On eco-efficiency and sustainable development in Estonia

Tiina Randla, Tõnu Kurissoo and Raivo Vilu

Tallinn Technical University, Ehitajate tee 5, Tallinn, 19086, Estonia
Fax: +372 6202020 E-mail:tiinar@ttu.ee
E-mail: kurissoo@kbfi.ee E-mail: raivo@kbfi.ee

Abstract: The basic idea of sustainable development is a firm understanding that all resources, renewable as well as non-renewable, are limited. Human activities should not exceed the buffering capacity of the earth's ecosystems and the replenishment potential of material cycles. Use of non-renewable, mainly mineral, resources should be kept at the minimum possible level, postponing the depletion of resources as far as possible. Concepts of environmental space and dematerialisation lie at the foundation of the practical launching of sustainable development. Analysis of regional sustainability and ecological efficiency of energy production, the balance of CO_2, water, etc. were analysed for Estonia and Ida-Virumaa, north-eastern region of the country. The analysis carried out should be considered as a first step in the development and implementation of a national 'green' accounting system and environmental tax system based on the concept of environmental space.

Keywords: Sustainable development; eco-efficiency; Estonia; environmental space; renewable resources; environmental taxes.

Reference to this paper should be made as follows: Randla, T., Kurissoo, T. and Vilu, R. (2002) 'On eco-efficiency and sustainable development in Estonia', *Int. J. Environment and Sustainable Development*, Vol. 1, No. 1, pp.32-41.

Biographical notes: Tiina Randla is an assistant and doctoral student at Tallinn Technical University, Tallinn, Estonia.

Tõnu Kurissoo is an engineer at Tallinn Technical University, Chair of Biochemistry, Tallinn, Estonia.

Raivo Vilu is a Professor and Head of the Chair of Biochemistry at Tallinn Technical University, Tallinn, Estonia.

1 Introduction

Life-supporting conditions on earth depend on the balance of the energy of the sun in the atmosphere, determining the average temperature of the surface. The periodically changing pattern of the heating of the earth's surface (changing seasons) is determined by the angle of inclination of the earth's axis of rotation, and by the movement of the earth round the sun. The temperature differences on the earth's surface and in the atmosphere generate the motion of the air and water masses. The peculiarities of the functioning of the 'climate engine' depend on the content of CO_2 in the atmosphere, determining eventually the amount of absorption of the sun's energy into the atmosphere of the earth. From the main factors determining functioning of the climate engine only CO_2 content in the atmosphere depends directly on human activities. The CO_2 content in the atmosphere is a key factor determining global climate patterns and corresponding to those patterns, mosaics of ecosystems. Developing human society (noosphere) is quite well adapted to the existing climate and ecosystem patterns. However, the unbalanced exponential growth of mankind during pervious centuries with the rapidly growing use of resources and growing pressure on nature is severely jeopardising the functioning of the 'climate engine'.

An understanding of the processes determining living conditions on earth described above (although simplified) should be the rational basis for the practical management of sustainable development.

In order to realise sustainable development we should know to what extent we can disturb environmental conditions through our economic and other human activities without compromising the functioning of the 'climate engine'. Essentially we have to know and 'honour' the extent of the buffering capacity of the environment and renewable resources (even if we do not know the exact numbers). In addition we should know and agree upon the principles of distribution of the usable resources between users (people, enterprises). The buffering capacity divided by the number of users gives us a good (and acceptable) estimation of the individualised limit of resource use and the value of environmental space [1]. Surpassing the environmental spaces of CO_2, water, humus and other main renewable resources by individual users leads through the mechanism of multiplication (up to six billion times), inevitably to the violation of the dynamic balance of natural systems. A chain of essentially unpredictable processes of induced alterations would go on until a new balance is reached in the geological time scale. These changes would most probably involve changes in the functioning of the 'climate engine', diminishing of biological diversity etc., which would be injurious to humankind. This logic should lead us to the development and implementation of ecological economic mechanisms enforcing honouring of the quantitative limits in buffering capacities and environmental spaces indicated. Mechanisms of progressive resource taxation based on the environmental space as a 'threshold concept' should be considered as a necessary instrument for the enforcement of sustainable development. Depending on the nature of the factors and resources a hierarchy of harmonised local, regional and global mechanisms should be developed and implemented.

The use of non-renewable resources cannot, strictly speaking, be sustainable. However, the level of use of non-renewable resources, and their efficiency should be determined and agreed upon, taking into account the needs of the economy, availability of resources, prospects of technological developments etc. A key concept in the use of non-renewable (but also renewable) resources is an increase in the dematerialisation of material flows in the technosphere – a reduction in resource use and an increase in the ecological efficiency of the production of goods, eventually leading to the well-being of society [2].

Summarising, launching sustainable development, requires:

1 elaboration of the rational understanding of the essentials of functioning of Gaia, taking into account the limits described above, i.e. understanding based on the environmental space concept,

2 development and implementation of a ‘green’ national and international accounting system which explicitly takes into account the environmental space and dematerialisation concepts, and

3 elaboration of appropriate economic, political etc. enforcement mechanisms.

Taking this into account it goes without saying that a substantial transformation of human society should take place on the way towards sustainable development. This transformation most probably cannot take place simultaneously in a short time everywhere on earth. Pilot states, areas and communities are needed for the realisation of the elements and mechanisms of the new ‘world order’. Estonia, a small state in substantial transition could be one of the pilots. There is quite a good legislative basis for the launching of sustainable development in Estonia – the Law of Sustainable Development was introduced in 1995, the National Environmental Action Plan (NEAP) was developed etc. The level of ‘green awareness’ of its society is probably one of the highest in the world. It should be remembered that political transition in Estonia was started as a ‘Phosphate War’, a spontaneous popular environmentalist movement etc. Estonia has also implemented rather bold (and successful) economic reforms – currency board monetary system, zero customs tariffs etc. However, as everywhere, environmental factors have no real economic force in Estonia. As also in other parts of the world, decision-makers in Estonia are not interested in following the principles of ecological economics. Moreover, some recent political decisions encourage to think that (our own) Republic of Estonia is even more hostile to the environment than Soviet Estonia was. However, all in all we have a good basis for the elaboration and introduction of effective political, economic and other mechanisms for launching sustainable development.

Preliminary results of the study of indicators of sustainability and the level of sustainability and eco-efficiency of Estonia are presented in the paper. An attempt is made to elaborate taxation mechanisms based on the concept of environmental space. The data presented should be considered as a first step in the development of a comprehensive ‘green’ accounting system for a country.

2 Results and discussion

2.1 Balance of CO_2 and the energy industry

The use of fossil fuels (mainly oil shale) decreased from 31 10^6 t/a in the beginning of the 1990s to the current 17-18 10^6 t/a. CO_2 emissions decreased accordingly from 38 10^6 t (1990) to 21.2 10^6 t (1997) [3-7]. Total consumption of fuels as well as the per capita use of fuels decreased rapidly in 1990-1994, and then stabilised. The share of oil shale in the balance of fuel is 62% but because of the high carbon emission coefficient, oil shale gives 70% of the total carbon emissions caused by the use of fuels (1997).

Despite the reduction indicated, the Estonian anthropogenic emission of CO_2 is exceeding the environmental space (1.7 tons of CO_2 per capita per year according to Friends of Earth [1]) about ninefold and emissions due to the use of fossil fuels 8.4 times (Figure 1). The carbon emissions associated with fuel use exceed the carbon fixation potential of the Estonian forests 2.8 times in conditions where about half of the Estonian territory is covered by forests. Accordingly, the ecological footprint of Estonia calculated on the basis of the use of fossil fuels exceeds the territory of the forests about three times and the whole territory of Estonia about 1.5 times.

Carbon emissions from Ida-Virumaa, an industrialised oil shale region of Estonia, exceed the carbon fixation potential of the district about 20 times (Table 1). The ecological footprint of Ida Virumaa is 20 times larger than the territory of the forests of the area and ten times larger than the territory of the district.

Figure 1 Relationship between CO_2 emissions and environmental space of Estonia

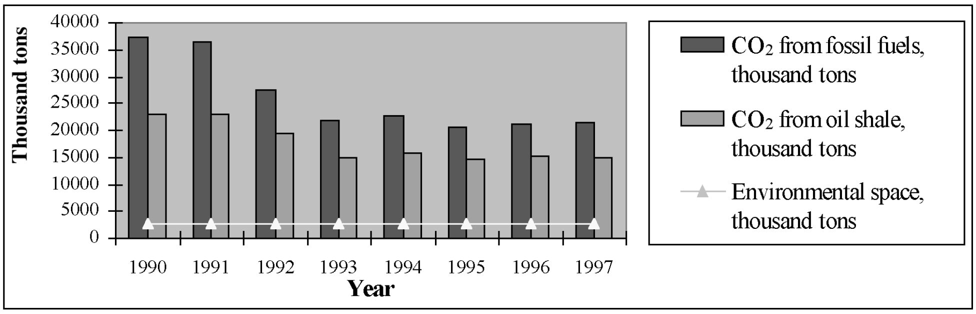


Table 1 Comparison of carbon balances and carbon fixing potential of Estonia and Ida-Virumaa

	Estonia:	*Ida-Virumaa:*
CO_2 emission from energy production, kg-C/day per person:	10.7	44.5
Carbon fixing potential of forests, kg-C/day per person:	3.8	2.3
Carbon emission/carbon fixation potential:	2.8	19.3
The ecological footprint calculated on the basis of CO_2 emissions (the necessary compensation area, forests, 10^3 km^2)	60.6	33.8
Current territory of forests, 10^3 km^2:	21.65	1.75
Necessary compensation area per person, ha/per person:	4	16.7
Current territory of forests, ha/per person:	1.44	0.86
Compensating territory of forests/current forest area:	2.8	19.5

The second largest source of unbalanced carbon flow in Estonia is drained wetlands. According to estimates, the average rate of decomposition of sphagnum in drained wetlands is about 4.3 t CO_2-C/a per hectare, whereas the fixation rate of carbon due to the formation of the sphagnum is only 0.9 t CO_2-C/a per hectare. The amount of decomposed sphagnum exceeded the amount of sphagnum formed for about 2,660 thousand tons of CO_2-C annually. According to data at the beginning of the 1990s [8] carbon flow originating from drained wetlands alone was exceeding the environmental space of Estonia about four times and was 6.7 times higher than the world's average per capita emissions of carbon from land use changes. Primary production of Estonian forests is not compensating for the carbon flow from the wetlands.

The elaboration of economic mechanisms inclining Estonian society towards the trajectory of sustainable development should be started from the solution of the problems of oil shale energetics (and drained wetlands). Currently the oil shale industry is considered to be the ‘holy cow’ of the Estonian economy, and environmental as well as resource taxes are kept very low for industry. Estonia is in fact the off-shore territory for the oil shale industry. The main users of oil shale are the power industry and the chemical industry (oil production). Government regulates the price of oil shale – the main factor determining economic conditions and the profitability of the industry. The price of oil shale has risen stepwise during the last decade to the level of 120-130 EEK/ton (8 EEK=1 DEM since 1992) for the power industry and about 100 EEK for the chemical industry. The price of oil shale for the production of oil has been kept lower than for the power industry, even despite the fact that the shale used by the chemical industry has to be of much higher quality than that used by the power plants. However, this is not the most peculiar fact about the state regulated economy of the oil shale industry.

The price of oil shale has been kept artificially low because of the simple overestimation of the role of cheap energy in the national economy, and fear of social problems possibly arising if unemployment increased in the region inhabited mainly by the Russian speaking population. Severe environmental problems associated with the industry have not been addressed using economic mechanisms. Indeed, the resource taxes and pollution charges for oil shale industry have been kept at much lower levels than for the other industries. For example, the water resource tax for non-oil-shale-industries depends on the groundwater layer and is in the range of 0.25–0.40 EEK/ m^3. The oil shale industry, by far the biggest user and polluter of water resources is paying 0.04 EEK/ m^3. The resource tax for the mining of oil shale is currently 4 EEK/t and the CO_2 tax 5 EEK/t (introduced since 1 January 2000) have a more symbolic than regulatory role for the industry. The Estonian pollution charges, fine tuned to the needs of the oil shale industry are several times (in some cases tens of times) less than the charges in neighbouring countries – in Latvia, Lithuania, and Poland, not to mention Finland, or Sweden.

Besides not preventing severe environmental problems, the skewed taxation policy does not encourage people to save energy in production. The amount of energy used to produce $1 of GDP in Estonia is about 4 times higher than that used in Finland and about ten times higher than in Japan or in Denmark. There is a great need to increase the level of dematerialisation in the Estonian economy in terms of energy use. And it should be mentioned that there is a good example where a substantial increase in the level of dematerialisation has been realised. The price of all fuels other than oil shale has increased constantly, and is currently close to world level prices. Because of this the use of these fuels has decreased substantially. Use of heating oil decreased from the equivalent of 25 thousand GWh in 1990 to 10 thousand GWh in 1998. Use of motor fuels decreased from the equivalent of 14 thousand GWh in 1990 to 11 thousand GWh in 1998, despite the substantial increase in the number of cars (three to four times).

It should be clear from the analysis carried out above that the taxation system regulating the oil shale industry in the first place should be changed. Two main problems should be solved. First, the level of taxes should be gradually increased and harmonised with the level of other countries. Foreseeing Estonia joining the EC in a few years, taxes should correspond in the foreseeable future to those valid in EC countries. But besides that, keeping in mind the idea of launching sustainable development in Estonia, the foundations of the taxation system should be changed. The level of taxes and the practice of taxation should take into account explicitly the concept of environmental space. One of the ideas could be that the basic level of taxes (for example CO_2 tax) is calculated for emissions equal to the value of the environmental space (for example 1.7 tons of CO_2 per capita annually). If the real emissions are higher than the environmental space the tax increases, and the increase could be progressive depending on the level at which environmental space value is exceeded. We are not in a position to propose a concrete scheme for taxation but our preliminary analysis has shown that the mechanism could be worked out. True, this would make it necessary to change the system of national accounting but in our opinion, a genuine turn towards sustainable development would not be possible without the implementation of 'green accounting' anyway. Another problem to be solved is the introduction of a carbon trading scheme between Ida-Virumaa and other regions of the country.

2.2 Water

In a sustainable economy the amount of water used should not exceed the surface run-off of water – the difference between the amount of precipitation and evaporation in a certain region. The environmental space of water is determined by the limit of the amount of water which could be used without endangering the natural water cycle. The total environmental space of water could be calculated by dividing the surface run-off of water of a region by the number of people inhabiting the region. The environmental space of groundwater is determined by the level of use and regeneration potential of a certain groundwater layer. We can regard as the environmental space of groundwater the proven reserves of groundwater per person – the amount of water we can use without jeopardising the regeneration capacity of groundwater.

The analysis of water use of Estonia indicates that the total water use should be considered sustainable. Replenishment of water resources (surface run-off) exceeds total use about sevenfold. Total water use has decreased rapidly during the last decade: from 3300 10^6 m^3/a in 1990 to 1670 10^6 m^3/a in 1998 [3-5]. However, because of the oil shale mining and processing per capita water extraction in the Ida-Virumaa (oil shale district) is more than six times higher and the groundwater extraction more than five times higher than the Estonian average (Table 2) [9-11].

Table 2 Comparison of water consumption and environmental space in Estonia and Ida-Virumaa (in 1996)

	Estonia	*Ida-Virumaa*
Precipitation, km^3/a	33	2.4
Surface run-off, km^3/a	12.54	0.91
Sustainable level of water use (environmental space), m^3/a per person:	8300	4560
Water extraction per person, m^3/a	1150	7150
Proven reserves of groundwater, km^3/a	0.2	0.03
Sustainable level of groundwater use (environmental space of groundwater), m^3/a per person:	133	150
Groundwater extraction, m^3/a per person:	173	900
Groundwater consumption without mining water, m^3/a per person:	66.6	100
Mining water, m^3/a per person:	106.4	800
Use of water in Estonia exceeds average European water consumption (0.77 thousand m^3 /a per person), times:	1.5	9.3

Because of the water pumped out from the oil shale mines, groundwater extraction of Estonia and of the Ida-Viru district, exceed the corresponding environmental spaces by 1.3 times (Figure 2) and six times (Figure 3). The share of water from mines is about 2/3 of the total water extraction of Estonia and 9/10 of water extraction in the district. After subtraction of the oil shale mines' water 'consumption' the use of groundwater both in Estonia and in the Ida-Virumaa is sustainable (except local over-consumption in bigger cities – Tallinn, Kohtla-Järve and Narva.)

Figure 2 Relationship between groundwater consumption and environmental space of Estonia

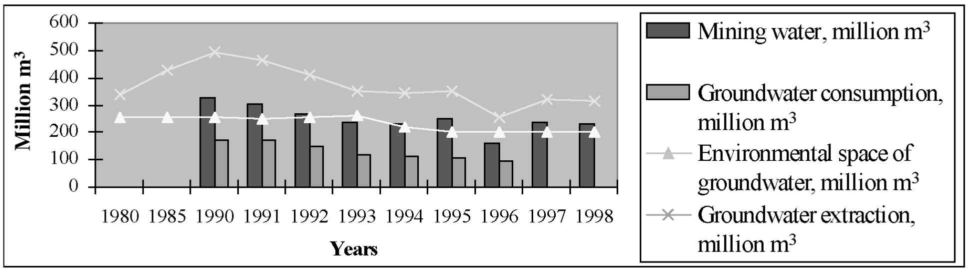
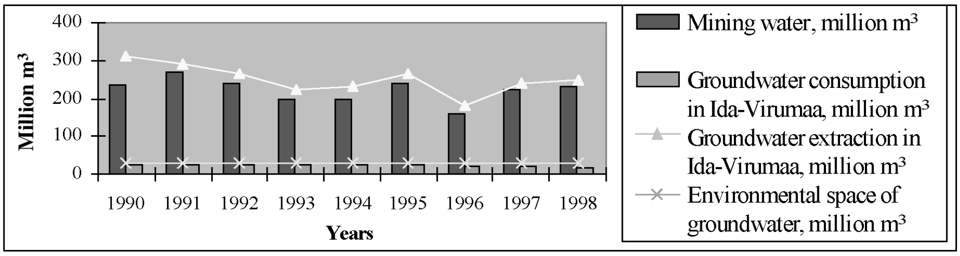


Figure 3 Relationship between groundwater consumption and environmental space of Ida-Virumaa



Total water extraction in Ida Virumaa exceeds the environmental space of the region 1.4 times even without taking mining waters into account. Such over-consumption is possible because of the use of water from the River Narva as the cooling water for oil shale power plants located near the town Narva. The water used from the River Narva is precipitated in the drainage area of Lake Peipus mainly outside Ida-Virumaa.

Because of the extensive water consumption, especially because of the pumping out of water from the oil shale mines, the supply to all the groundwater layers in Ida-Virumaa is disturbed. Wells have dried up; water levels of lakes have decreased. The area of groundwater depression exceeds the area of mining, which covers, 11% of the territory of the region.

Water use in municipalities and industry, except the oil shale industry, is decreasing and efficiency of use is growing – mainly due to the increasing cost of water. Due to the lower resource tax for the oil shale industry, the share of the water price is 0.5% of the price of oil shale. The strategy of change in water use taxation should be similar to the one discussed above. The level of water tax should be increased for the oil shale industry (and made equal to that valid for other users). The second step could be the introduction of an environmental-space-based taxation system in the case of water also. And also in the case of water there seems to be a place for a water quota trade between the regions of the country but also between Russia and Estonia.

2.3 Forestry

The management of forests in Estonia is prima facie sustainable. The territory of forest covers approximately 47% of the territory of Estonia and it has been increasing since World War II. The annual renewal of forests is, by the official data of Estonian Statistical Office, 11.5 10^6 m^3/a and the amount of felling only 7-7.65 10^6 m^3/a [3-5]. The maximum sustainable amount of felling, estimated according to the annual renewal, is 7.8 10^6 tm. The amount of felling increased dramatically during the last decade, partly because of the change in the system of accounting, partly due to the economic reasons. The annual amount of felling reaches ~2% of the total growing stock of Estonian forests.

However, about 20% of annual renewal is in the form of practically unexploitable woodlands. The amount of usable timber is 9.4 10^6 t/a. The maximum sustainable level of use must not exceed 75% of natural renewal. Therefore the level of sustainable use of timber in Estonia should not exceed 7 10^6 m^3/a [12]. As noted above the current use of the forests exceeds the sustainable level.

Comparison of the areas of final cutting and renewal of forests (Table 3) shows also that the management of Estonian forests is unsustainable. The territory of renewed forests is decreasing whereas the territory of final cutting is continuously increasing and is substantially exceeding the territory of reforestation. Needless to say, mechanisms enforcing the sustainable use of timber should be developed and implemented.

Table 3 Comparison of amounts of final felling and reforestation

	1991	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*
Reforestation, thousand ha	7.7	4.4	4.5	4.8	5.3	5.4	6.1	6.8
Final felling, thousand ha:	8	4.2	4.4	7.9	7.9	9.8	14.9	17.1
Reforestation, %	96	105	102	61	67	55	41	40

2.4 Humus

Soil, but particularly humus as the carbon reservoir of the soil, is probably the most important, but also the most vulnerable, resource in the world. Humus is a resource belonging to a certain territory. The sustainable use of soil requires that the losses should not exceed the local renewal capacity of humus. However, in the case of current industrial agricultural practices, the rate of losses from the soil is exceeding the rate of regeneration 13-80 times. The formation of a one-inch (2.5 cm) layer of soil requires in natural conditions 200–1000 years. The loss of organic carbon from 1 ha of Swedish fields has equated to seven tons since 1950 and in the USA the production of 1 kg of crops causes the loss of five kilos of soil [13]. Simplified calculations show that the total estimated losses of humus in Estonia are smaller than the estimated renewal capacity (about 144 thousand t/a if all of the productive land is producing humus). However, the renewal of humus in the fields in use is practically non-existent since most of the organic substances are removed with the harvest. The loss of humus from the fields would reach

0.15-0.36 t/a per hectare, exceeding the regeneration capacity up to 4-9 times – using unsustainable tilling practices, the stock of humus of 4-9 years is used in one year. Sustainable agricultural technologies should be developed to avoid the progressive loss of humus. For example, returning of all the wastes of plant and animal origin from cities to the fields would allow the renewal of up to 40% of the loss of organic substances. Launching sustainable agriculture would need the development of new technologies as well as the implementation of supporting economic mechanisms.

2.5 Non-renewable resources

Building materials – sand, gravel, limestone, clay etc. are used as the main local non-renewable resources. Total use of building materials has increased after a low in 1993-96 and are reaching the level of the beginning of 1990s – about 8 10^6 t /a (1998) [3-5]. The economic efficiency of the use of the building materials has increased during the last decade, and the level of dematerialisation is comparable to that in Finland.

3 Results

- It was shown that the use of the major renewable resources of Estonia (carbon, humus, timber, water) is currently not sustainable. The most severe sustainability problems are encountered in the oil shale industry region in North-Eastern Estonia, in Ida-Virumaa.
- Environmental spaces for the consumption of the main renewable resources of Estonia and the Ida-Virumaa district – water, carbon fixing potential of the environment, humus and forest were estimated.
- It was concluded that the touchstone for the launching of sustainable development in Estonia is in finding an environmentally friendly and economically feasible solution to energy production. The introduction of reasonable economic mechanisms should lead to the development of efficient and environmentally friendly energy sector in Estonia. The opening of the Estonian energy market through launching the Baltic Rings of gas and power supplies is the precondition for rational development. The further development of the oil shale chemical industry should be rejected as economically and environmentally unfeasible.
- The development of environmental tax system based on the environmental space concept was proposed as an essential instrument for launching sustainable development.

4 Conclusion

Launching of sustainable development in Estonia is an attractive possibility to take advantage of the current state of transition, small size of the country, and the high level of environmental awareness. A remarkable change in the tax system, national accounting system etc. is, however, necessary to develop the technical preconditions to launch sustainable development. In addition to the technical preconditions, strong political will is needed to realise these opportunities.

References

1 McLaren, D. (1996) 'Sustainable Europe and environmental space', *Eur. Env.*, Vol. 6, No 3, May-June. 'Friends of the Earth' (US), retrieved 5 May, 1998 from the World Wide Web: http://www.foe.co.uk/camps/susdev/eenvtart.html

2 Hoffren, J. (1988) *Material Flow Accounting as a Measure of the Total Consumption of Natural Resources*, Ministry of the Environment, Helsinki.

3 (1996) *Statistical Yearbook of Estonia 1996*, Statistical Office of Estonia, Tallinn.

4 (1997) *Statistical Yearbook of Estonia 1997*, Statistical Office of Estonia, Tallinn.

5 (1988) Statistical Yearbook of Estonia 1998, Statistical Office of Estonia. Tallinn.

6 Tarand, A. and Kallaste, T. (Eds.) (1998) *Country Case Study on Climate Change Impacts and Adaptation Assessments in the Republic of Estonia,* Tallinn

7 Kallaste, T., Liik, O. and Ots, A. (Eds.) (1999) *Possible energy sector trends in Estonia. Context of Climate Change,* SEI, Tallinn Center, TTU, Tallinn.

8 (1995) *Estonian's First National Communication under the United Nations Framework Convention on Climate Change*, Ministry of Environment of the Republic of Estonia, Tallinn.

9 (1997) *Põhjavee seisund 1996, aastal*. Eesti geoloogiakeskus, Tallinn.

10 (1999) *Põhjavee seisund 1997-1998, aastal*. Eesti geoloogiakeskus, Tallinn.

11 (1997) *Veekasutus 1996*, Keskkonnaministeeriumi Info- ja Tehnokeskus, Tallinn.

12 Parmasto, E. (2000) *Metsastatistika räägib lapsesuuna tõtt. Eesti Päevaleht*, 14 April.

13 Trainer, T. (1999) 'Global crisis', retrieved 10 June, from World Wide Web: http://www1.tpgi.com.au/users/resolve/globalcrisis/environment.html