Review of specific environmental indicators

Zoe Gareiou[1], *Nectaria* Gizani[1], *Iro* Laskari[1], *Irene* Mavromati[1] and *Efthimios* Zervas[1,*]

[1]Laboratory of Technology and Policy of Energy and Environment, Hellenic Open University, Parodos Aristotelous 18, 26335, Patra, Greece

Abstract. Indicators are used in almost every scientific field to quantify and/or record and/or follow the evolution of a specific parameter. Environmental indicators are related to the environment quality and are specifically used to monitor the quality of the environment and to measure the environmental performance. They can be categorized into specific, composite and personal environmental indicators. A review of the specific environmental indicators used in the literature are presented here. Specific environmental indicators include indicators related to the natural or to the anthropogenic environment. The specific environmental indicators for the natural environment are mainly related to climate change, reduction of the ozone layer, air quality, water quality, forest resources, fishing resources, biodiversity etc, while the specific environmental indicators for the anthropogenic environment are mainly related to socio-economic indicators, such as population, consumption, energy, waste, transportation, etc.

1 Introduction

The general term "indicator" refers to anything that indicates something. It is a sign or a measure of something [1]. The term indicator finds application in various scientific fields, like in the environment. Environmental indicators are related to the environment and are powerful tools to monitor the quality and status of the environmental and to measure the environmental performance [2].

Environmental indicators are categorized in various ways. Here, the categorization of the indicators is chosen based on the characteristic they examine. Specifically, the indicators are divided into specific, composite and personal environmental indicators. However, the limits separating indicators into specific, composite or personal are not always clear [2].

Specific environmental indicators include indicators related to the natural and to the anthropogenic environment. In particular, the specific environmental indicators for the natural environment refer to the atmosphere, water, soil and biodiversity [3]. On the other hand, the specific environmental indicators for the anthropogenic environment are mainly related to socio-economic activities. Socio-economic anthropogenic activities (e.g. waste production, energy activities, population, transport, etc.) are directly linked to the environment and the use of resources and ecosystems, as human activities have a direct impact on the environment and are in large degree the cause of change in the state of the natural environment [2].

The environment is considered as one of the three pillars of development, where it is directly linked to the other two pillars, the economic and the social ones. Therefore, there is a need for indicators that could capture the relationships between the environment and the other two pillars [4]. Composite environmental indicators either include all three of these pillars or are a combination of specific environmental indicators. These indicators are presented in another work [5].

Personal environmental indicators are indicators related to the attitudes and behaviors of citizens towards environmental issues. The behavior of citizens towards the environment is directly related to their opinion of nature and their relationship with it [4] and various works have studied the attitude and behavior of citizens on various environmental issues e.g. climate change [6], renewable energy sources [7], waste management [8], green growth [9], etc. The personal environmental indicators are created by the researchers themselves and the main of them are the New Environmental Paradigm Scale [10], the Environmental Attitude Inventory, the General Ecological Behavior Scale, the Motivation Toward the Environment Scale, the Connectedness to Nature Scale, the Ecocentric Scale and the Anthropocentric Scale. These indicators are presented in another work [11].

This paper reviews and synthesizes the main specific environmental indicators used in the literature and is the first of a series of three papers. The second and third ones present respectively the composite and the personal indicators [5, 11].

2 Specific environmental indicators

For each one of the environmental problems, we will present the main causes of these problems, the agreements or actions undertaken to mitigate these problems and the main indicators used to monitor the

* Corresponding author: zervas@eap.gr

corresponding environmental quality. The indicators that will be presented come either from related works that examine specific indicators such as e.g. OECD environmental indicators [2], energy, transport and environment indicators [12], energy indicators for sustainable development [3] and sustainable development indicators [13, 14], either from websites that contain indicator statistics, or from websites of countries that measure various specific indicators.

2.1 Special environmental indicators for the natural environment

The main specific environmental indicators for the natural environment refer to atmosphere, water, soil and biodiversity, and are mainly related to climate change, reduction of the ozone layer, air quality, water quality, forest and fisheries resources and biodiversity [15].

2.1.1 Climate change

Industrialization and increased energy consumption have increased greenhouse gas emissions from human activities. These gases, as well as land use and forestry changes, affect the greenhouse effect, leading to global temperature increase and to other changes in the earth's climate. These changes are of concern mainly for their impact on ecosystems (biodiversity), but also for their consequences on socio-economic activities [2].
To deal with climate change, global agreements have been drawn up and related measures have been taken, such as:
• The Paris Agreement on climate change, where the European Union (EU) submitted a long-term emissions reduction strategy and climate adaptation plans to make the EU the first climate-neutral economy and society by 2050 [16].
• The Glasgow Climate Agreement, with the aim of accelerating the fight against climate warming [17].
• The United Nations Global Agreement to adopt the 17 Sustainable Development Goals (SDGs), where goal 13 refers exclusively to the climate and the fight against climate change and its consequences [18].
The Intergovernmental Panel on Climate Change (IPCC) is the international body for assessing the science related to climate change. It was created to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, as well as adaptation and mitigation options [15].
Furthermore, the United Nations Statistical Service compiles global statistical information, such as information on CO_2, CFCs, CH_4 and N_2O emissions for a number of countries [19].
In addition, in the context of climate change, various indicators have been defined by scientists, e.g. index for the quantification of temperature variability (TEVY index) [20], development and application of water and land resources degradation index (WLDI) [21, 22].
The main indicators related to climate change are:
• Increase of the mean global temperature and evolution of other parameters related to global and local climatic conditions.
• CO_2 emissions from energy use, as CO_2 from burning fossil fuels and biomass are the main greenhouse gas: CO_2 emissions per year, per country, per fuel, per unit of GDP, per inhabitant, per economic activity, etc.
• Emissions of other CHG: CH_4, N_2O, chloro-fluorinated gases (HFCs, PFCs, SF6) (per year, per country, per unit of GDP, per inhabitant, per economic activity, etc.).
• Atmospheric concentrations of greenhouse gases (CO_2, CH_4, N_2O, chloro-fluorinated gases (HFCs, PFCs, SF6)) and substances that destroy the ozone layer and also play a role in the greenhouse effect (CFC-11, CFC-12, total chlorine,…).

2.1.2 Reduction of the Ozone Layer

The reduction of the ozone layer increases the UV radiation received by the Earth's surface. This increase has serious impacts on for human health, crops and the natural environment, but also contributes to the ageing of several materials [2].
The release into the atmosphere of certain substances containing halogens endangers the stratospheric ozone layer, which protects the earth's surface from ultraviolet radiation. These are anthropogenic chemical compounds, such as CFCs, halons, methyl chloroform, carbon tetrachloride, HCFCs and methyl bromide. These compounds are used in air conditioning and refrigeration equipment, aerosols, foam plastics and fire extinguishers, and are also used as solvents and pesticides [2].
For the protection of atmospheric ozone, global agreements/laws have been drawn up and related measures have been taken, such as:
• The Montreal Protocol in 1987, where parties must adapt to the provisions of the protocol, respond quickly to new scientific information and agree to accelerate the reductions required by the chemical compounds covered by the protocol. The parties to the protocol meet annually and take various decisions aimed at the effective implementation of this important legal instrument [23]. The protocol has undergone significant amendments and adaptations: London Amendment (1990), Copenhagen Amendment (1992), Montreal Amendment (1997), Beijing Amendment (1999) and Kigali Amendment (2006) [24, 25].
• Regulation (European Parliament) no. 1005/2009, where it is the main implementation tool of the European policy for the protection of the ozone layer (it incorporates the latest amendments (up to 2009) to the Montreal Protocol). The Regulation defines stricter and specialized measures for the prohibition of use or gradual reduction depending on the controlled substance, for the production and circulation in general of the controlled substances and products containing them, for the limitation of emissions during the maintenance of the equipment (mainly in the phase of withdrawal) and for the control of imports and exports [24].

• Regulation (European Commission) no. 517/2014 on fluorinated greenhouse gases, where it aims to reduce fluorinated greenhouse gas emissions and facilitate a global agreement to phase out hydrofluorocarbons. Fluorinated gas typically replaced ozone-depleting substances when they were banned [25].
The main indicators for the depletion of the ozone layer are related to:
• The production and consumption of compounds that destroy the ozone layer, per year, per country and per product (e.g. air conditioning units, refrigerators, aerosols, fire extinguishers).
• Atmospheric ozone levels, per year and per region of the Earth.

2.1.3 Air Quality

The main air pollutants are emitted from the transformation and consumption of energy, as well as from industrial processes and other anthropogenic activities. Air pollution affects human health, ecosystems, buildings, monuments, etc. Poor air quality can have economic and social consequences and leads to a lower quality of life [2].
The European Union and North America countries have entered into international agreements/laws setting upper emission limits and establishing commitments to reduce emissions in order to limit the population's exposure to air pollution. They have adopted protocols to reduce sulphur emissions (Helsinki, 1985, Oslo, 1994, Gothenburg, 1999), nitrogen oxides (Sofia, 1988, Gothenburg, 1999), heavy metal emissions (Aarhus, 1998) and organic pollutants. (Aarhus, 1998) [2].
In the case of the European Union, the Effort Sharing Regulation sets mandatory targets for annual emission reductions for EU countries, for the period 2021-2030, so as to ensure that all Member States participate in efforts to reduce emissions in the aforementioned sectors. The regulation also sets out the annual distribution of emissions and how progress will be assessed [26].
Air pollution statistics are collected by many agencies. For example, the United Nations Statistical Office collects statistical information, for a number of countries, for SO_2 and NO_2 emissions [19].
The main indicators for air quality are related to:
• Emissions of gaseous pollutants, such as CO, SO_x or NO_x, and of particulate matter, and their changes over time, as well as emission intensities, expressed as emitted quantities, per country, per unit of GDP and per inhabitant. These indicators are supplemented with information on the acidity of rain and snow and the excess of critical loads on soils and waters that reflect the actual acidification of the environment.
• Concentrations of air pollutants, such as ozone, carbon monoxide, particulate matter (PM10, PM2.5, total suspended particulate matter [TSP], black smoke, …), sulphur dioxide, nitrogen dioxide, benzene, lead etc., per city or country, or per time (average or max concentrations in the day, week, month, year,…).

2.1.4 Water Quality

The quality and quantity of available water has a significant environmental, social and economic importance. Water quality is mainly affected by water abstraction, pollution by human activities (energy, agriculture, industry, households, etc.) and by the local, and even wider, climate. Water quality has many aspects (physical, chemical, biological); this quality can be defined based on the suitability of the water for various uses, such as public water supply, bathing or the protection of aquatic life [2].
There are several agreements/laws at the international level, such as the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), the Commission's International Joint Agreement on the Water Quality of the North American Great Lakes and the EU water directives [2].
Furthermore, protecting the quality and availability of fresh water is an important part of Agenda 21, adopted at the United Nations Conference on Environment and Development. The main objective is to protect and restore all surface and groundwater systems to ensure the achievement of water quality objectives and to implement integrated water resources management based on the ecosystem approach [2].
In addition, the Sustainable Development Goals refer to water and life in water. The Goal 6 refers to ensuring the availability and sustainable management of water and sanitation for all, while Goal 14 refers to the protection and sustainable use of oceans and seas [18].
The main indicators for water quality are related to:
• The water quality of selected rivers, i.e. their content of dissolved oxygen, or the content of nitrates or other pollutants, per time (day, month, year) and per geographic area (river, hydrological basin, region, country,…). The necessary data are collected at representative locations at the estuary or downstream boundary, giving a snapshot of pollution loads and clean-up efforts in the upstream watershed.
• Wastewater treatment, especially the percentages of residential, industrial, etc. connections to wastewater treatment plants, that is, the percentage of the national population connected to wastewater treatment plants. The rate of secondary and/or tertiary (chemical and/or biological) wastewater treatment is an indication of efforts to reduce pollution loads of wastewater.
• Liquid waste emissions from all energy-related activities (e.g., electricity production, coal, oil or natural gas combustion,…), including cooling water discharge, which can increase stream temperature, pH, total organic carbon (TOC), hydrocarbons, suspended solids, ammonia and total nitrogen, chlorides, sulphides, phenols, heavy metals, etc. time (day, month, year) and per geographic area (facility, hydrological basin, region, country,…).
• The intensity of use of water resources, time (day, month, year) and per geographic area (river, city, facility, hydrological basin, region, country,…)., expressed as gross withdrawals, as % of total available renewable freshwater resources (including inflows from neighbouring countries), as a percentage of internal

resources (i.e. precipitation - evapotranspiration) and per capita.
• The intensity of use of water resources by human activity (e.g. agriculture, fishing, domestic production, households and services), by time (day, month, year) per geographic area (hydrological basin, region, country,…) and per activity.
• Price for water supply to households or to economic activities (agriculture, industry, …), per cubic meter supplied, by time (day, month, year), per geographic area (municipality, region, country,…) and per economic activity.

2.1.5 Forest Resources

Forests are among the most diverse and widespread ecosystems on Earth. They are important reservoirs for biodiversity and regulate many parameters for ecosystems, such as soil, air and water regulation. They also significantly contribute to many socio-economic activities, such as providing timber and other products or providing recreational services. Many forest resources are threatened by overexploitation, degradation of environmental quality and conversion to other types of land use [2].
Agenda 21, adopted at the United Nations Conference on Environment and Development (UNCED – Rio de Janeiro, 1992), endorses international principles for the sustainable management of forests. Other international initiatives are the Ministerial Conferences on the Protection of Forests in Europe (Strasbourg, 1990; Helsinki, 1993; Lisbon, 1998), which led to the establishment of Europe-wide criteria and indicators for the sustainable management of forests, the Montreal Process for Sustainable Development of Temperate and Boreal Forests and the United Nations Forum on Forests. The aim is to ensure the sustainable management of forest resources, avoiding overexploitation and degradation [2].
In addition, the Sustainable Development Goals refer to the use of forests. The Goal 15 mainly refers to the sustainable use of forests and combating desertification [18].
The main indicators for forest resources relate to:
• The extent of forests and forest lands, as a percentage of the total area and per capita population, and their evolution in time (year,…) and per geographic area (region, country,…).
• The intensity of use of forest resources (timber), per geographic area (region, country,…), which links the annual production capacity to the actual harvest.

2.1.6 Fishing Resources

Marine species play an important role in the regulation of aquatic ecosystems as well as in food supply. Fishing, coastal development, pollution loads from land-based sources and marine transport are the main pressures on fishing resources, affecting both freshwater quality and marine species and habitats, degrading biodiversity and affecting the supply of fish for consumption [2].
The aim is to ensure the sustainable management of marine resources so that resource extraction does not exceed replenishment over a long period of time. To achieve this goal, there are a number of bilateral and multilateral agreements, such as those on the conservation and use of fisheries resources (Atlantic Ocean, Pacific Ocean, Baltic Sea, etc.), the Rome Consensus on World Fisheries, the Code of Conduct for Responsible Fisheries (FAO, November 1995), which sets out plans to address the problem of illegal, unreported and unregulated fishing, and the United Nations Convention on the Law of the Sea [2].
Furthermore, the Sustainable Development Goals refer specifically to aquatic life. The Goal 14 refers to the protection of marine resources for sustainable development [18].
The main indicators for fishing resources relate to:
• National catches, expressed as percentages of total worldwide, per region, country and per capita (totally or per species).
• National (or regional) fish consumption (fish supply per inhabitant, totally or per species).
• Annual global and regional catches, by species.

2.1.7 Biodiversity

Biodiversity is defined as the variety among living organisms. It covers both ecosystem and species level diversity and genetic diversity within species. Pressures on biodiversity can be natural (e.g. habitat alteration and fragmentation from land use changes), chemical (e.g. pollution from human activities) or biological (e.g. altered population dynamics and structure of species from the release of exotic species or the commercial use of wild animals) [2].
International agreements such as the Convention on Biological Diversity (Rio de Janeiro, 1992), the Convention on the Conservation of Migratory Species of Wild Animals (Bonn, 1979), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, Washington, 1973), the Convention on Wetlands of International Importance (Ramsar, 1971) and the Convention on the Conservation of European Wildlife and Natural Habitats (Bern, 1979), aim to maintain or restore the diversity and integrity of ecosystems, of species and genetic material and to ensure the sustainable use of biodiversity [2].
Furthermore, the Sustainable Development Goals refer to life on land. The Goal 15 refers to promoting the sustainable use of terrestrial ecosystems and reversing soil and biodiversity degradation [18].
The main indicators related to biodiversity conservation relate to:
• The number of threatened or extinct species compared to the number of known species, such as mammals, birds, fish, reptiles and amphibians, per region or per country, or per time (year, …).
• Protected areas, i.e. areas under categories I to VI of the International Cooperative Union (IUCN) classification, which refer to different levels of protection, per region or per country.

2.2 Special environmental indicators for the anthropogenic environment

Socio-economic indicators significantly influence environmental indicators, as socio-economic activities are directly linked to the environment and have a direct impact on it. Specific environmental indicators for the anthropogenic environment are mainly related to population, consumption, energy, waste, transportation and the agricultural sector [2].
With regard to the economic part, the gross domestic product (GDP) is a key indicator of the economic development of the states [27]. For this reason, all the indicators that follow, except for per capita indicators, are calculated both by GDP and by GDP/capita.

2.2.1 Population

Population is an important factor in environmental conditions and trends, as it affects production and consumption patterns, and hence the sustainability of development. Population growth puts pressure on natural resources and affects the environment in the way that its structural components (e.g. working population, household size,…) affect consumption and waste generation patterns. Furthermore, the economic development of the population implies the use of energy and other resources, as well as the generation of pollutants and the production of waste, significantly affecting the environment [2].
The Review of World Population Prospects [28], published annually by the United Nations Population Service of the Department of Economic and Social Affairs of the United Nations Secretariat, is an extensive source of data on world population and the official estimate of world population. The Review provides a comprehensive set of demographic data and indicators for assessing population trends at global, regional and national levels and for calculating many other key indicators commonly used by the United Nations system, such as the Sustainable Development Goals (SDGs) [18].
The main indicators for the population relate to:
• The annual total population, overall and by gender, by country and by region.
• The annual population growth rate (birth rate – death rate), per country and per region.
• The annual sex ratio of the total population, by country and by region.
• The annual average age of the population, by country and by region.
• The annual population density (population per square kilometre).
• The annual population by age group and sex, by country and by region.
• Gross domestic product (GDP), total and per capita.

2.2.2 Consumption

Consumption is a decisive factor for the economic development, having significant economic, environmental and social dimensions. It has significant implications for the level of demands and production of natural resources. An increase in private consumption implies increased use of transport, higher energy consumption, increased use of goods and higher generation of waste [2].
Agenda 21, adopted at the United Nations Conference on Environment and Development (UNCED – Rio de Janeiro, 1992), emphasizes that changes in consumption and production patterns are necessary to ensure sustainable development [2].
Furthermore, the Sustainable Development Goals refer to responsible consumption and production. The Goal 12 refers to ensuring sustainable consumption and production methods [18].
The main indicators for consumption relate to:
• Private consumption by households, presenting private consumption expenditure expressed as a percentage of GDP and per capita, per time (year,…) and geographic area (region, country,..).
• The structure of private consumption, i.e. spending on food, clothing, rent, furniture, health, transport, leisure, etc., per time (year,…) and geographic area (region, country,..).
• Public consumption, showing the government's final consumption expenditure, as a percentage of GDP and per capita, per time (year,…) and geographic area (region, country,..).

2.2.3 Energy

Energy production and use have significant environmental impacts, depending on the energy source. Combustion of conventional fuels is the main source of air pollution and greenhouse gas emissions; moreover, this combustion and the fossil fuels lifecycle, from the extraction, to their transportation, their treatment to their use has also impacts on water quality and land use [2]. Also, nuclear power has significant risks related to the nuclear fuel cycle [2].
The Kyoto Protocol (agreement under the United Nations Framework Convention on Climate Change (UNFCCC, 1992)) and the Convention on Long-Range Transboundary Air Pollution (1979), set targets to energy efficiency and on the share of renewable energy sources [2].
In addition, the Sustainable Development Goals refer to cheap and clean energy. The Goal 7 refers to ensuring access to affordable, reliable, sustainable and modern energy for all [18]. Furthermore, the United Nations Statistical Service collects and reports global statistical information, such as information on energy production and use, such as electricity production from renewable sources, for a number of countries annually [19].
The main indicators for energy per time (day, month, year,…) and per geographic area (city, region, country,…) relate to:
• Energy dependence on coal, oil and natural gas.
• Energy mix.
• Energy intensities, expressed as energy supply per unit of GDP and per capita.
• Primary energy production.

• Imports of energy products by country of origin and by product.
• The final energy consumption per sector and per fuel.
• Gross domestic consumption (total and per capita).
• Gross domestic consumption from renewable energy sources and share to the total one,
• The thermal efficiency of power plants.

2.2.4 Waste

Waste is produced at all stages of human activities. The composition and quantity of waste depends largely on consumption and production patterns. Improper waste management may have an impact on human health and the environment (soil pollution, water pollution, air quality degradation, landscape use degradation, …). Management issues mainly concern the collection, treatment and disposal of waste [2].
Agreements and regulations on waste and transboundary movements of hazardous waste mainly include European Union directives, OECD decisions and recommendations, the Lomé IV Convention and the 1989 Basel Convention. The main objective is to strengthen waste minimization measures, in particular waste prevention and recycling [2]. Furthermore, the United Nations Statistical Office collects and reports global statistical information, such as information on waste collection, composition and management, for a number of countries annually [27].
The main waste indicators per time (day, month, year,…) and per geographic area (mainly countries) relate to:
• The composition of municipal waste, i.e. the total amounts of waste per source sector (municipal, industrial, nuclear waste, etc.).
• Hazardous waste (total and per capita).
• Recyclable hazardous waste (total and per capita).
• Treated or disposed hazardous waste (total and per capita).
• Urban waste: percentage of collection, quantity, composition, …
• The collection of urban waste at city level.
• Municipal waste treatment at city level.
• The percentage of hazardous waste that is treated or disposed of in relation to the hazardous waste that is produced.
• The percentage of municipal waste that is recycled (e.g. paper, glass, plastic, organic waste).
• The total population served by waste collection.

2.2.5 Transportation

Transportation is a major component of economic activity, with a significant impact on the environment, such as air pollution, climate change, fragmentation of natural habitats, waste generation, etc.. The main issue is to reduce environmental and transport impacts, particularly in terms of air pollution and climate change [2].
The UNECE Working Party on Transport Statistics deals with the development of appropriate methodologies and terminology for the harmonization of statistics as well as the collection of data from member States and the dissemination of these data for road, rail, inland waterway transport, pipelines and combined transport, as well as for road traffic accidents [29]. Furthermore, the UNECE Transport works to facilitate the international movement of persons and goods by inland transport modes. It aims to improve competitiveness, safety, energy efficiency and security in the transport sector. At the same time, it focuses on reducing the adverse effects of transport activities on the environment and contributing effectively to sustainable development. It is also a centre for multilateral transport standards and agreements in Europe and beyond, e.g. regulations for dangerous goods transport and road vehicle construction at the global level, gateway for technical assistance and exchange of best practices, promoter of multi-country investment planning, substantive partner for transport and trade facilitation initiatives and historic centre for transport statistics [30].
The main transport indicators, per time (day, month, year,…) and per geographic area (city, region, country,…), relate to:
• Infrastructure number, i.e. the length of roads, highways and railways, number of airports and ports, etc. and their density (per square kilometer of land area).
• The volume and capacity of commercial transport (land, sea and air; per mode of transport).
• The number of passenger cars or vehicles per 1,000 inhabitants and per kilometre of road.
• Rail, road, air and sea transport, in kilometers per inhabitant and in number of national or international trips per inhabitant.
• The number of people killed or injured in road accidents.
• Fuel consumption per fuel and per mode of transport.
• Road fuel prices and taxes and the respective prices and % of taxation of diesel and petrol.

2.2.6 Agricultural Sector

The agricultural sector has significant environmental impacts, both positive and negative. It depends on the type, scale and intensity of agriculture, as well as on natural factors, such as climate and weather. Agriculture can lead to the degradation of soil, water and air quality and the loss of natural habitats and biodiversity, with significant impacts on the level of agricultural production and food supply. On the other hand, it can absorb some of the greenhouse gases, preserve biodiversity and landscapes, and help absorb floods and landslides [2].
The main environmental concerns related to agriculture are N and P runoff, responsible for water eutrophication, from the use of fertilizers, pesticides, deforestation and intensive livestock farming.
Furthermore, the Food and Agriculture Organization (FAO), is engaged in the collection, analysis, interpretation and dissemination of food and agriculture statistics related to decision making [31].

The main indicators for agriculture, per time (day, month, year,…) and per geographic area (region, country,…) relate to:
• Livestock densities (number of cattle, pigs, sheep, etc. per km2 of agricultural land).
• The intensity of pesticide uses in agriculture, through the consumption and sale of N and P per km2 of agricultural land.
• The intensity of use of nitrogen and phosphate fertilizers in agriculture, which is reflected through the consumption of nitrogen and phosphorus per km2 of agricultural land.
• Nitrogen balances, measured by the soil surface balance (the difference between the total amount of nitrogen inputs entering and the amount of nitrogen leaving the soil for a year, per hectare of agricultural land).
• The amount of N and P produced by animal manure per km^2 of agricultural land.

3 Conclusions

Environmental indicators are indicators related to the environment. The main specific environmental indicators are mainly related to climate change, ozone depletion, air quality, water quality, forest and fisheries resources and biodiversity, while the main specific environmental indicators for the anthropogenic environment are mainly related to population, consumption, energy, waste, transportation and the agricultural sector. Specific environmental indicators, as a whole, are powerful tools for monitoring the quality and status of environmental progress and for the measurement of their environmental performance.

References

1. Cambridge Dictionary (Available online: https://dictionary.cambridge.org/dictionary/english/index)
2. OECD, *Environmental indicators - towards sustainable development* (OECD Publications, Paris, 2001)
3. IAEA, *Energy indicators for sustainable development: guidelines and methodologies* (IAEA, Vienna, 2005)
4. B. Moldan, T. Hák, J. Kovanda, M. Havránek, P. Kušková, OECD Word Forum of Key Indicators, 10-13 November 2004 (Palermo)
5. Z. Gareiou, N. Gizani, I. Laskari, I. Mavromati, E. Zervas, *Review of composite environmental indicators,* International Conference on Environmental Design ICED2023 22-24 October 2023 (Athens, Greece)
6. D. Papoulis, D. Kaika, C, Bampatsou, E. Zervas, Climate **3**(3), 715-26 (2015)
7. Z. Gareiou, E. Drimili, E. Zervas, *Public acceptance of renewable energy sources* on Low carbon energy technologies in sustainable energy systems, 309-327 (2021)
8. E. Drimili, R. Herrero-Martin, J. Suardiaz-Muro, E. Zervas, Waste Manag. Res. **38**(6), 614-25 (2020)
9. E. Drimili, Z. Gareiou, E. Zervas, Env. Dev. Sust. **22**(7), 6053-76 (2020)
10. Z. Gareiou, E. Zervas, IOP Conference Series: Earth and Env Sc **899**(1), 012047 (2021)
11. Z. Gareiou, N. Gizani, I. Laskari, I. Mavromati, E. Zervas, *Review of personal environmental indicators,* International Conference on Environmental Design ICED2023 22-24 October 2023 (Athens, Greece)
12. Eurostat, *Energy, transport and environment indicators* (Office for Official Publications of the European Communities, Luxembourg, 2005)
13. H. Bossel, *Indicators for Sustainable Development: Theory, Method, Applications: A Report to the Balaton Group* (IISD, Canada, 1999)
14. P. Lawn, *Sustainable Development Indicators in Ecological Economics* (Edward Elgar Publishing, 2006)
15. IPCC, *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel* on Climate Change (Switzerland IPCC, Geneva, 2014)
16. European Council (Available online: https://www.consilium.europa.eu/el/policies/climate-change/paris-agreement/).
17. UN Climate Chance Conference (Available online: https://ukcop26.org/)
18. United Nations (Available online: https://sdgs.un.org/goals)
19. UNSD (Available online: https://unstats.un.org/home/)
20. T. Kalyvas, S. Manika, E. Zervas, IOP Conference Series: Earth and Env Sc **899**(1), 012023 (2021)
21. D.E Tsesmelis et al., Earth **2**(3), 515-531 (2021)
22. D.E Tsesmelis et al., Atm. **13**(1), 135 (2022)
23. Publications Office of the European Union (Available online: https://op.europa.eu/en/publication-detail/-/publication/67b8beeb-d23f-49f8-a6f6-edad181925d8/language-el)
24. YPEN (Available online: https://ypen.gov.gr/perivallon/klimatiki-allagi/prostasia-stivadas-tou-ozontos/)
25. European Commission (Available online: https://ec.europa.eu/commission/presscorner/detail/el/IP_22_2189)
26. European Parliament (Available online: https://www.europarl.europa.eu/at-your-service/el/be-heard/eurobarometer)
27. Eurostat (Available online: https://ec.europa.eu/eurostat/statistics-

explained/index.php?title=Archive:GDP_and_household_accounts_at_regional_level/el&oldid=108025)
28. United Nations (Available online: https://population.un.org/wpp/)
29. UNECE (Available online: https://unece.org/transport/about-us)
30. UNECE (Available online: https://unece.org/about-us-16)
31. FAO (Available online: https://www.fao.org/statistics/en/)