al., 2016).

Authorities in many parts of the world attempt to measure environmental awareness through surveys (Ham et al., 2016). The European Commission measures the importance of environmental issues for European citizens through the Eurobarometer survey (Special Eurobarometer 501, 2020). The Chinese Social Science Comprehensive Survey surveys more than 11,000 households nationwide. It includes questions on the perception of pollution and environmental awareness (Wang and Zhang, 2022). Robelia and Murphy (2012) review 15 state and national surveys in the US on environmental knowledge including the survey from the National Environmental Education Foundation. The authors criticize a lack of consistency in the surveys regarding environmental knowledge which makes a comparison among different studies difficult. Hence, an approach for consistently measuring environmental awareness over time and among different countries can provide many benefits for different stakeholders.

We construct an EAI using search data from Google Trends. Mellon (2013) verifies that Google search data adequately measures the intended concept (as recommended in Scheitle, 2011) and reflects general views rather than the ones of unrepresentative subsets. He does a validity test for several issues including global warming in the UK and Spain. To do so, he compares Google search results of the expression "global warming" with the salience of the issue in surveys. He finds a

[1] The EU countries used in this study are Austria, Belgium, Bulgaria, Czech Republic, Germany, Greece, Denmark, Spain, Finland, France, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Romania, Sweden, Slovakia, Slovenia.

strong relationship between "global warming" searches and the importance of the issue in surveys in both countries.

Of course, not every person uses Google to gather information. Many people might prefer getting information from, e.g. newspapers or the TV. Still, Google search data from Google Trends has been widely used in the scientific literature in medicine and bioscience, public health, agriculture, information system and computer as well as economics, finance, and business fields (Jun et al., 2018). Notably, in economics, Choi and Varian (2009) used Google Trends data to forecast the unemployment rate. Choi and Varian (2012) showed that Google searches can be used to predict car sales, unemployment claims, and travel destinations, among others. These findings show that Google searches are a good indicator of the interest of the whole population in certain topics although not everyone uses Google.

2.2. Environmental awareness and pro-environmental behaviors

Prior works established that environmental problems are mainly caused by human behavior (Steg and Vlek, 2009). Therefore, changing individuals' behavior towards a more environmentally friendly one can alleviate environmental problems (Fu et al., 2020). As argued by De Medeiros et al. (2018), society can realize environmental benefits if users change their behavior and how they deal with products. However, it is widely acknowledged that people with a high level of environmental awareness have a higher probability to adopt environmentally sustainable behavior (Sekhokoane et al., 2017; Kikuchi-Uehara et al., 2016; Zhang and Zhou, 2016). According to Carmi (2013), environmental awareness is reflected in environmentally friendly conscious behavior. Further, according to behavioral change theory, people characterized by high levels of environmental values are knowledgeable about the influence of their behaviors on the environment. This theory was used in the literature to explain how environmental awareness can lead to more pro-environmental behaviors (Mkumbachi et al., 2020). It reflects the concept that dictates that more environmentally aware individuals are more likely motivated to adopt pro-environmental behaviors. It is therefore very important to be able to measure environmental awareness which is considered the main driver for environmental behavior and to test the validity of the proposed index by empirically assessing the relationship between environmental awareness and behavior. Finally, this step will add to the literature particularly since there is no consensus yet regarding the environmental awareness behavior relationship (Fu et al., 2020).

The Special Eurobarometer has been used in the literature to measure pro-environmental behavior. Punzo et al. (2019) use the Eurobarometer data as a measure of pro-environmental behavior to study the relation between perceived values, felt responsibility, and pro-environmental behavior. Silvi and Padilla (2021) use them to study the relationship between social norms, intrinsic motivation, external conditions, and pro-environmental behavior. Meyer (2015) studies the influence of education on pro-environmental behavior using data from the Eurobarometer. This study, therefore, tests the validity of the proposed EAI, by empirically assessing the impact of the computed index on individuals' pro-environmental behaviors measured using the Eurobarometer data.

2.3. Urbanization and environmentally friendly behavior

Urbanization is one of the most influential human activities that impact the earth (Cui et al., 2019) and is considered one of the most important factors influencing carbon emissions and consequently environmental degradation (Alhassan, 2021). It modifies land use with the urban environment (Angel et al., 2012) and is considered a complex phenomenon that links individuals to the land surface as well as includes all the related social and economic activities (Fragkias et al., 2017). Urbanization influences the ecosystem biodiversity and alters biogeochemical cycles by adopting several methods for discharging waste (Kalantari et al., 2017; Schneider et al., 2015). However, existing studies tackling the relationship between urbanization and the environment did not reach a consensus yet. Some show that urbanization raises energy use and leads to more carbon emissions (Chen et al., 2020; Y. Wang et al., 2021). Others show that urbanization helps reduce carbon emissions (Tang et al., 2021; Zhou et al., 2021). For instance, Zhang et al. (2021) argue that by enhancing public infrastructure and fostering the use of public transport, urbanization will likely decrease energy use and reduce carbon emissions. Further, based on the ecological modernization theory (Sadorsky, 2014), the magnitude of the environmental issues and problems differ with the various levels of a society's development (Jacobi et al., 2010). In the beginning, higher economic development increases pollution, as the wealth of people increases, environmental degradation falls due to technological advancement and better regulation (Sadorsky, 2014). Hence, the net impact of urbanization on the environment cannot be depicted and further studies are requested (Adams et al., 2020). Further as discussed by Sarwar and Alsaggaf (2019), higher urban income will probably lead to a reduction in carbon emissions as it changes the buying behaviors of urban individuals. This rise in income will direct urban people toward the adoption of more environmentally friendly behavior such as using green technology which requires less energy consumption and has lower levels of carbon emissions (Sarwar and Alsaggaf, 2019).

At the individual level, household income is used as a control variable. Zorić and Hrovatin (2012) analyze the willingness to pay for green electricity in Slovenia. They find that age, household income, education, and environmental awareness are the most important factors determining household attitudes toward green electricity. The willingness to pay for green electricity depends principally on household income. Stern et al. (1999) find that income is positively associated with more pro-environmental consumer behavior. Whitmarsh and O'Neill (2010) find that household income has no effect on pro-environmental behavior. Longhi (2013), using panel data and a pro-environmental behavior index shows that higher household income is associated with lower individual pro-environmental behavior and that poorer people have more pro-environmental behavior such as greater usage of public transportation. Blankenberg and Alhusen (2019) review the literature on the determinants of pro-environmental behavior, including education and income.

It, therefore, is essential to investigate if urbanization is a distinct factor from environmental awareness that can influence environmental behavior.

2.4. Control variables

2.4.1. Education

Johnson et al. (2004) empirically investigate a model where the probability of a respondent's self-assessed degree of involvement in pro-environmental behavior is a function of education level. He finds a statistically significant positive relationship between education and pro-environmental behavior. Torgler and Garcia-Valiñas (2007) specify the willingness to contribute to preventing environmental damage as a function of education. They find that positive significant relation, but this result is not robust to alternative model specifications. Meyer (2015) performs a causality analysis and finds that education causes individuals to adopt more pro-environmental behaviors. Lynn and Longhi (2011) find that different levels of education are associated with different pro-environmental behavior. Higher education is positively associated with recycling, lower heaters temperature, and boycott of over-packaged products. Lower education is positively associated among others with using public transportation and turning lights off. Longhi (2013) finds that the impact of education on pro-environmental behaviors is greater than the ones of other factors like income. Chankrajang and Muttarak (2017) exploit the instrumental variables strategy to study the causality between education and pro-environmental behaviors. They find that longer education led to a greater probability of adopting knowledge-based pro-environmental behavior. They also find no significant impact of education on concern about climate change. Xin et al. (2022) study the relationship between education, unemployment, and CO2 emissions in China between 1991 and 2020. They find that average years of schooling hinder CO2 emissions in both the short and long term, while the literacy rate reduces CO2 emissions in the long run only.

2.4.2. Gross Domestic Product

At the country level, Gross Domestic Product (GDP) or GDP per capita is used as a control variable. Pisano and Lubell (2017) find that citizens of countries with higher GDP have higher pro-environmental behavior. W.Z Wang et al. (2021) find that GDP per capita has a marginally significant positive effect on pro-environmental behavior.

2.4.3. Population

Google only provides a SVI for a keyword if a certain minimum number of search queries was sent. We observe that the number of keywords that receives a valid SVI is smaller for countries with a smaller population. Hence, we include the countries' population as a control variable to account for the observed pattern.

3. Methodology

This study combines two approaches to identify search terms that may be used by environmentally-aware individuals. First, the authors select keywords from the Sustainable Development Goals (SDGs) of the United Nations. Specifically, we focus on the SDGs with the most obvious relation to environmental issues: #2, #6, #7, #11, #12, #13, #14, and #15. Second, we select keywords from related academic studies. Moreover, this study differentiates between keywords with a positive (e.g. "affordable drinking water", "afforestation"), neutral (e.g. "air quality", "drinking water"), and negative connotation (e.g. "air pollutants", "floods"). A detailed overview of the 342 identified keywords, from which SDGs/studies the keywords are selected, and with which connotation the keywords are associated is provided in Tables A1 and A2 in Appendix A.

This study assumes that most individuals use keywords in their native language to search the internet. Therefore, this work translates the English keywords into each country's official language by using Google Translate. Thereafter, the monthly SVI of the translated keywords between January 2004 and July 2022 per country from Google Trends is gathered.

To compute the EAI per country, this study sums up the SVI of all keywords per month. Medeiros and Pires (2021) point out that researchers probably receive a different time series of the SVI every time they download data for the same keyword, timestamp, and region. The reason is that Google Trends has to use data sampling to respond quickly to queries. By summing up the SVI of 342 keywords, this study assumes that the noise associated with the time series of a single keyword should average out in the cross-section. In addition, a positive, a negative, and a neutral EAI are computed by summing up just the SVI of the keywords with respective connotations. This study abstains from computing a sentiment index, e.g., by computing the difference between the positive and the negative EAI. The reason is that the authors believe that pro-environmental behaviors can either be induced by a willingness to do something good (e.g., reducing waste or carbon emissions), worries about negative consequences of environmental issues (e.g., environmental disasters, global heating), or a combination of both. Hence, the positive, the negative, and the neutral EAI are computed to e.g., see whether searches of positive connotated keywords (i.e., a focus on solutions to environmental issues) are stronger related to pro-environmental behaviors than the searches of negative connoted keywords (i.e., a focus on possible harm and losses) or vice versa.

Pro-environmental behaviors per country are measured by the answers to the "Special Eurobarometer: Attitudes of European citizens towards the Environment". More specifically, the focus is on the item "Have you done any of the following during the past month for environmental reasons?". The item covers a battery of pro-environmental behaviors such as "Chosen an environmentally friendly way of traveling (by foot, bicycle, public transport)". The dataset provided by the EU includes the percentage of respondents that agrees with the suggested pro-environmental behaviors. This study computes the average approval rate over all suggested pro-environmental behaviors per country. The dataset covers five waves of the Eurobarometer. The surveys for these five waves have been conducted in November and December 2007 (first wave in our dataset), April 2011 (second wave), April and May 2014 (third wave), September 2017 (fourth wave), and December 2019 (fifth wave). These seven monthly observations per country are the data basis of the empirical analyses described in the following, unless stated otherwise.

All statistical analyses are done with Stata version 16. In addition to the usual correlation and regression commands, we also use the command xtgcause implemented by Lopez and Weber (2017) to conduct a Granger Causality Test for panel data and the command xtserial implemented by Drukker (2003) to perform Wooldridge (2002) tests for autocorrelation in panel data. The relation between the EAIs and pro-environmental behaviors is analyzed with correlation, stepwise pooled OLS, and panel regression analyses. The full regression model is as follows:

$$EFB_{i,t} = \beta_{1i} * EAI_{i,t} + \gamma * Controls_{i,t} + \delta * Month + \alpha + u_{i,t} \quad (1)$$

Where $EFB_{i,t}$ is the pro-environmental behavior in country i in month t, EAI is the Environmental Awareness Index for country i in month t, $Controls_{i,t}$ represents a vector of control variables, and *Month* represents a vector of month-dummies to control for month-specific effects. This study includes random country effects in the panel regressions. Moreover, robust standard errors are used. The control variables are the GDP per capita in US dollars, the mean years of schooling,[2] the population, and the degree of urbanization per country i in month t. Urbanization is the number of people living in urban areas divided by the population of the country. Due to collinearity, the study only includes either population or urbanization as a control variable. Unless indicated otherwise, the data of the control variables are retrieved from OECD. Stat. Descriptive statistics of the described variables are presented in Table 1.

Pearson correlations between the EAIs as well as between the EAI, the pro-environmental behaviors according to the Eurobarometer and the control variables are presented in Table 2. The coefficients of the correlation between the EAI and the positive, negative, and neutral EAI, reported in Panel A, exceed 0.90. Hence, we focus on reporting results for the EAI. Correlations displayed in Panel B show a significant positive correlation between the EAI and pro-environmental behaviors, GDP, population, and urbanization. The pro-environmental behaviors are significantly positively correlated with GDP, mean years of schooling, and urbanization.

4. Results and discussion

The results of stepwise pooled OLS and panel regression analyses with the pro-environmental behaviors measured by the Eurobarometer as the dependent variable and the EAI as the independent variable are provided in Table 3. The values for the adjusted R^2 indicate a good model fit. Results for the regression models (1) and (4) show that the EAI is positively related to pro-environmental behaviors with a statistical significance at the one percent level. This finding stays robust in pooled

[2] As the average number of completed years of education of a country's population aged 25 years and older, excluding years spent repeating individual grades. The data is from https://www.sustainabledevelopmentindex.org/time-series and is introduced by Hickel (2020).

Table 1
Descriptive statistics.

	Mean	Median	Std. Dev.	Min	Max	N
Panel A: Environmental Awareness Indexes						
Environmental Awareness Index (EAI)	1530	1470	964	273	5090	147
Positive EAI	642	590	490	47	2221	147
Negative EAI	353	331	195	77	1198	147
Neutral EAI	534	507	306	103	1671	147
Panel B: Control Variables						
GDP	37.3	36.8	11.6	16.8	87.6	147
Mean Schooling	11.9	12.3	1.2	7.7	14.2	147
Population	22.0	10.1	25.1	1.3	83.1	147
Urbanization	72.7	70.2	12.0	52.0	97.8	147
Panel C: Eurobarometer data						
Pro-environmental behaviors	35.0%	34.6%	7.2%	21.5%	53.9%	147
Traveling	33.6%	33.0%	11.0%	8.0%	63.0%	147
Disposable items	31.7%	29.0%	9.8%	14.0%	56.0%	147
Recycling	66.3%	69.0%	14.0%	25.0%	92.0%	147
Water consumption	34.0%	34.0%	10.2%	10.0%	63.0%	147
Energy consumption	45.1%	46.0%	11.5%	14.0%	64.0%	147
Label	22.0%	19.0%	11.9%	4.0%	71.0%	147
Local products	34.4%	32.0%	14.4%	9.0%	68.0%	147
Car	18.4%	18.0%	7.4%	4.0%	36.0%	147

OLS as well as panel regression analysis when GDP, mean years of schooling, and population are included as control variables and when time-fixed effects are introduced (see models (2) and (5)). The results of the regression model (5) indicate that an increase of the EAI by one-standard deviation is related to an up to four-percentage-points increase of the average approval rate over all suggested pro-environmental behaviors per country. However, the coefficient of EAI decreases in magnitude and loses its statistical significance when urbanization is included in the regression model (see models (3) and (6)). This effect can have two not necessarily distinct origins. First, environmental awareness increases with the degree of urbanization, which could make urbanization a proxy for environmental awareness (see also the correlation of 0.51 between the two variables). Second, environmental awareness and urbanization are related to different pro-environmental behaviors.

$$EFB_{i,t} = \beta_{1i} * EAI_{i,t} + \beta_{2i} * GDP_{i,t} + \beta_{3i} * Mean\_Schooling_{i,t} + \beta_{4i} * Population_{i,t} + \beta_{5i} * Urbanization_{i,t} + \alpha_i + u_{i,t}$$

Where $EFB_{i,t}$ are the pro-environmental behaviors in country i in month t, $EAI_{i,t}$ is the Environmental Awareness Index for country i in month t, $GDP_{i,t}$ is the GDP per capita, $Mean\_Schooling_{i,t}$ is the mean years of schooling, $Population_{i,t}$ is the population, and $Urbanization_{i,t}$ is the degree of urbanization per country i in month t. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively. Coefficients with p-values≥.10 are not labeled as significant. Example: Regressing $EFB_{i,t}$ on regression model (2) yields a coefficient of 0.30 with a p-value <.01 for the Environmental Awareness Index $EAI_{i,t}$ as an independent variable.

To address this issue it is analyzed whether urbanization Granger-causes environmental awareness or vice versa with a Granger Causality Test for panel data (Lopez and Weber, 2017). Untabulated results show that the EAI does Granger-cause urbanization and vice versa with statistical significance at the one percent level. It is beyond the scope of this study to analyze the reason for this reciprocal relation, therefore further analysis will be left for future work. Nevertheless, it is of importance for this study's research question that the EAI Granger-causes urbanization. Hence, it seems plausible that both environmental awareness and urbanization have a distinct influence on

Table 2
Pearson correlations.

Panel A: Environmental Awareness Indexes	EAI	Positive EAI	Negative EAI	Neutral EAI
EAI	1	.98***	.94***	.98***
Positive EAI	.98***	1	.89***	.94***
Negative EAI	.94***	.89***	1	.91***
Neutral EAI	.98***	.94***	.91***	1

Panel B: EAI, Eurobarometer, and Control Variables	EAI	Pro-environmental behaviors	GDP	Mean Schooling	Population	Urbanization
EAI	1	.36***	.43***	.09	.76***	.51***
Pro-environmental behaviors	36***	1	.46***	.32***	.05	.48***
GDP	.43***	.46***	1	.25***	.13	.42***
Mean Schooling	.09	.32***	.25***	1	−.07	.14
Population	.76***	.05	.13	−.07	1	.21**
Urbanization	.51***	.48***	.42***	.14	.21**	1

Notes: We provide Pearson correlation coefficients. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

Table 3
Regressions of pro-environmental behaviors on EAI.

	(1)	(2)	(3)	(4)	(5)	(6)
EAI*10^{-4}	.29*** (.06)	.30*** (.09)	.01 (.05)	.24*** (.08)	.44*** (.17)	.16* (.09)
GDP*10^{-6}		2.67*** (.53)	2.97*** (.47)		−.17 (1.00)	−.08 (.77)
Mean Schooling		.01*** (.00)	.01*** (.00)		.01 (.01)	.01 (.01)
Population*10^{-9}		−.83*** (.29)			−1.11 (.70)	
Urbanization*10^{-2}			.15*** (.04)			2.48** (1.02)
α	.31*** (.01)	.07 (.04)	−.03 (.04)	.31*** (01)	.22 (.11)	.06 (.11)
Pooled/Panel	Pooled	Pooled	Pooled	Panel	Panel	Panel
Effects	No	Time-fixed	Time-fixed	Random country	Time-fixed Random country	Time-fixed Random country
Adj. R^2	.15	.55	.57	.15	.47	.45

Notes: We provide coefficients, robust standard errors (in parentheses) clustered by company, and R^2 for pooled/panel regression analysis with the model. .

pro-environmental behaviors.

To identify these distinct influences, this study analyzes the relations of EAI and urbanization with the individual pro-environmental behaviors covered by the Eurobarometer: environmental-friendly traveling, reduction of disposable items, engaging in recycling, reduction of water consumption, reduction of energy consumption, purchase of products with an environmental label, purchase of local products, reduction of car usage. The expectation is that a higher degree of urbanization leads to more infrastructure-related pro-environmental behaviors such as environmental-friendly traveling and the reduction of car usage, because people in large cities are better connected to affordable and convenient public transport. In addition, it is expected that a lower degree of urbanization is related to lower approval rates regarding the reduction of water and energy consumption. Typically, households in rural areas are more likely to live in detached houses. Hence, these households are provided with more opportunities to produce energy or use sustainable energy sources (e.g. with solar panels on the roof or by heating with wood) and to collect rain water (e.g. in cisterns). Therefore, rural households have more opportunities to behave environmentally friendly even without explicitly reducing the usage of water and energy. In contrast, the possibilities to reduce disposable items or to engage in recycling hardly depend on whether a household lives in the city or a rural area. The same is true regarding the possibility to purchase products with an environmental label.[3]

The described relations are analyzed with panel regressions. In these regressions, the pro-environmental behaviors covered by the Eurobarometer are the dependent variables, and the EAI, urbanization, and the remaining control variables are the independent variables. The results of these regressions are presented in Table 4 and show distinct influences of environmental awareness and urbanization.[4] As expected, the EAI, in contrast to urbanization, is significantly positively related to the reduction of disposable items, engaging in recycling, and the purchase of products with an environmental label (see Panel A). According to the results of regression models (3), (6), and (9) an increase of the EAI by one-standard deviation is associated with a 4.5-percentage-points increase of households that reduce disposable items, a 5.5-percentage-points increase of households that engage in recycling, and a 4.5-percentage-points increase of households that purchase products with an environmental label. As further expected, urbanization, in contrast to the EAI, is significantly positively related to environmental-friendly traveling, reduction of water and energy consumption, and the reduction of car usage (see Panel B). Hence the EAI is related to pro-environmental behaviors that are driven by the intrinsic motivation to protect the environment while urbanization accounts for pro-environmental behaviors that are enabled by the public infrastructure (e.g., public transport). This finding underlines the necessity to have a separate measure of environmental awareness.

$$EFB_{i,t} = \beta_{1i} * EAI_{i,t} + \beta_{2i} * \ GDP_{i,t} + \beta_{3i} * \ Mean\_Schooling_{i,t} + \beta_{4i} * \ Population_{i,t} + \beta_{5i} * \ Urbanization_{i,t} + \alpha_i + u_{i,t}$$

where $EFB_{i,t}$ is one of the following pro-environmental behaviors in country i in month t: Reduction of disposable items, engaging in recycling, the purchase of products with an environmental label, environmental-friendly traveling, reduction of water and energy consumption, and the reduction of car usage. $EAI_{i,t}$ is the Environmental Awareness Index for country i in month t, $GDP_{i,t}$ is the GDP per capita, $Mean\_Schooling_{i,t}$ is the mean years of schooling, $Population_{i,t}$ is the population, and $Urbanization_{i,t}$ is the degree of urbanization per country i in month t. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively. Coefficients with p-values$\geq$.10 are not labeled as significant. Example: Regressing reduction of disposable items on regression model (3) yields a coefficient of 0.47 with a p-value $<$.01 for Environmental Awareness Index $EAI_{i,t}$ as independent variable.

The EAI shall be a timely measure of peoples' environmental awareness. Such a measure is important since existing measures rely on surveys that are infrequently conducted. However, if environmental awareness was a stable construct, survey evidence may be sufficient. As a robustness check, Wooldridge (2002) tests for autocorrelation in panel data with the implementation of Drukker (2003) are run on the monthly EAI from January 2004 to July 2022 to provide evidence that environmental awareness is not stable over time and to highlight the need for a timely measure of environmental awareness. The EAI shows negative autocorrelation with a statistical significance at the one percent level. Hence, lagged observations of the EAI are suitable to predict recent observations of the EAI. Therefore, the regression analyses are re-run with lagged variables of the EAI in the regression model of equation (1). In untabulated results, it is found that the lagged EAI observations are significantly related to pro-environmental behaviors, however, with lower levels of statistical significance than the most recent observation of the EAI. This indicates that environmental awareness is not stable over time and underlines the importance of having a timely measure of environmental awareness at hand.

Nevertheless, the significant autocorrelation may also be an indication of an endogeneity effect at the country level. On the individual level, it seems straight forward that a person with higher environmental awareness behaves more environmentally friendly. On a country level, however, it additionally is possible that the pro-environmental behaviors of some persons lead to an increasing environmental awareness of others. We assume that at least some of the latter persons should show more pro-environmental behaviors in the following. But some persons might not. This would explain why an increase of the EAI by one-standard deviation is associated with only a 5-percentage-point increase in households' pro-environmental behaviors. However, proofing these relations in detail would require micro-level data and we are not aware of a suitable dataset.

When the positive, negative, or neutral EAI instead of the EAI is applied in the regression model of equation (1), the results are similar to those presented for the EAI in Table 3, however, with slightly lower levels of statistical significance. The same pattern is observed when the individual pro-environmental behaviors of the Eurobarometer are used as dependent variables, i.e., the results for the positive, negative, or neutral EAI are similar to those of the EAI shown in Table 4 but with slightly lower levels of statistical significance. This means, that none of the observed pro-environmental behaviors is stronger related to positively or negatively connoted search terms. Hence, the EAI, which summarizes the positive, negative, and neutral EAI, is the best proxy for the kind of pro-environmental behavior that is observed. However, this does not mean that the positive, negative, or neutral EAI are not more suitable proxies for other pro-environmental behaviors (e.g., investments in green assets, voting for green parties, etc.).

5. Conclusion, implications, and limitations

This study proposes a new approach to measure environmental awareness. It constructs an Environmental Awareness Index using Google search data provided by Google Trends. The EAI is based on monthly search volumes on Google Trends for the period between January 2004 and July 2022. The EAI per country is constructed as the sum of the SVI of all selected keywords per month for 18 EU countries and Great Britain.

Environmental awareness is considered a major factor that fosters pro-environmental behaviors (Mkumbachi et al., 2020). This study builds on the assumed positive relationship between these two variables to test the validity of the proposed environmental awareness index while

[3] Since products with an environmental label are usually more expensive than products without such a label, urbanization could have an indirect effect if households in cities or in rural areas were wealthier.

[4] In an untabulated analysis it is found that neither the EAI nor urbanization is related to the purchase of local products at statistically significant levels.

Table 4
Regressions of Eurobarometer items on EAI and Urbanization.

Panel A: Pro-environmental behaviors related to Environmental Awareness Index: Reduction of disposable items, engaging in recycling, and the purchase of products with an environmental label

	reduction of disposable items			engaging in recycling			purchase of products with an environmental label		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
EAI*10^{-4}	.72*** (.24)		.47*** (.15)	.96*** (.28)		.57*** (.19)	.81** (.34)		.45* (.23)
GDP*10^{-6}	.40 (2.01)	2.31 (2.26)	1.21 (1.88)	-2.61 (2.33)	-1.00 (2.47)	-2.23 (2.00)	-.06 (1.43)	.73 (1.52)	.08 (1.27)
Mean Schooling	.01 (.01)	.01 (.01)	.01* (.01)	-.01 (.02)	-.01 (.02)	-.01 (.02)	-.03* (.02)	-.03 (.02)	-.03* (.02)
Population*10^{-9}	-1.27 (.85)			-1.86* (1.07)			-3.06** (1.50)		
Urbanization*10^{-2}		.13 (.14)	-.01 (.17)		.40** (.16)	.22 (.20)		.41* (.23)	.28 (.20)
α	.04 (.12)	-.03 (.12)	.02 (.12)	.65 (.21)	.46* (.24)	.50 (.24)	.42** (.19)	.20 (.16)	.22 (.16)
Adj. R^2	.46	.42	.46	.25	.17	.22	.13	.05	.03

Panel B: Pro-environmental behaviors related to Urbanization: Environmental-friendly traveling, reduction of water and energy consumption, and the reduction of car usage

	environmental-friendly traveling			reduction of water consumption			reduction of energy consumption			reduction of car usage		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
EAI*10^{-4}	.54* (.28)		-.01 (.17)	-.23 (.20)		-.12 (.16)	.31 (.22)		.11 (.13)	.23 (.18)		.09 (.11)
GDP*10^{-6}	-.25 (.81)	-.03 (.76)	-.02 (.66)	.73 (1.35)	-.33 (1.62)	-.10 (1.64)	1.59 (1.59)	1.58 (1.13)	1.26 (1.01)	1.21* (.65)	1.36** (.61)	1.16* (.62)
Mean Schooling	.02 (.01)	.02 (.01)	.02 (.01)	-.02 (.01)	-.02* (.01)	-.02* (.01)	.01 (.01)	.01 (.01)	.01 (.01)	.01 (.01)	.01 (.01)	.01 (.01)
Population*10^{-9}	-2.62*** (.91)			1.27 (.92)			-.18 (.65)			-.12 (.65)		
Urbanization*10^{-2}		.39** (.17)	.39* (.18)		.21* (.11)	.26** (.11)		.38*** (.11)	.35*** (.10)		.36*** (.08)	.33*** (.09)
α	.09 (.17)	-.15 (.16)	-.16 (.15)	.55 (.12)	.45 (.14)	.43 (.14)	.26*** (.08)	.06 (.08)	.08 (.09)	.02 (.08)	-.21*** (.08)	-.20** (.08)
Adj. R^2	.49	.43	.44	.36	.35	.34	.54	.58	.59	.50	.63	.64

Notes: We provide coefficients, robust standard errors (in parentheses) clustered by company, and R^2 for panel regression analysis with random company and time-fixed effects with the model.

accounting for several control variables such as urbanization, GDP, population, and level of education.

The results of the stepwise pooled OLS and the panel regression analyses confirm that the EAI has a significant positive impact on all considered environmental behaviors. Further, the findings indicate that urbanization and EAI have distinct impacts on environmental behavior. EAI is associated with pro-environmental behaviors that are driven by the intrinsic motivation to protect the environment while urbanization relates to pro-environmental behaviors that are enabled by the public infrastructure. Finally, analyses with lagged variables provide evidence that environmental awareness is not stable over time.

The findings offer several theoretical implications. First, the results confirm the need to construct a timely measure for environmental awareness. This advances prior works which rely on survey instruments to measure environmental awareness using cross-sectional data. Second, the findings highlight the importance of environmental awareness as a factor driving environmental behavior when conducting studies aiming to predict this behavior. Third, the results showing that EAI and urbanization exert distinct influence on the different environmental behaviors underlines the need to have a specific measure of environmental awareness. Finally, this study reveals Google trends search volumes can be used to construct a time-varying indicator for environmental awareness, a measure that was considered very hard to quantify.

The results also are of great importance for individuals, policymakers, and managers. First, the constructed index could be used to monitor the development of the level of environmental awareness in a particular country or region across time. This is considered highly important given the dire environmental challenges the world is facing and the importance of environmental awareness to solve environmental issues. Second, policymakers and managers could rely on this index to assess what will be the impact of a certain newly adopted environmental policy on peoples' environmental behavior. Hence, the influence of their campaign aiming to increase environmental awareness can now be quantified using the proposed EAI index. Finally, the obtained results serve to guide policymakers and managers on the particular types of environmental behaviors that will be affected by a change in the level of environmental awareness.

This study is not without some limitations. First, a different list of keywords could have been adopted to construct the index. Future studies can consider a more comprehensive list of keywords. Second, this study uses the Eurobarometer data as a measure of environmental behaviors. Even though, this data is widely used in the literature as a proxy for environmental behavior, it is not continuously calculated. The available surveys cover five waves that have been conducted in 2007, 2011, 2014, 2017, and 2019. Future studies can replicate the empirical analysis using a different measure for environmental behavior that is continuously computed once data become available.

Although our and previous findings show that Google searches are a good indicator of the interest of the whole population in certain topics, it is clear that not every person uses Google to gather information. Our environmental awareness index does not directly capture the environmental awareness of people that use only e.g. newspapers, TV, and/or radio as information sources. Future studies might add data on the information provided by such information to our environmental awareness index. In addition, future studies might address possible endogeneity effects by using micro-level datasets.

CRediT authorship contribution statement

Amal Dabbous: Conceptualization, Methodology, Writing – original draft, Project administration. **Matthias Horn:** Conceptualization, Methodology, Software, Data curation, Formal analysis, Writing – original draft. **Alexandre Croutzet:** Conceptualization, Methodology, Data curation, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix

Table A1
Sustainable Development Goals (SDGs) and Search Terms

SDG		Indicator	Search Term Neutral	Search Term Positive	Search Term Negative
2 Zero Hunger	2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	2.4.1 Proportion of agricultural area under productive and sustainable agriculture	climate change soil quality	sustainable food production system sustainable food organic food sustainable farming resilient agriculture maintain ecosystem sustainable agriculture	extreme weather drought flooding natural desaster
	2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed	2.5.1 Number of (a) plant and (b) animal genetic resources for food and agriculture secured in either medium- or long-term conservation facilities 2.5.2 Proportion of local breeds classified as being at risk of extinction	genetic resources gene bank	genetic diversity diversified seed banks diversified plant banks equitable sharing of benefits utilization of genetic resources traditional knowledge agricultural research agricultural productive capacity	breeds at risk of extinction
6 Clean Water and Sanitation	6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all	6.1.1 Proportion of population using safely managed drinking water services	drinking water	safe drinking water affordable drinking water	
	6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	6.3.1 Proportion of domestic and industrial wastewater flows safely treated	water quality	recycling reuse	pollution dumping hazardous chemicals hazardous materials untreated wastewater
		6.3.2 Proportion of bodies of water with good ambient water quality			
	6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	6.4.1 Change in water-use efficiency over time 6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	freshwater	water-use efficiency	water scarcity water stress
6 Clean Water and Sanitation	6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	6.5.1 Degree of integrated water resources management		water resources management	
	6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	6.6.1 Change in the extent of water-related ecosystems over time	water-related ecosystems glaciers forests wetlands rivers aquifers lakes		
7 Affordable and Clean Energy	7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.2 Proportion of population with primary reliance on clean fuels and technology	energy services	clean fuels clean technology	

(continued on next page)

Table A1 (*continued*)

SDG		Indicator	Search Term Neutral	Search Term Positive	Search Term Negative
	7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	energy mix energy consumption	renewable energy Renewable energy share	
	7.3 By 2030, double the global rate of improvement in energy efficiency	7.3.1 Energy intensity measured in terms of primary energy and GDP	Energy intensity	energy efficiency	
11 Sustainable Cities and Communities	11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities	sustainable transport systems	public transport	
	11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	11.3.1 Ratio of land consumption rate to population growth rate		sustainable urbanization sustainable human settlement planning sustainable human settlement management	land consumption land consumption rate
	11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	11.4.1 Total per capita expenditure on the preservation, protection and conservation of all cultural and natural heritage, by source of funding (public, private), type of heritage (cultural, natural) and level of government (national, regional, and local/municipal)	natural heritage	preservation of natural heritage protection of natural heritage conservation of natural heritage	
12 Responsible Consumption and Production	12.1 Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries	12.1.1 Number of countries developing, adopting or implementing policy instruments aimed at supporting the shift to sustainable consumption and production		Sustainable Consumption Sustainable Production	
	12.2 By 2030, achieve the sustainable management and efficient use of natural resources	12.2.1 Material footprint, material footprint per capita, and material footprint per GDP	Material footprint	sustainable management of natural resources efficient use of natural resources	
		12.2.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP	material consumption		
	12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses	12.3.1 (a) Food loss index and (b) food waste index	Food loss index food waste index		food waste food losses post-harvest losses
12 Responsible Consumption and Production	12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	12.4.1 Number of parties to international multilateral environmental agreements on hazardous waste, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement 12.4.2 (a) Hazardous waste generated per capita; and (b) proportion of hazardous waste treated, by type of treatment			hazardous waste hazardous waste release to air hazardous waste release to water hazardous waste release to soil
	12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	12.5.1 National recycling rate, tons of material recycled	waste generation recycling rate	reduce waste generation prevention reduction recycling reuse	
	12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate	12.6.1 Number of companies publishing sustainability reports	sustainability report sustainability information	sustainable practices	

(*continued on next page*)

Table A1 (*continued*)

SDG		Indicator	Search Term Neutral	Search Term Positive	Search Term Negative
	sustainability information into their reporting cycle				
12 Responsible Consumption and Production	12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities	12.7.1 Number of countries implementing sustainable public procurement policies and action plans	public procurement		
	12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	12.8.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment		sustainable development lifestyle in harmony with nature education for sustainable development	
13 Climate Action	13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	13.1.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population		resilience adaptive capacity	climate-related hazard natural disaster
		13.1.2 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030		disaster risk reduction disaster risk reduction strategies Sendai Framework for Disaster Risk Reduction	
13 Climate Action	13.2 Integrate climate change measures into national policies, strategies and planning	13.2.1 Number of countries with nationally determined contributions, long-term strategies, national adaptation plans and adaptation communications, as reported to the secretariat of the United Nations Framework Convention on Climate Change		climate change measures	
		13.2.2 Total greenhouse gas emissions per year			greenhouse gas emissions
	13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	13.3.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment		climate change mitigation climate change adaptation climate change impact reduction climate change early warning	
14 Life Below Water	14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	14.1.1 (a) Index of coastal eutrophication; and (b) plastic debris density			marine pollution marine debris nutrient pollution coastal eutrophication plastic debris density
14 Life Below Water	14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans	14.2.1 Number of countries using ecosystem-based approaches to managing marine areas		sustainably manage marine ecosystems sustainably manage coastal ecosystems protect marine ecosystems protect coastal ecosystems ecosystem-based approaches to managing marine areas	
	14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels	14.3.1 Average marine acidity (pH) measured at agreed suite of representative sampling stations	marine acidity		ocean acidification
	14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can	14.4.1 Proportion of fish stocks within biologically sustainable levels		restore fish stocks	overfishing illegal fishing unreported fishing unregulated fishing destructive fishing practices

(*continued on next page*)

Table A1 (*continued*)

SDG		Indicator	Search Term Neutral	Search Term Positive	Search Term Negative
	produce maximum sustainable yield as determined by their biological characteristics				
14 Life Below Water	14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information	14.5.1 Coverage of protected areas in relation to marine areas		protected areas conserved areas	
	14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation	14.6.1 Degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing	World Trade Organization fisheries subsidies negotiation		overcapacity
	14.7 By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism	14.7.1 Sustainable fisheries as a proportion of GDP in small island developing States, least developed countries and all countries	aquaculture	Sustainable fisheries sustainable use of marine resources sustainable management of fisheries sustainable management of aquaculture sustainable management of tourism	
15 Life on Land	15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	15.1.1 Forest area as a proportion of total land area	forests wetlands mountains drylands	conservation of freshwater ecosystems restoration of freshwater ecosystems sustainable use of freshwater ecosystems	
		15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type	biodiversity terrestrial biodiversity freshwater biodiversity	protected areas	
	15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally	15.2.1 Progress towards sustainable forest management		sustainable forest management sustainable management of forests restore forests afforestation reforestation	deforestation
	15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world	15.3.1 Proportion of land that is degraded over total land area	Proportion of degraded land	restore degraded land restore degraded soil	desertification drought floods
15 Life on Land	15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development	15.4.1 Coverage by protected areas of important sites for mountain biodiversity		conservation of mountain ecosystems mountain biodiversity	
		15.4.2 Mountain Green Cover Index	Mountain Green Cover Index		
	15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and,	15.5.1 Red List Index	Red List Index	protect the extinction of threatened species prevent the extinction of threatened species	degradation of natural habitats

(*continued on next page*)

Table A1 (*continued*)

SDG		Indicator	Search Term Neutral	Search Term Positive	Search Term Negative
	by 2020, protect and prevent the extinction of threatened species				
	15.7 Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products	15.7.1 Proportion of traded wildlife that was poached or illicitly trafficked	wildlife		poaching of protected species trafficking of protected species illegal wildlife products illicitly trafficked wildlife
	15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species	15.8.1 Proportion of countries adopting relevant national legislation and adequately resourcing the prevention or control of invasive alien species	alien species		
15 Life on Land	15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts	15.9.1 (a) Number of countries that have established national targets in accordance with or similar to Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011–2020 in their national biodiversity strategy and action plans and the progress reported towards these targets; and (b) integration of biodiversity into national accounting and reporting systems, defined as implementation of the System of Environmental-Economic Accounting	Aichi Biodiversity Target 2 Strategic Plan for Biodiversity	integration of biodiversity System of Environmental-Economic Accounting	

Table A2
Search Term for Environmental Awareness Index

Search Term Neutral	Search Term Positive	Search Term Negative
Aichi Biodiversity Target 2	adaptive capacity	adverse environmental impact of cities
air quality	affordable drinking water	air pollutants
alien species	afforestation	air pollution
aquaculture	agricultural productive capacity	biodiversity losses
aquifers	agricultural research	breeds at risk of extinction
biodiversity	alternative fuels	climate-related hazard
biodiversity and habitat	bioenergy	CO2 from industrial processes
carbon	bioenergy for electricity	CO2 from bio-based processes
carbon emissions	bioenergy for transport	CO2 from fuel combustion industrial processes
carbon footprint	biofuels	coal
climate change	Carbon capture	coal for electricity generation
CO2 emissions	carbon removal	coastal eutrophication
drinking water	carbon storage	damage to critical infrastructure
drylands	carbon utilization	deforestation
ecosystem	carbon-free electricity	degradation biodiversity
electricity generation	CCUS	degradation of natural habitats
electricity security	CCUS emissions reduction technology	desertification
energy	CCUS technologies	destructive fishing practices
energy consumption	clean fuels	disaster
energy demand	Clean hydrogen	disruptions to basic services
energy footprint	clean technologies	drought
energy intensity	clean technology	dumping
energy mix	cleaner energy source	environmental impacts
energy security	climate change adaptation	extreme weather
energy services	climate change early warning	fine particulate matter
energy storage systems	climate change impact reduction	flooding
energy system	climate change measures	floods
energy transition	climate change mitigation	food losses
environment	CO2-neutral certification	food waste
environmental	Concentrating solar power	fossil fuels
environmental impact	conservation of freshwater ecosystems	fuels
food loss index	conservation of mountain ecosystems	gasoline
food waste index	conservation of natural heritage	GHG emissions
forests	conserved areas	global warming
freshwater	corporate social responsibility	greenhouse gas emissions
freshwater biodiversity	CSP	greenwashing
fuel consumption	CSR	hazardous chemicals
gene bank	decarbonising electricity generation	hazardous materials

(*continued on next page*)

Table A2 (*continued*)

Search Term Neutral	Search Term Positive	Search Term Negative
genetic resources	decarbonising the power system	hazardous waste
glaciers	decarbonization	hazardous waste release to air
global climate goals	disaster risk reduction	hazardous waste release to soil
green spaces	diversified plant banks	hazardous waste release to water
lakes	diversified seed banks	illegal fishing
marine acidity	ecological friendly products	illegal wildlife products
material consumption	ecosystem-based approaches to managing marine areas	illicitly trafficked wildlife
material footprint	education for sustainable development	industrialization
Mountain Green Cover Index	efficient use of natural resources	land consumption
mountains	electric car	marine debris
natural heritage	electric mobility transition	marine pollution
nuclear plants	electric vehicles	natural disaster
oil demand	electrification of transport	natural gas
ozone exposure	emissions reduction	negative emissions
Proportion of degraded land	emissions reduction technology	nuclear power
public procurement	emissions-free power	nutrient pollution
recycling rate	energy diversification	ocean acidification
Red List Index	energy economies of scale	oil
rivers	energy efficiency	overcapacity
soil quality	energy efficiency gains	overfishing
strategic Plan for Biodiversity	energy efficient technologies	petrochemicals
sustainability information	environment friendly	plastic debris density
sustainability report	environmental attention	plastics use
sustainable transport systems	environmental, social, and governance factors	poaching of protected species
terrestrial biodiversity	environmentally friendly products	pollution
urbanization	equitable sharing of benefits	pollution emissions
water quality	ESG factors	post-harvest losses
water resources	EVs	rainforest destruction
water-related ecosystems	fuel economy	rising global temperature
wetlands	fuel economy standards	solid waste
wildlife	fuel economy vehicle	trafficking of protected species
World Trade Organization fisheries subsidies negotiation	genetic diversity	unregulated fishing
	geothermal	unreported fishing
	Geothermal energy	untreated wastewater
	green bonds	waste generation
	green crowdfunding platforms	water pollution
	green finance	water scarcity
	green financing	water stress
	green fintech	water-related disasters
	green products	
	green solutions	
	green taxonomies	
	green technologies	
	green-oriented investors	
	hydrogen	
	hydrogen produced from fossil fuels	
	hydrogen produced from nuclear	
	hydrogen produced from renewables	
	hydropower	
	integration of biodiversity	
	intergovernmental panel on climate change	
	IPPC	
	less carbon intensive	
	less polluting technologies	
	lifestyle in harmony with nature	
	low-carbon energy systems	
	lower carbon emissions	
	maintain ecosystem	
	methane abatement technologies	
	mountain biodiversity	
	net zero energy systems	
	non emitting renewable energies	
	ocean power	
	offshore wind	
	onshore wind	
	organic food	
	power grids solar	
	power sector decarbonization	
	power system flexibility	
	preservation of natural heritage	
	prevent the extinction of threatened species	
	prevention	
	protect coastal ecosystems	
	protect marine ecosystems	
	protect the extinction of threatened species	
	protected areas	

(*continued on next page*)

Table A2 (*continued*)

Search Term Neutral	Search Term Positive	Search Term Negative
	protection of natural heritage	
	public transport	
	pumped storage plant	
	recycling	
	reduce waste generation	
	reduction	
	reforestation	
	renewable electricity generation	
	renewable energy	
	renewable energy share	
	renewable energy technologies	
	renewables	
	reservoir hydropower plants	
	resilience	
	resilient agriculture	
	restoration of freshwater ecosystems	
	restore degraded land	
	restore degraded soil	
	restore fish stocks	
	restore forests	
	reuse	
	run-of-river hydropower plants	
	safe drinking water	
	savings certificates digitally	
	SDGs	
	Sendai Framework for Disaster Risk reduction	
	smart grid	
	socially responsible	
	solar cooling	
	solar energy	
	solar heating	
	solar panels	
	solar photovoltaics	
	solar plants	
	solar power generation	
	solar systems off-grid applications	
	solar technologies	
	solar thermal electricity	
	solid waste collected	
	sustainability	
	sustainable agriculture	
	sustainable consumption	
	sustainable development	
	sustainable development goals	
	sustainable economic growth	
	sustainable energy system	
	sustainable energy use	
	sustainable farming	
	sustainable finance	
	sustainable financing	
	sustainable fisheries	
	sustainable food	
	sustainable forest management	
	sustainable human settlement management	
	sustainable human settlement planning	
	sustainable management of aquaculture	
	sustainable management of fisheries	
	sustainable management of forests	
	sustainable management of natural resources	
	sustainable management of tourism	
	sustainable practices	
	sustainable production	
	sustainable urbanization	
	sustainable use of freshwater ecosystems	
	sustainable use of marine resources	
	sustainably manage coastal ecosystems	
	sustainably manage marine ecosystems	
	System of Environmental-Economic Accounting	
	traditional knowledge	
	utility scale solar power generation	
	utilization of genetic resources	
	vehicle efficiency	
	waste management	
	wastewater treatment	
	water resources management	
	water-use efficiency	

(*continued on next page*)

Table A2 (*continued*)

Search Term Neutral	Search Term Positive	Search Term Negative
	wind electricity production	
	wind energy	
	wind power	
	Wind turbines	
	zero-emission vehicle	

References

Adams, S., Boateng, E., Acheampong, A.O., 2020. Transport energy consumption and environmental quality: does urbanization matter? Sci. Total Environ. 744, 140617 https://doi.org/10.1016/j.scitotenv.2020.140617.

Alhassan, H., 2021. The effect of agricultural total factor productivity on environmental degradation in sub-Saharan Africa. Scientific African 12, e00740. https://doi.org/10.1016/j.sciaf.2021.e00740.

Angel, S., Parent, J., Civco, D.L., 2012. The fragmentation of urban landscapes: global evidence of a key attribute of the spatial structure of cities. Environ. Urbanization 24 (1), 249–283. https://doi.org/10.1177/0956247811433536, 1990–2000.

Blankenberg, A.K., Alhusen, H., 2019. On the Determinants of Pro-environmental Behavior: A Literature Review and Guide for the Empirical Economist. Center for European, Governance, and Economic Development Research (CEGE), 350.

Bülbül, H., Büyükkeklik, A., Topal, A., Özoğlu, B., 2020. The relationship between environmental awareness, environmental behaviors, and carbon footprint in Turkish households. Environ. Sci. Pollut. Control Ser. 27 (20), 25009–25028. https://doi.org/10.1007/s11356-020-08813-1.

Carmi, N., 2013. Caring about tomorrow: future orientation, environmental attitudes and behaviors. Environ. Educ. Res. 19 (4), 430–444. https://doi.org/10.1080/13504622.2012.700697.

Chankrajang, T., Muttarak, R., 2017. Green returns to education: does schooling contribute to pro-environmental behaviours? Evidence from Thailand. Ecol. Econ. 131, 434–448. https://doi.org/10.1016/j.ecolecon.2016.09.015.

Chen, J., Wang, L., Li, Y., 2020. Research on the impact of multi-dimensional urbanization on China's carbon emissions under the background of COP21. J. Environ. Manag. 273, 111123 https://doi.org/10.1016/j.jenvman.2020.111123.

Choi, H., Varian, H., 2009. Predicting Initial Claims for Unemployment Benefits, vol. 1. Google Inc., pp. 1–5, 2009. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=4d91786f9f88e0ec8dd5a25ca7c08f4d8e693b53

Choi, H., Varian, H., 2012. Predicting the present with Google trends. Econ. Rec. 88, 2–9. https://doi.org/10.1111/j.1475-4932.2012.00809.x.

Clayton, S., Myers, G., 2015. Conservation Psychology: Understanding and Promoting Human Care for Nature. John Wiley & Sons.

Conrad, C.C., Hilchey, K.G., 2011. A review of citizen science and community-based environmental monitoring: issues and opportunities. Environ. Monit. Assess. 176 (1), 273–291. https://doi.org/10.1007/s10661-010-1582-5.

Cui, X., Fang, C., Liu, H., Liu, X., 2019. Assessing sustainability of urbanization by a coordinated development index for an Urbanization-Resources-Environment complex system: a case study of Jing-Jin-Ji region, China. Ecol. Indicat. 96, 383–391. https://doi.org/10.1016/j.ecolind.2018.09.009.

Daziano, R.A., Bolduc, D., 2013. Incorporating pro-environmental preferences towards green automobile technologies through a Bayesian hybrid choice model. Transportmetrica: Transport. Sci. 9 (1), 74–106. https://doi.org/10.1080/18128602.2010.524173.

De Medeiros, J.F., Da Rocha, C.G., Ribeiro, J.L.D., 2018. Design for sustainable behavior (DfSB): analysis of existing frameworks of behavior change strategies, experts' assessment and proposal for a decision support diagram. J. Clean. Prod. 188, 402–415. https://doi.org/10.1016/j.jclepro.2018.03.272.

Drukker, D.M., 2003. Testing for serial correlation in linear panel-data models. STATA J. 3 (2), 168–177. https://journals.sagepub.com/doi/pdf/10.1177/1536867X0300300206.

Fragkias, M., Islam, S., Sprague, C., 2017. Modeling teleconnected urban social–ecological systems: opportunities and challenges for resilience research. Int. J. Urban Sustain. Dev. 9 (2), 207–225. https://doi.org/10.1080/19463138.2017.1324455.

Fu, L., Sun, Z., Zha, L., Liu, F., He, L., Sun, X., Jing, X., 2020. Environmental awareness and pro-environmental behavior within China's road freight transportation industry: moderating role of perceived policy effectiveness. J. Clean. Prod. 252, 119796 https://doi.org/10.1016/j.jclepro.2019.119796.

Giudici, G., Guerini, M., Rossi-Lamastra, C., 2019. The creation of cleantech startups at the local level: the role of knowledge availability and environmental awareness. Small Bus. Econ. 52 (4), 815–830. https://doi.org/10.1007/s11187-017-9936-9.

Ham, M., Mrčela, D., Horvat, M., 2016. Insights for measuring environmental awareness. Ekonomski Vjesnik: Review of Contemporary Entrepreneurship, Business, and Economic Issues 29 (1), 159–176. https://hrcak.srce.hr/161021.

Hanisch, A., Rank, A., Seeber, G., 2014. How green are European Curricula? A comparative analysis of primary school syllabi in five European countries. Eur. Educ. Res. J. 13 (6), 661–682. https://doi.org/10.2304/eerj.2014.13.6.661.

Hopwood, B., Mellor, M., O'Brien, G., 2005. Sustainable development: mapping different approaches. Sustain. Dev. 13 (1), 38–52. https://doi.org/10.1002/sd.244.

Hickel, J., 2020. The sustainable development index: measuring the ecological efficiency of human development in the anthropocene. Ecol. Econ. 167, 106331 https://doi.org/10.1016/j.ecolecon.2019.05.011.

Jacobi, P., Kjellen, M., McGranahan, G., Songsore, J., Surjadi, C., 2010. The Citizens at Risk: from Urban Sanitation to Sustainable Cities. Routledge.

Johnson, C.Y., Bowker, J.M., Cordell, H.K., 2004. Ethnic variation in environmental belief and behavior: an examination of the new ecological paradigm in a social psychological context. Environ. Behav. 36 (2), 157–186. https://doi.org/10.1177/0013916503251478.

Jun, S.P., Yoo, H.S., Choi, S., 2018. Ten years of research change using Google Trends: from the perspective of big data utilizations and applications. Technol. Forecast. Soc. Change 130, 69–87. https://doi.org/10.1016/j.techfore.2017.11.009.

Kalantari, Z., Ferreira, C.S.S., Walsh, R.P.D., Ferreira, A.J.D., Destouni, G., 2017. Urbanization development under climate change: hydrological responses in a peri-urban Mediterranean catchment. Land Degrad. Dev. 28 (7), 2207–2221. https://doi.org/10.1002/ldr.2747.

Kikuchi-Uehara, E., Nakatani, J., Hirao, M., 2016. Analysis of factors influencing consumers' proenvironmental behavior based on life cycle thinking. Part I: effect of environmental awareness and trust in environmental information on product choice. J. Clean. Prod. 117, 10–18. https://doi.org/10.1016/j.jclepro.2015.12.030.

Longhi, S., 2013. Individual pro-environmental behaviour in the household context (No. 2013-21). ISER Working Paper Series. https://www.econstor.eu/handle/10419/91690.

Lopez, L., Weber, S., 2017. Testing for Granger causality in panel data. STATA J. 17 (4), 972–984. https://journals.sagepub.com/doi/pdf/10.1177/1536867X1801700412.

Lynn, P., Longhi, S., 2011. Environmental Attitudes and Behaviour: Who Cares about Climate Change. Understanding Society. https://www.basw.co.uk/system/files/resources/basw_115614-1_0.pdf#page=109.

Medeiros, M.C., Pires, H.F., 2021. The Proper Use of Google Trends in Forecasting Models. https://doi.org/10.48550/arXiv.2104.03065 arXiv preprint arXiv:2104.03065.

Mellon, J., 2013. Where and when can we use Google Trends to measure issue salience? PS Political Sci. Polit. 46 (2), 280–290. https://doi.org/10.1017/S1049096513000279.

Mellon, J., 2014. Internet search data and issue salience: the properties of Google Trends as a measure of issue salience. J. Elections, Public Opin. Parties 24 (1), 45–72. https://doi.org/10.1080/17457289.2013.846346.

Meyer, A., 2015. Does education increase pro-environmental behavior? Evidence from Europe. Ecol. Econ. 116, 108–121. https://doi.org/10.1016/j.ecolecon.2015.04.018.

Mkumbachi, R.L., Astina, I.K., Handoyo, B., 2020. Environmental awareness and pro-environmental behavior: a case of university students in Malang city. Jurnal Pendidikan Geografi 25 (2), 161–169. http://journal2.um.ac.id/index.php/jpg/.

Pisano, I., Lubell, M., 2017. Environmental behavior in cross-national perspective: a multilevel analysis of 30 countries. Environ. Behav. 49 (1), 31–58. https://doi.org/10.1177/0013916515600494.

Poumanyvong, P., Kaneko, S., 2010. Does urbanization lead to less energy use and lower CO2 emissions? A cross-country analysis. Ecol. Econ. 70 (2), 434–444. https://doi.org/10.1016/j.ecolecon.2010.09.029.

Punzo, G., Panarello, D., Pagliuca, M.M., Castellano, R., Aprile, M.C., 2019. Assessing the role of perceived values and felt responsibility on pro-environmental behaviours: a comparison across four EU countries. Environ. Sci. Pol. 101, 311–322.

Ramsey, J.M., Hungerford, H.R., Volk, T.L., 1992. Environmental education in the K-12 curriculum: finding a niche. J. Environ. Educ. 23 (2), 35–45. https://doi.org/10.1080/00958964.1992.9942794.

Robelia, B., Murphy, T., 2012. What do people know about key environmental issues? A review of environmental knowledge surveys. Environ. Educ. Res. 18 (3), 299–321. https://doi.org/10.1080/13504622.2011.618288.

Sadorsky, P., 2014. The effect of urbanization on CO2 emissions in emerging economies. Energy Econ. 41, 147–153. https://doi.org/10.1016/j.eneco.2013.11.007.

Sarwar, S., Alsaggaf, M.I., 2019. Role of urbanization and urban income in carbon emissions: regional analysis of China. Appl. Ecol. Environ. Res. 17 (5), 10303–10311. http://www.aloki.hu.

Schneider, A., Mertes, C.M., Tatem, A.J., Tan, B., Sulla-Menashe, D., Graves, S.J., et al., 2015. A new urban landscape in East–Southeast Asia, 2000–2010. Environ. Res. Lett. 10 (3), 034002 https://doi.org/10.1088/1748-9326/10/3/034002.

Scheitle, C.P., 2011. Google's insights for search: a note evaluating the use of search engine data in social research. Soc. Sci. Q. 92 (1), 285–295. https://doi.org/10.1111/j.1540-6237.2011.00768.x.

Sekhokoane, L., Qie, N., Rau, P.L.P., 2017. Do consumption values and environmental awareness impact on green consumption in China?. In: International Conference on Cross-Cultural Design. Springer, Cham, pp. 713–723. https://doi.org/10.1007/978-3-319-57931-3_58. July.

Silvi, M., Padilla, E., 2021. Pro-environmental behavior: social norms, intrinsic motivation and external conditions. Environmental Policy and Governance 31 (6), 619–632. https://doi.org/10.1002/eet.1960.

Special Eurobarometer 501, 2020. Attitudes of European Citizens towards the Environment. European Commission.

Steg, L., Vlek, C., 2009. Encouraging pro-environmental behaviour: an integrative review and research agenda. J. Environ. Psychol. 29 (3), 309–317. https://doi.org/10.1016/j.jenvp.2008.10.004.

Stern, P.C., Dietz, T., Abel, T., Guagnano, G.A., Kalof, L., 1999. A value-belief-norm theory of support for social movements: the case of environmentalism. Human ecology review. 81–97. https://www.jstor.org/stable/24707060.

Sudarmadi, S., Suzuki, S., Kawada, T., Netti, H., Soemantri, S., Tri Tugaswati, A., 2001. A survey of perception, knowledge, awareness, and attitude in regard to environmental problems in a sample of two different social groups in Jakarta, Indonesia. Environ. Dev. Sustain. 3 (2), 169–183. https://doi.org/10.1023/A:1011633729185.

Tang, W., Xu, Y.J., Li, S., 2021. Rapid urbanization effects on partial pressure and emission of CO2 in three rivers with different urban intensities. Ecol. Indicat. 125, 107515 https://doi.org/10.1016/j.ecolind.2021.107515.

Torgler, B., Garcia-Valiñas, M.A., 2007. The determinants of individuals' attitudes towards preventing environmental damage. Ecol. Econ. 63 (2–3), 536–552. https://doi.org/10.1016/j.ecolecon.2006.12.013.

United Nations Environment Program, 2022. UN Biodiversity Conference (COP 15). https://www.unep.org/un-biodiversity-conference-cop-15.

United Nations Climate Change, 2022. Climate Plans Remain Insufficient: More Ambitious Action Needed Now. October 26. https://unfccc.int/news/climate-plans-remain-insufficient-more-ambitious-action-needed-now.

Von Borgstede, C., Andersson, M., Johnsson, F., 2013. Public attitudes to climate change and carbon mitigation—implications for energy-associated behaviours. Energy Pol. 57, 182–193. https://doi.org/10.1016/j.enpol.2013.01.051.

Wang, S., Fan, J., Zhao, D., Yang, S., Fu, Y., 2016. Predicting consumers' intention to adopt hybrid electric vehicles: using an extended version of the theory of planned behavior model. Transportation 43 (1), 123–143. https://doi.org/10.1007/s11116-014-9567-9.

Wang, Y., Hao, F., Liu, Y., 2021. Pro-environmental behavior in an aging world: evidence from 31 countries. Int. J. Environ. Res. Publ. Health 18 (4), 1748. https://doi.org/10.3390/ijerph18041748.

Wang, W.Z., Liu, L.C., Liao, H., Wei, Y.M., 2021. Impacts of urbanization on carbon emissions: an empirical analysis from OECD countries. Energy Pol. 151, 112171 https://doi.org/10.1016/j.enpol.2021.112171.

Wang, X., Zhang, W., 2022. Taxes versus tradable permits considering public environmental awareness. Economics of Disasters and Climate Change 6 (2), 293–315. https://doi.org/10.1007/s41885-022-00108-8.

Whitmarsh, L., O'Neill, S., 2010. Green identity, green living? The role of pro-environmental self-identity in determining consistency across diverse pro-environmental behaviours. J. Environ. Psychol. 30 (3), 305–314. https://doi.org/10.1016/j.jenvp.2010.01.003.

Wooldridge, J.M., 2002. Econometric Analysis of Cross Section and Panel Data. MIT Press, Cambridge, MA.

Xin, Y., Yang, S., Rasheed, M.F., 2022. Exploring the Impacts of Education and Unemployment on CO2 Emissions. Economic Research-Ekonomska Istraživanja. https://doi.org/10.1080/1331677X.2022.2110139, 1–13.

Zhang, S., Li, Z., Ning, X., Li, L., 2021. Gauging the impacts of urbanization on CO2 emissions from the construction industry: evidence from China. J. Environ. Manag. 288, 112440 https://doi.org/10.1016/j.jenvman.2021.112440.

Zhang, L., Zhou, J., 2016. The effect of carbon reduction regulations on contractors' awareness and behaviors in China's building sector. J. Clean. Prod. 113, 93–101. https://doi.org/10.1016/j.jclepro.2015.12.032.

Zhou, Y., Chen, M., Tang, Z., Mei, Z., 2021. Urbanization, land use change, and carbon emissions: quantitative assessments for city-level carbon emissions in Beijing-Tianjin-Hebei region. Sustain. Cities Soc. 66, 102701 https://doi.org/10.1016/j.scs.2020.102701.

Zorić, J., Hrovatin, N., 2012. Household willingness to pay for green electricity in Slovenia. Energy Pol. 47, 180–187. https://doi.org/10.1016/j.enpol.2012.04.055.