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Intellectual Economics 9 (2015) 67–79

www.elsevier.com/locate/intele

Environmental indicators for the assessment of quality of life

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Available online 19 October 2015

Abstract

This paper deals with quality of life in terms of the environment and develops a system of indicators to assess this. An improvement in quality of life is the main aim of sustainable development and is evaluated by applying various factors and indicators. The environmental dimension is one of the major influences on quality of life, and this can be assessed by applying the following groups of indicators: environmental quality, environmentally responsible behaviour and consumption of environmental services. These groups are related because responsible behaviour has a positive impact on environmental quality and leads to greater consumption of services provided by the environment. This paper presents the concept of assessing the environmental dimension in quality-of-life measurements and the main associated indicators. These dynamics were investigated and compared in Lithuania and other EU member states, with policy recommendations developed.

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1. Introduction

There is a close relationship between quality of life and the environment (Diener & Suh, 1997; UNECE, 2009). People's lives are strongly affected by the health of their physical environment. The impact of pollutants and hazardous substances on people's health is sizeable. Environmental quality also matters intrinsically because most people value the beauty and health of the place where they live and care about the depletion of its natural resources (Brajša-Žganec, Merkaš, & Šverko, 2011). Preserving environmental and natural resources is also one of the most important factors in ensuring the preservation of well-being over time (Van Liere & Dunlap, 1980). Environmental policies have a critical role to play in dealing with global health priorities, as well as improving environmentally responsible behaviour and lives (Reto & Garcia-Vega, 2012).

Environmental quality is a key factor in people's well-being because quality of life is strongly affected by the health of the physical environment (Holman & Coan, 2008; Kahn, 2002). More extreme environmental events, such as natural

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<http://dx.doi.org/10.1016/j.intele.2015.10.001>

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disasters (earthquakes, cyclones, floods, droughts and volcanic eruptions) and epidemics may also cause elevated levels of death, injury and disease. In the long term, drastic changes in the environment may also impair human health through climate change (Ahmad & Yamano, 2011).

Aside from affecting people's health, the environment also matters intrinsically because many people attach importance to the beauty and health of the place where they live, and because they care about the degradation of the planet and the depletion of natural resources (Balestra & Dottori, 2011; Kahn & Matsusaka, 1997). People also directly benefit from environmental assets and services, such as water, clean air, land, forests and access to green spaces, because these allow them to satisfy their basic needs and enjoy free time and the company of others (Balestra & Sultan, 2012; Pretty, Peacock, Sellens, & Griffin, 2005).

Environmental indicators can be grouped on the basis of their relationships with quality of life in the following categories: environmental quality, environmentally responsible behaviour and consumption of environmental services. These groups are tightly interrelated because responsible behaviour has a positive impact on environmental quality, which leads to a higher consumption of services provided by the environment.

Preserving environmental and natural resources is one of the most important factors in ensuring the sustainability of well-being over time. However, measuring environmental indicators is difficult: firstly, because the size of impact of current environmental factors on future well-being is uncertain; and secondly, because there are few comparable indicators that meet agreed standards.

The aim of this paper is to develop a framework for the assessment of environmental indicators relevant to the quality of life and apply this to a comparative assessment of such factors in the Baltic states.

The main steps to achieving this aim are to:

- Develop a framework for the assessment of environmental indicators relevant to the quality of life.
- Select indicators for the assessment of environmental quality, environmentally responsible behaviour and consumption of environmental services based on the Eurostat database.
- Analyse and compare the trends of environmental indicators in the Baltic states, and compare these with EU-27 averages for the 2004–2011 period.
- Develop and apply an integrated indicator for the assessment of environmental factors relevant to quality of life in the Baltic states.
- Develop policy recommendations based on the analysis provided.

2. Environmental indicators related to quality of life

The concept of environmental indicators relevant to quality of life is a broad one, and an ideal set of criteria would detail the quality of a number of mediums (including soil, water and air) on people's access to environmental services and amenities, as well as looking at the impact of hazards on human health and environmentally responsible behaviour (Mace, Bell, & Loomis, 1999). Unfortunately, data are scattered and not comparable across countries. For these reasons, the objective indicators presented in this paper are limited to only a subset of indicators reported by Eurostat.

In general, objective indicators – such as the concentrations and emissions of various pollutants – should be combined here with indicators based on people's subjective perceptions of the quality of the environment where they live. As in the case of other subjective data, indicators of satisfaction with environmental quality may be affected by cultural biases and other limits that could affect cross-country comparisons, so these indicators are excluded from the assessment of environmental indicators of quality of life (Liao, 2009).

The quality of the local living environment has a direct impact on human health and well-being. An unspoiled environment is a source of satisfaction, improves mental well-being, and allows people to recover from the stresses of everyday life and perform physical activities. Access to resources such as green spaces, forests and rivers is an essential aspect of quality of life. Economies rely not only on healthy and productive workers, but also on natural resources like water, timber, fisheries, plants and crops (Zheng, 2010). The consumption of environmental services and amenities has a direct impact on quality of life, and conversely, the quality of these services is affected by human behaviour. Environmentally responsible behaviour through activities such as saving energy, using renewable resources and sustainable consumption is the main driver of the quality of environmental services provided (Osbaldiston & Sheldon, 2003; Thogersen, 2006).

Table 1 presents environmental indicators that are relevant to quality of life.

Table 1
Environmental indicators relevant to quality of life.

Category	Indicators				
Environmental quality	Exposure of urban population to air pollution through particulate matter, $\mu\text{g}/\text{m}^3$	Exposure of urban population to air pollution by ozone, $\mu\text{g}/\text{m}^3$ per day	Biochemical oxygen demand in rivers, mg/l	Average carbon dioxide emissions per kilometre from new passenger cars, gCO_2/km	Municipal waste generated per capita, kg
Environmentally responsible behaviour	Resource productivity, EUR/kg	Energy productivity in EUR/kg of oil equivalent	The share of renewables in final energy, %	Sewage sludge production and disposal, thousand tonnes	Recycling rates for packaging waste, %
Consumption of environmental services	Sufficiency of sites designated under the EU Habitats Directive, %	Protected terrestrial areas, %	Total fresh water abstraction per capita, m^3/capita	Total inland fishery products per capita, tonnes of live weight	Total area of forests and other wooded land per capita, ha/capita

Environmental indicators relevant to quality of life can be assessed by using the following groups: environmental quality, environmentally responsible behaviour and consumption of environmental services. These groups are related because responsible behaviour has a positive impact on environmental quality, which leads to higher consumption of services provided by the environment.

3. Indicators of environmental quality

Indicators of environmental quality encompass a number of environmental mediums (such as soil, water and air). However, a lack of relevant data for some of these mediums and evidence of sizeable effects from air pollutants on human health means that most attention has been paid to air-pollution indicators. Objective measurements of air quality in this paper take into account only concentrations of PM_{10} and ground-level ozone. Another important indicator of air quality selected in this study relates to CO_2 emissions from transport because this sector poses a major problem for sustainable development in the EU. Such emissions have constantly grown with improvements in living standards, and the use of more efficient cars can help to reduce greenhouse gas (GHG) emissions in the transport sector.

Access to clean water is fundamental for human well-being. Managing water to meet that need is a major – and growing – challenge in many parts of the world, and many people suffer from an inadequate quantity and quality of water. Despite significant progress in EU member states in reducing water pollution from fixed sources such as industrial and municipal waste-water treatment plants, diffuse pollution from agriculture and urban run-off remains a challenge and improvements in freshwater quality are not always easy to discern. Biochemical oxygen demand is the main indicator of water quality in rivers.

EU society has grown wealthier and created more and more rubbish. In this region alone we throw away 3 billion tonnes of waste each year – with some 90 million tonnes of it hazardous. This amounts to about 6 tonnes of solid waste for every man, woman and child, according to Eurostat statistics. It is clear that treating and disposing of all this material without harming the environment becomes a major headache. The main indicator of environmental quality in this area is municipal waste generated per capita, which indicates the rate of its accumulation and the size of the problem in EU member states.

Rises in all these selected indicators lead to negative effects on environmental quality and quality of life.

Up to 50% of the population living in urban areas may have been exposed to levels of ozone that exceed the EU's target value. The fraction of PM_{10} particles thought to be most poisonous is less than $2.5 \mu\text{m}$ across and is called $\text{PM}_{2.5}$. Epidemiological studies conducted over the past 20 years have reported significant associations between short-term and long-term exposure to increased ambient PM concentrations and increased morbidity (such as cardiovascular and respiratory diseases) and (premature) mortality (Goldberg et al., 2001). PM_{10} particles are readily inhalable and, because of their small size, are not filtered and reach the upper part of the airways and lungs (Arruti, Fernández-Olmo, & Irbien, 2010). Those smaller than $2.5 \mu\text{m}$ penetrate deep into the bottom of the lungs, where they can move into

Table 2
Dynamics of environmental quality indicators in the Baltic states and averages for the EU.

	2004	2005	2006	2007	2008	2009	2010	2011
Exposure of urban population to PM ₁₀ , µg/m ³								
EU average (27 countries)	27	28	30	28	26	26	26	27
Estonia	18	21	23	19	11	13	14	13
Latvia	23	24	23	24	24	20	24	23
Lithuania	23	23	20	21	19	23	27	23
Exposure of urban population to air pollution by ozone, µg/m ³								
EU average (27 countries)	3491	3677	4478	3611	3580	3648	3368	3706
Estonia	1299	1321	4331	2308	1381	1668	5467	2402
Latvia	1030	1308	1758	:	1354	1260	1213	1806
Lithuania	2909	5048	4621	1891	3653	2110	1416	3057
Biochemical oxygen demand in rivers, mg/l								
EU average (27 countries)	2.55	2.19	3.76	4.41	3.82	–	3.22	
Estonia	2.19	2.50	2.30	2.17	2.00	–	1.50	
Latvia	1.98	1.68	1.44	1.52	1.48	–	1.33	
Lithuania	2.90	2.80	2.90	2.50	2.70	–	2.80	
Carbon dioxide emissions from new passenger cars in EU, gCO ₂ /km								
EU average (27 countries)	160	159.0	159.0	158.7	153.6	145.7	140.3	135.7
Estonia	179	183.7	182.7	181.6	177.4	170.3	162	156.9
Latvia	192.4	187.2	183.1	183.5	180.6	176.9	162	154.4
Lithuania	187.5	186.3	163.4	176.5	170.1	166	150.9	144.4
Municipal waste per capita, kg								
EU average (27 countries)	513	515	521	522	519	509	505	500
Estonia	449	436	399	449	391	337	303	298
Latvia	311	311	412	378	332	334	304	350
Lithuania	367	377	391	401	408	361	381	442

the bloodstream – thus allowing many chemicals that are harmful to human health to reach internal organs and cause a wide range of illnesses, including cancer, brain damage and harm to fetuses. Fine particulate matter (PM_{2.5}) in the air has been estimated to reduce life expectancy in the EU by more than 8 months (Dockery, 2001; Katsouyanni et al., 2001). Although it is commonly assumed that there is no threshold below which the health effects of PM are unlikely to occur, the update of the WHO Air Quality Guidelines for PM proposed that benchmarks should be established to minimise the risk of adverse effects from both short- and long-term exposure to PM (WHO, 2004). These values are set at 20 µg/m³ as an annual mean and 50 µg/m³ as a daily mean for PM₁₀, with corresponding values of 10 µg/m³ and 25 µg/m³ for PM_{2.5}.

The ozone-exposure indicator for the urban population shows the population-weighted concentration of ozone to which the urban population is potentially exposed. The principle metric for assessing the effects of this gas on human health is, according to WHO recommendations, the daily maximum 8-h mean. Ozone effects should be assessed over a full year. Current evidence is insufficient to deduce a level below which ozone has no effect on mortality. However, for practical reasons it is recommended that an exposure parameter is considered that is the sum of the excess of daily maximum 8-h means over the cut-off of 70 ¼ g/m³ (35 ppb) calculated for all days in a year.

CO₂ emissions are the main factor in climate change. Particularly significant problems are related to transport pollution, which has been constantly increasing in the EU.

In Table 2, the dynamics of urban population exposure to air by PM₁₀ particulate matter and ozone, and those of average carbon dioxide emissions per kilometre from new passenger cars in the Baltic states and the EU-27 average are presented.

Organic matter, measured as biochemical oxygen demand (BOD) and total ammonium, is a key indicator of the oxygen content of water bodies. Concentrations of these parameters normally increase as a result of organic pollution caused by discharges from waste-water treatment plants, industrial effluent and agricultural run-off. Severe organic pollution may lead to rapid deoxygenation of river water, a high concentration of ammonium and the disappearance of fish and aquatic invertebrates. The most important sources of organic waste load are: household waste water, industries

such as the paper and food-processing sectors; and silage effluent and manure from agriculture. The dynamics of biochemical oxygen demand in rivers in the Baltic states and the EU average are presented in [Table 2](#).

The EU's Sixth Environment Action Programme identifies waste prevention and management as one of four top priorities. The primary objective is to decouple waste generation from economic activity so that EU growth will no longer lead to increasingly more rubbish – and there are signs that this is beginning to happen. The region is aiming to significantly cut the amount of rubbish generated through new waste-prevention initiatives, better use of resources, and encouragement of a shift towards more sustainable consumption patterns. The dynamics of municipal waste generated per capita in the Baltic states and the average for the EU-27 countries are presented in [Table 2](#).

As can be seen from the information provided in [Table 2](#), the exposure of the urban population in Lithuania to air pollution by particulate matter was stable during the 2004–2011 period. Compared with the EU-27 average, it can be noted that exposure to air pollution was lower for the whole period investigated, but it was higher than WHO Air Quality Guidelines for PM₁₀, which are set at 20 µg/m³ as an annual mean.

Between 2001 and 2011, 14–65% of the urban population in the EU-27 countries were exposed to ambient ozone concentrations that exceeded the EU target value set for the protection of human health (120 µg O₃/m³ as a daily maximum 8-hourly average, not to be exceeded more than 25 times a calendar year, averaged over 3 years and to be achieved where possible by 2010). The 65% figure was recorded in 2003, which was the record year. There was no discernible trend over the period until 2004. In Lithuania, the exposure of the urban population to air pollution by ozone was lower than the EU-27 average over the whole period investigated, but also significantly higher than the EU target value.

As shown by the information provided in [Table 2](#), oxygen-demanding matter measured as BOD in European rivers decreased in the EU-27 by 55% (from 4.9 mg O₂/l to 2.2 mg/l) from 1992 to 2010. The decrease is due mainly to improved sewage treatment resulting from implementation of the Urban Waste Water Treatment Directive and national legislation. The economic downturn of the 1990s in Central and Eastern European countries also contributed to this fall because there was a decline in heavily polluting manufacturing industries. In recent years, however, downward trends in BOD across Europe have levelled off. This suggests that either further improvement in waste-water treatment is required, that other sources of organic pollution – such as from agriculture – require greater attention, or both. In Lithuania, BOD was stable in the 2004–2010 period. It was slightly higher than the EU-27 average and the level in Latvia.

[Table 2](#) shows that municipal waste generated by capita increased in Lithuania until 2008. The country's municipal waste per capita was 442 kg in 2010, an increase from 367 kg in 2005. It was lower than the EU-27 average (500 kg/capita) in 2010. In 2008, there was a significant reduction, but a new increasing trend followed after the economic crisis.

Compared to the EU-27 average, the Baltic states are performing better with regard to all environmental quality indicators except carbon dioxide emissions per kilometre from new passenger cars.

4. Indicators of environmentally responsible behaviour

Environmentally responsible behaviour is associated with resource and energy savings, the use of renewable energy sources instead of fossil fuels, waste recycling and proper waste-water management and disposal. The main indicators for this that were selected based on Eurostat data therefore include resource and energy productivity, the share of renewables in final energy consumption, the recycling rate for packaging waste, and sewage sludge production and disposal per capita. These indicators have a direct impact on quality of life because they are the main drivers of environmental quality. An increase in these indicators is therefore the desired trend, and the Baltic states can be compared, with higher values indicating the best-performing country.

Resource productivity is GDP divided by domestic material consumption (DMC). DMC measures the total amount of materials directly used by an economy. It is defined as the annual quantity of raw materials extracted from the domestic territory of the focal economy, plus all physical imports and minus all physical exports. It is important to note that the term “consumption” as used in DMC denotes apparent consumption and not final consumption. DMC does not include upstream flows related to imports and exports of raw materials, and products originating outside of the focal economy. When examining resource productivity trends over time in a single geographic region, the GDP that should be used is in units of euros in chain-linked volumes to the reference year 2005 at 2005 exchange rates. If comparisons

Table 3
Dynamics of indicators for environmentally responsible behaviour in the Baltic states and averages for the EU.

	2004	2005	2006	2007	2008	2009	2010	2011
Resource productivity in the EU, EUR/kg								
EU average (27 countries)	1.39	1.4	1.42	1.43	1.46	1.57	1.65	1.6
Estonia	0.35	0.39	0.39	0.35	0.38	0.36	0.38	0.42
Latvia	0.31	0.3	0.31	0.32	0.37	0.39	0.34	0.32
Lithuania	0.49	0.51	0.55	0.51	0.49	0.62	0.57	0.56
Energy productivity in EUR/kg of oil equivalent								
EU (27 countries)	6	6.1	6.3	6.5	6.6	6.7	6.6	–
Estonia	1.8	2	2.3	2.2	2.2	2.1	1.8	–
Latvia	2.7	2.9	3.1	3.3	3.3	2.9	2.7	–
Lithuania	2.1	2.4	2.6	2.7	2.7	2.5	3.2	–
The share of renewables in final energy consumption, %								
EU average (27 countries)	8.1	8.5	9.0	9.7	10.4	11.6	12.5	13.0
Estonia	18.4	17.5	16.1	17.1	18.9	23.0	24.6	25.9
Latvia	32.8	32.3	31.1	29.6	29.8	34.3	32.5	33.1
Lithuania	17.3	17.0	17.0	16.7	18.0	20.0	19.8	20.3
Sewage sludge production and disposal per capita, kg								
EU average (27 countries)	18	18	20	20	22		22	
Estonia	22	22	20	21	17		16	
Latvia	16	13	10	10	10		11	
Lithuania	19	19	21	23	16		15	
Recycling rates for packaging waste, %								
EU (27 countries)	54.0	54.6	56.9	59.2	60.5	62.5	63.3	63.6
Estonia	33.5	40.3	45.7	49.6	43.5	57.2	56.1	62.9
Latvia	45.6	47	42.2	39.6	46.8	44.9	48.9	50.9
Lithuania	32.7	32.5	37	42.9	51.7	57.7	60.4	62.2

of resource productivity between countries are made, then the GDP in purchasing power standards should be used. Energy productivity is an important indicator that is assessed by dividing GDP by primary energy consumption, and indicates a country's efficiency in energy use.

An increased use of renewables is a priority in EU energy and environmental policy. More use of these leads to a reduction in GHG emissions and security of the energy supply because renewables are local and domestic energy-supply sources.

Table 3 presents the dynamics of resource and energy productivity and the share of renewables in final energy consumption in the Baltic states, and averages for the EU.

Waste-water treatment and the quality of both drinking and bathing water have improved significantly in Europe over the past 20 years, but continued efforts are needed to further improve the quality of water resources. The bioaccumulation of mercury and some persistent organic pollutants, for example, can be high enough to raise health concerns in vulnerable population groups such as pregnant women. The residual of waste-water treatment is sewage sludge. Four different types of disposal typically make up a considerable share of the total volume of sewage sludge treated: more than two-thirds was used as fertiliser in agriculture in Spain and Ireland, and another eight member states (Lithuania, Hungary, Bulgaria, Cyprus, Luxembourg, France, the Czech Republic and Latvia) reported between one- and two-thirds of their total mass of sewage sludge being disposed of through agricultural uses (Table 3).

Between 1990 and 1995, the amount of waste generated in Europe increased by 10%. Most of what we throw away is either burnt in incinerators or dumped into landfill sites (67%), but both these methods create environmental damage. Recycling is the main policy measure to reduce the negative impact of waste accumulated. Table 3 presents the dynamics of recycling rates for packaging waste in the EU.

As can be seen from the information provided in Table 3, the best-performing country in terms of indicators for environmentally responsible behaviour is Estonia. Latvia is distinguished by a high share of renewables in the country's final energy consumption. Comparing energy- and resource-productivity indicators in the Baltic states with the average for the EU-27, it can be noted that levels in the former are significantly lower, although trends are positive. Recycling

rates for packaging waste in 2010 were highest in Lithuania among the Baltic states, although in 2004 the country was in the worst position among EU member states.

While the amount of sludge generated per inhabitant depends on many factors and is therefore fairly variable across countries, the nature of this sludge – being rich in nutrients, but also often loaded with high concentrations of pollutants such as heavy metals – has led countries to seek different pathways for its disposal, as illustrated in [Table 3](#). More than two-thirds of sewage sludge were composted in Estonia. Otherwise, alternative forms of disposal may be used to reduce or eliminate the spread of pollutants on agricultural or gardening land, including incineration and landfill.

Compared with the EU-27 average with respect to environmentally responsible behaviour, the Baltic states are performing better only in terms of the use of renewable energy sources, while all other indicators are behind.

5. Indicators for the consumption of environmental services

Almost 75% of European citizens live in urban areas, a figure that is expected to increase to 80% by 2020. Under the 6th EAP, the “thematic strategy” on the urban environment highlights the consequences for human health of environmental challenges facing cities, as well as the quality of life of urban citizens and the performance of cities. The aim is to improve the urban environment and make it more attractive and healthier to live, work and invest in, while trying to reduce adverse impacts on the wider environment. The quality of life and the health of urban dwellers depend strongly on the quality of the urban environment, which functions in a complex system of interactions with social, economic and cultural factors.

The main indicators for the consumption of environmental services and amenities provided are selected on the basis of data provided by Eurostat. These include an index of the sufficiency of sites designated under the EU Habitats Directive, the proportion of terrestrial area protected, total fresh water abstraction per capita, inland fishery products per capita and area of forests and other wooded land per capita. An increase in these indicators shows a rise in use of services provided by the environment, with a direct positive impact on quality of life.

The index of sufficiency for member states measures the extent to which their proposals for Sites of Community Importance adequately cover the species and habitats listed in Annexes I and II to the habitats directive. A figure of 100% indicates the sufficiency of proposals for all Annex I terrestrial habitat types and Annex II terrestrial species of Community interest occurring in member states’ territories. This is an important indicator of the quality of life linked to biodiversity-protection measures.

The dynamics of the sufficiency of sites designated under the EU Habitats Directive and protected terrestrial areas for Baltic states, as well as EU-27 averages, are presented in [Table 4](#).

Water is essential for life, as well as being an indispensable resource for the economy and playing a fundamental part in the climate-regulation cycle. There are considerable differences in amounts of fresh water abstracted per inhabitant in each of the EU member states. This partly reflects the resources available, but abstraction practices also depend on the climate and a country’s industrial and agricultural structure.

Fish represent a natural, biological, mobile (sometimes over long distances) and renewable resource. Aside from fish farming, fish in the wild are generally not owned until they have been caught – although some lakes and stretches of rivers may be privately owned. Fish stocks continue to be regarded as a natural resource provided by the environment for human needs. Catches of fishery products include items taken for all purposes (commercial, industrial, recreational and subsistence) by all types and classes of fishing units operating in inland, inshore, offshore and high-seas fishing areas. The catch is normally expressed in live weight and derived through the application of conversion factors to the landed or product weight. As such, catch statistics exclude quantities that are caught and taken from the water (that is, before processing) but which, for a variety of reasons, are not kept.

The main function of forests in Europe has traditionally been for wood production. However, the recreational and tourism functions of these resources are becoming more important in many of the region’s countries – particularly their benefits for economic development, health and well-being, and quality of life.

The dynamics of total fresh water abstraction, inland fishery products and area of forests per capita in the Baltic states and EU averages are presented in [Table 4](#).

As shown in [Table 4](#), Estonia is distinguished by having high indicators for the consumption of environmental services. Particularly high levels can be seen for fresh water abstraction, inland fishery products per capita and its

Table 4
Dynamics of indicators for the consumption of services provided by the environment in the Baltic states and averages for the EU.

	2004	2005	2006	2007	2008	2009	2010
Sufficiency of sites designated under the EU Habitats Directive, %							
EU average (27 countries)	80	80	83	84	84	–	89
Estonia	84	84	84	84	84	–	98
Latvia	88	88	89	89	89	–	95
Lithuania	61	61	61	61	61	–	66
Protected terrestrial area, %							
EU average (27 countries)	14	14	14	14	14	14	14
Estonia	16	16	16	17	17	17	17
Latvia	11	11	11	11	11	11	11
Lithuania	10	10	10	10	10	13	14
Total fresh water abstraction per capita, m ³ /capita							
EU average (27 countries)	620	612	613	587	587	–	577
Estonia	1295	1171	1160	1366	1197	–	1036
Latvia	99	103	91	93	93	–	93
Lithuania	951	690	611	670	673	–	720
Total inland fishery products, tonnes of live weight/capita							
EU average (27 countries)	0.9	0.9	0.8	0.8	0.8	–	0.8
Estonia	2.0	2.1	2.8	2.6	2.5	–	2.8
Latvia	0.4	0.4	0.4	0.4	0.4	–	0.4
Lithuania	1.3	1.1	1.1	1.6	1.5	–	1.5
Total area of forests and other wooded land per capita							
EU average (27 countries)	0.35	0.36	–	–	–	–	0.35
Estonia	1.72	1.69	–	–	–	–	1.76
Latvia	1.46	1.47	–	–	–	–	1.62
Lithuania	0.62	0.64	–	–	–	–	0.72

protected terrestrial area. Lithuania has fairly low indicators for the consumption of environmental services compared with the other Baltic states, but the country is distinguished through positive trends for these indicators.

With regard to the consumption of environmental services, the Baltic states are performing better in almost all indicators.

Other important indicators include access to green areas and satisfaction with the quality of the local environment, but these are not provided by Eurostat databases. In addition to the objective data and indicators presented above, subjective data on environmental quality therefore also provide critical information on environmental conditions. This indicator sheds light on people's subjective appreciation of the environment in which they live, and is based on the following two question: "In the city or area where you live, are you satisfied or dissatisfied with the air quality?" Since the sample is small and the data set suffers from other methodological limitations, evidence from this indicator must be taken with caution.

Another subjective indicator with regard to access to green areas refers to the share of people who have "very many reasons" or "many reasons" to complain about the lack of access to recreational or green zones, as measured on a four-item scale. Access to green spaces is essential for quality of life because an unspoiled environment is a source of satisfaction (Milligan, Gatrell, & Bingley, 2004), improves mental well-being (Brown & Grant, 2007), and allows people to recover from the stress of everyday life (Mace et al., 1999) and perform physical activity. Cross-sectional studies find that levels of physical activity are higher and obesity lower in areas with more greenery (Ellaway, Macintyre, & Bonnefoy, 2005). Because the samples are small and the data set suffers from other methodological limitations, the evidence from this indicator also has to be taken with caution.

6. Integrated index of quality of life in terms of the environment

To compare countries in terms of environmental indicators related to quality of life, integrated indices were developed for Lithuania, Latvia and Estonia.

The integrated index I_E of quality of life related to the environmental dimension can be assessed by applying the following formula:

$$I_E = \sum_i a_i I_i; \quad (1)$$

where I_i is the integrated index of environmental indicators; a_i is the weights of integrated indexes of environmental indicators ($\sum_i a_i = 1$); and I_{DV} is the integrated index of quality of life related to the environmental dimension.

As in our case, we have three groups of indicators, so Eq. (1) can be presented in the following way:

$$I_E = a_1 I_{EQ} + a_2 I_{ER} + a_3 I_{CE}; \quad (2)$$

where I_{EQ} is the integrated index of environmental quality; I_{ER} is the integrated index of environmentally responsible behaviour; I_{CE} is an integrated index for the consumption of environmental services; and a_1 , a_2 and a_3 are the weights of the integrated indicators ($a_1 + a_2 + a_3 = 1$).

Each of these integrated indicators consists of 5 indicators and are developed by applying the formula:

$$I_n = \sum_{i=1}^n w_i \cdot Q_{in} \text{ here : } \sum_{i=1}^n w_i = 1; \quad (3)$$

where I_n is the integrated index of an environmental indicator at time n , Q_{in} is the index of environmental indicator i at time n ; and w_i is the weight of indicator i ;

The index of environmental indicator i is obtained by using the following formula if an increase in indicators is the desirable trend:

$$Q_{in} = q_{ni}/q_{oi}; \quad (4)$$

where Q_{in} is the index of environmental indicator i at time n ; q_{ni} is the value of environmental indicator i at time for a specific country; and q_{oi} is the value of environmental indicator i at time n for the EU-27 average.

If an increase in indicators is an undesirable trend, inverted indicators should be calculated as in the case of environmental quality indicators:

$$Q_{in} = 1/(q_{ni}/q_{oi}) \quad (5)$$

Table 5 presents the dynamics for the integrated indices of quality of life relevant to the environment for the Baltic states. These were obtained by normalising all indicators on the basis of EU average data (Eq. (4)). All indicators and integrated indices are treated equally, so weights have not been applied in the assessment of integrated indices for quality of life. More research and surveys by experts are needed to define the weights of indicators in integrated indices.

The dynamics of integrated indices of quality of life relevant to the environment in the Baltic states are presented in Table 5. These were calculated by applying the data in Tables 2 and 3 and formulas presented above. As an increase in indices is a desirable trend, with a higher index representing a higher quality of life, the indices of environmental quality indicators were assessed in an inverted form because Eurostat data for this is presented in the form of negative indicators (such as the exposure of the urban population to pollution, biochemical oxygen demand and municipal waste per capita).

From the information in Table 5, the highest integrated index of quality of life in terms of the environment was attained by Estonia in 2010. Lithuania and Latvia had very similar integrated indices, but the development trends of these indices since 2004 were diverse. Lithuania is distinguished from the other Baltic states by having very positive trends in terms of the development of all indicators and also the lowest carbon dioxide emissions per kilometre from new passenger cars, as well as fairly high productivity indicators for energy and resources. In the 2004–2010 period, the integrated environmental index of quality of life increased significantly in Lithuania. At the same time, these indices have declined in Estonia and Latvia. Policies implemented in Lithuania since EU accession have therefore had a positive impact on improvements in quality of life in terms of the environment.

With regard to quality of the environment, the best situation in 2010 was in Latvia – mainly as a result of low indicators for the exposure of the urban population to ozone and biochemical oxygen demand in rivers. In terms of indicators for environmentally responsible behaviour, the best-performing country was also Latvia, mainly because high energy productivity rates and a large share of renewables in energy consumption were related to a high share of

Table 5

The dynamics of integrated indices for quality of life relevant to the environment in the Baltic states.

	2004	2005	2006	2007	2008	2009	2010	2011
Environmental quality indicators								
Exposure of urban population to PM ₁₀ index								
Estonia	1.49	1.33	1.30	1.47	2.38	2.00	1.87	2.08
Latvia	1.18	1.16	1.30	1.16	1.09	1.30	1.09	1.18
Lithuania	1.18	1.22	1.49	1.33	1.37	1.14	0.96	1.18
Exposure of urban population to air pollution by ozone index								
Estonia	2.70	2.78	0.83	1.56	2.56	2.17	0.62	1.54
Latvia	3.33	2.85	2.56	2.04	2.63	2.83	2.78	2.04
Lithuania	1.20	0.73	0.97	1.92	0.98	1.72	2.38	1.22
Biochemical oxygen demand in rivers index								
Estonia	1.16	0.88	1.64	2.04	1.92	–	2.17	–
Latvia	1.28	1.32	2.63	2.94	2.56	–	2.44	–
Lithuania	0.88	0.78	1.27	1.75	1.41	–	1.16	–
Carbon dioxide emissions per kilometre from new passenger cars index								
Estonia	0.89	0.87	0.87	0.88	0.87	0.85	0.86	0.87
Latvia	0.83	0.85	0.87	0.86	0.85	0.83	0.86	0.88
Lithuania	0.85	0.85	0.97	0.90	0.90	0.88	0.93	0.94
Municipal waste per capita index								
Estonia	1.13	1.18	1.30	1.16	1.33	1.51	1.67	1.67
Latvia	1.63	1.63	1.26	1.39	1.56	1.52	1.67	1.43
Lithuania	1.22	1.37	1.33	1.12	1.27	1.41	1.33	1.14
Environmental quality index								
Estonia	7.37	7.04	5.94	7.11	9.06	–	7.19	–
Latvia	8.25	7.81	8.62	8.36	8.69	–	8.84	–
Lithuania	5.33	4.95	6.03	7.02	5.93	–	6.76	–
Environmentally responsible behaviour indicators								
Resource productivity index								
Estonia	0.25	0.27	0.28	0.25	0.26	0.23	0.23	0.26
Latvia	0.22	0.21	0.22	0.22	0.25	0.25	0.21	0.20
Lithuania	0.35	0.36	0.39	0.36	0.33	0.40	0.35	0.35
Energy productivity index								
Estonia	0.30	0.32	0.36	0.34	0.33	0.31	0.27	–
Latvia	0.45	0.47	0.49	0.51	0.50	0.43	0.41	–
Lithuania	0.35	0.39	0.41	0.42	0.41	0.37	0.49	–
The share of renewables in final energy consumption index								
Estonia	2.27	2.00	1.79	1.76	1.82	1.98	1.97	1.99
Latvia	4.05	3.80	3.50	3.05	2.87	2.96	2.60	2.55
Lithuania	2.14	2.0	1.89	1.72	1.73	1.72	1.58	1.56
Sewage sludge production and disposal per capita index								
Estonia	1.22	1.22	1.00	1.05	0.77	–	0.72	–
Latvia	0.89	0.72	0.50	0.50	0.45	–	0.50	–
Lithuania	1.05	1.05	1.05	1.15	0.73	–	0.68	–
Recycling rates for packaging waste index								
Estonia	0.62	0.73	0.80	0.83	0.72	0.92	0.89	0.98
Latvia	0.84	0.86	0.74	0.67	0.77	0.72	0.77	0.80
Lithuania	0.61	0.60	0.65	0.72	0.85	0.92	0.95	0.98
Environmentally responsible behaviour index								
Estonia	4.66	4.54	4.23	4.26	3.90	–	4.08	–
Latvia	6.45	6.06	5.45	4.95	4.84	–	4.49	–
Lithuania	4.47	4.40	4.39	4.40	4.05	–	4.05	–
Consumption of environmental services indicators								
Sufficiency of sites designated under the EU Habitats index								
Estonia	1.05	1.05	1.01	1.00	1.00	–	1.10	–
Latvia	1.10	1.10	1.07	1.06	1.06	–	1.07	–
Lithuania	0.76	0.76	0.73	0.72	0.73	–	0.74	–

(continued on next page)

Table 5 (continued)

	2004	2005	2006	2007	2008	2009	2010	2011
Protected terrestrial area index								
Estonia	1.14	1.14	1.14	1.21	1.21	1.21	1.21	–
Latvia	0.79	0.79	0.79	0.79	0.79	0.79	0.79	–
Lithuania	0.71	0.71	0.71	0.71	0.71	0.92	1.00	–
Total fresh water abstraction per capita index								
Estonia	2.09	1.91	1.89	2.33	2.04	–	1.8	–
Latvia	0.16	0.17	0.14	0.16	0.16	–	0.16	–
Lithuania	1.53	1.13	1.00	1.14	1.15	–	1.25	–
Total inland fishery products per capita index								
Estonia	2.22	2.33	3.50	3.30	3.10	–	3.50	–
Latvia	0.44	0.44	0.50	0.50	0.50	–	0.50	–
Lithuania	1.44	1.22	1.38	2.00	1.88	–	1.88	–
Total area of forests and other wooded land per capita index								
Estonia	4.91	4.69	–	–	–	–	3.03	–
Latvia	4.17	4.08	–	–	–	–	4.63	–
Lithuania	1.77	1.71	–	–	–	–	2.06	–
Consumption of environmental services index								
Estonia	11.4	11.1	–	–	–	–	10.6	–
Latvia	6.66	6.58	–	–	–	–	7.15	–
Lithuania	6.21	5.53	–	–	–	–	9.37	–
Integrated environmental index of quality of life								
Estonia	23.4	22.7	–	–	–	–	21.9	–
Latvia	21.4	20.5	–	–	–	–	20.5	–
Lithuania	16.0	14.9	–	–	–	–	20.2	–

hydropower in electricity generation. The best-performing country in terms of consumption of environmental services was Estonia, mainly because of a high level of fresh water abstraction and inland fishery rates per capita. The high level of consumption of environmental services in Estonia gave the county the highest integrated environmental index.

7. Conclusions

1. The set of indicators presented in this paper summarises information about major aspects of environmental quality and their impact on quality of life. These indicators relevant to quality of life are: quality of environment, environmentally responsible behaviour and services provided by the environment.
2. The environmental quality indicators encompass some environmental mediums (such as soil, water, air and waste). However, because of the lack of relevant data for some of these and evidence of sizeable effects from air pollutants on human health, most attention has been paid to air pollution indicators related to environmental quality. The objective measure of air quality used in this paper takes into account PM₁₀ and ground ozone concentrations only. Biochemical oxygen demand in rivers was selected as a water-quality indicator and municipal waste per capita was selected as an indicator to assess environmental quality in terms of waste generated.
3. Lifestyle and environmentally responsible behaviour have a significant impact on environmental quality, so several important indicators were selected to assess the patterns with regard to these that would lead to savings in resources and energy and increase the use of renewable energy sources, sewage sludge disposal and packaging waste recycling. The indicators of environmentally responsible behaviour selected in the paper correspond to environmental quality indicators addressed in the study (namely, atmospheric emissions, water pollution and the generation of waste).
4. The consumption of services provided by the environment has a significant impact on quality of life and is also related to environmental quality indicators such as air, water and land pollution by waste has a negative impact on environmental services and amenities such as forest area, sufficiency of sites designated under the EU Habitats Directive, fresh water abstraction and inland fishery products per capita.
5. Integrated environmental indicators relevant to the quality of life were calculated for the Baltic states on the basis of objective data provided by Eurostat databases. The indicators were normalised using EU-averaged data and

indices were obtained for the quality of the environment, environmentally responsible behaviour and services provided by the environment. These were summed to obtain an integrated environmental indicator for quality of life.

6. The analysis of integrated environmental indices for the Baltic states indicated that Estonia had the highest integrated index in 2010. Lithuania and Latvia had very similar integrated indices in 2010, but the trends in terms of development of these indices were diverse.
7. With regard to the quality of the environment, the best situation was revealed in Latvia in 2010, mainly because of low indicators for exposure of the urban population to ozone and biochemical oxygen demand in rivers.
8. With regard to indicators for environmentally responsible behaviour, the best-performing country was again Latvia, mainly because high energy productivity rates and a large share of renewables in final energy consumption were related to a high share of hydropower in electricity generation.
9. With regard to the consumption of environmental services, the best-performing country was Estonia, mainly because of high fresh water abstraction rates and total inland fishery rates per capita. The high rates of indicators for the consumption of environmental services in Estonia gave it the highest integrated environmental index.
10. Lithuania is distinguished from the other Baltic states by very positive trends in terms of the development of all indicators and by the lowest indicator for carbon dioxide emissions per kilometre from new passenger cars and fairly high energy and resource productivity indicators.
11. In the 2004–2010 period, the integrated environmental index of quality of life increased significantly in Lithuania, but declined in Estonia and Latvia. The policies implemented in Lithuania since EU accession have therefore had a positive impact on growth in quality of life in terms of the environment.
12. The objective data on environmental quality need to be combined with data on people's subjective perceptions of local environmental quality to provide a more detailed picture of both the determinants of satisfaction with the quality of natural assets and the socio-economic distribution of environmental impacts. More could be achieved by developing and coordinating activities in this field.

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