LAND USE CHANGE AND ECONOMICS OF LAND DEGRADATION IN THE BALTIC REGION

J. von Braun[*]
A. Mirzabaev[*]

[*] University of Bonn
3 Walter Flex Str, Bonn,
53113, Germany.

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In this paper, we adapt a new conceptual framework for the assessment of the economics of land degradation and sustainable land management to the Baltic region. The findings show that the problem of land degradation in the countries of the region is quite substantial, manifesting itself through reductions in the provision of land ecosystem services. Using a benefit transfer approach, the total economic value of these losses due to land degradation is estimated to be about 9 billion USD annually. On the other hand, we find that every dollar invested into restoring the degraded land ecosystems may return about 3 dollars in social gains after a 6-year period following the re-establishment of the higher value biome, making actions to address land degradation in the region both environmentally valuable and economically attractive.

Key words: sustainable land management, Total Economic Value, land degradation, benefit transfer approach, Baltic region

Introduction

Land and soils provide us with a numerous valuable and mostly irreplaceable local and regional ecosystem services. These land ecosystem services consist of provisional ones, such as food and fiber production, and of non-provisional services such as regulating, supporting and cultural ecosystem services [1]. Some examples of regulating ecosystem services are carbon sequestration and ground water purification. Though there is a substantial understanding of the value of provisional services, however, the non-provisional services of land ecosystems are often under-appreciated and, as a result, increasingly degraded [2]. In this article we adapt a new conceptual framework for the assessment of the economics of land degradation and sustainable land management to the Baltic region. This economic approach embraces both direct and external effects of land degradation. A cost of action versus cost of inaction against land degradation is presented as well. Land degradation in economic terms entails direct costs of reduced productivity, and indirect costs due to losses in ecosystems services. This article, by emphasizing the value of both provisional and non-provisional services in its economic analysis, seeks to contribute to filling the knowledge gap, by researching the following questions:

1. What is the extent of land degradation in the spatially disaggregated region?
2. What are the costs of land degradation?
3. How do the costs of inaction against land degradation compare with the costs of actions to address it?

To answer these research questions, the article seeks to make the following contributions. Firstly, we review the latest available research on the extent of land degradation in the region. Secondly, we estimate the total economic costs of land degradation. These estimates incorporate the value of both provisional and non-provisional ecosystem services. Finally, we compare the costs of action vs. inaction against land degradation over 6 and 30-year time horizons. In view of the region's strategic plans to engage increasingly in a knowledge-based sustainable bioeconomy and to use its biomass resources more effectively and efficiently [3], the natural resource base management of land and its use are considered to be of significant importance for such a strategy requiring strong policy commitment and actions for sustainable management of land and soil resources.

Conceptual framework

The conceptual framework of the paper adapts the Total Economic Value (TEV) approach as applied to the economics of land degradation [1, 2]. The TEV framework regards land and soil resources as a natural capital [4] provided with a flow of ecosystem goods and services. These ecosystem services include provisional services (such as crop yields), as well as regulating, supporting and cultural ecosystem services (e. g. carbon sequestration) [1]. The provisional ecosystem services are usually traded in markets and have market prices. On the other hand, non-provisional services are much more difficult to evaluate as they do not have market prices [1].

In this regard, there are several methods to assess the value of non-provisional services. They include hedonic pricing methods, which identify the value of non-provisional ecosystem services by separating their contribution to the price of a marketed good (e. g. the real estate value of land near a park may be higher than in an otherwise similar location, but without a park). Another approach is the travel costs method, when people are asked for their willingness to pay (WTP) to visit a certain location to access its ecosystem services (e. g. cultural and esthetic values). On the other hand, the replacement cost method assesses the value of an ecosystem service by estimating how much it may cost to substitute it. Contingent valuation method is used to infer people's willingness to pay for ecosystem services by directly asking them; and the benefit transfer approach transfers the values for ecosystem services from one location where they have been previously estimated to some other location with comparable conditions (cf. [5] for a review). This study applies the benefit transfer approach to assess the costs of land degradation in the Baltics region.

Methods and Data Sources

Methodologically, this study compares the costs of action vs. inaction against land degradation [2]. In the initial stage, the land use and land cover changes (LUCC) between 2001 and 2009 in the Baltics region is assessed with the help of Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data [6]. The MODIS dataset has eight types of land uses and covers: woodlands, forests, shrublands, grassland, croplands, urban areas barren lands, and water bodies (Table 3). In the second step, we used the benefit transfer approach to appraise the values of ecosystem services of these land uses and covers for the Baltic countries. The data on the ecosystem values is obtained from the Economics of Ecosystems and Biodiversity (TEEB) database [7]. The urban areas and water bodies are excluded from the analyses because the data on the ecosystem services they provide are unavailable. The TEEB database compiles the values of ecosystem services from about 300 case studies from all over the world, including the Baltic region [7]. These values cover both provisional ecosystem services, and non-provisional ecosystem values. As a result, the full ecosystem values of various biomes are taken into account. Specifically, under such analysis, the highest value among the biomes is attributed to forests; then to grasslands, woodlands, then further to shrublands, followed by croplands and barren areas. Croplands have a smaller value then forests because, even though they may produce higher amounts of provisional services, their total ecosystem services are lower, since forests may produce much more of non-provisional services (e.g. higher levels of carbon sequestration). To calculate the costs of action to address land degradation, three types of costs are used: re-establishment costs to transform the degraded lower value biome to the original higher value biome; maintenance costs, and opportunity costs of the lower value biome. The data for the costs of actions comes from the global dataset developed in [2].

Land degradation in the Baltic region and neighboring countries

The Baltic region consists of the countries having the coastline along the Baltic Sea. In the paper, we take a somewhat broader regional perspective, including Estonia, Lithuania, Latvia, Poland, the Kaliningrad oblast of Russia, as well as the neighboring Pskov oblast of Russia and Belarus. In these countries land degradation is one of the less recognized environmental problems, which results in a lack of public knowledge, scientific research and policy actions to address land degradation.

The research on land degradation is scarce in most of the countries of the Baltic region that we are focusing on in this paper. The National Report on the implementation of the United Nations Convention to Combat Desertification (UNCCD) by the Ministry of Environment of Latvia [8] indicates that major land degradation problems in the country are soil and wind erosion, including the erosion of the sea coastline. About 17.3 % of the total agricultural lands are considered to be eroded in the country [8]. Other types of land degradation include soil compaction, waterlogging, soil acidification, presence of heavy metals in agricultural soils, soil pollution by pesticides, eutrophication, and reduced organic matter content of soils. Major drivers of land degradation are unsustainable agricultural practices, inadequate land tenure limiting incentives for the uptake of SLM measures [8]. Due to acidification, almost half of agricultural lands in Latvia are in need of liming [9]. Besides, there is a considerable amount of agricultural lands polluted with heavy metals [9]. In the Kaliningrad province of Russia, deforestation alongside soil contaminations caused by open-pit mining, are the major types of land degradation leading to social conflicts [10]. It is estimated that in Poland, about 30 % of the total area is endangered with soil erosion [11]. Since its independence, Estonia has shown slower land degradation; at the same time, land improvement is observed in some areas due to lower use of heavy tillage in agricultural lands and more fallowing [12]. However, [12] indicate that about 0.5 mln ha of lands in Estonia are prone to soil erosion; apart from that, soil compaction, waterlogging, and soil degradation resulting from mining activities remain major land degradation issues in Estonia [12].

Land degradation often manifests itself through reduced biomass production and loss of surface vegetation [13]. Consequently, many studies use Normalized Difference Vegetation Index (NDVI) as a proxy for land degradation [14, 15]. The NDVI trend can be an indirect indicator of soil degradation if the nutrient source for vegetation growth predominantly comes from the soils. However, in croplands with intensive application of mineral fertilizers, or when crops can substitute the losses in soil organic carbon by a larger intake of carbon dioxide from the atmosphere, NDVI trend may be a biased indicator of soil fertility [15]. A recent mapping of land degradation in the Baltic region using satellite data and addressing the above potential biases points at a substantial increase in land degradation hotspots in the region over the period between 1982 and 2006 ([15], Figure 1).

According to [15], the extent of land degradation in the region ranges between 3 % in Estonia to 14 % in Poland (Table 1, Figure 1). Cropland and grassland degradation are the major types of land degradation in all of the countries of the region (Table 1). The land degradation hotspots are concentrated in the coastal areas of Lithuania and Latvia, central and southern Poland.

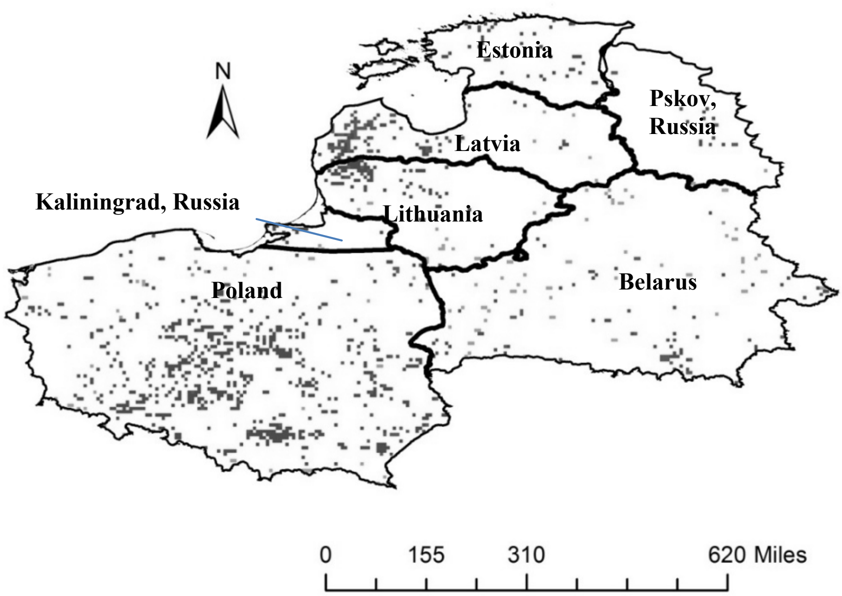

Fig. 1. Biomass-productivity based land degradation hotspots in the Baltic region

Note: This mapping of the Baltic region and neighboring countries and territories does not necessarily reflect the opinion or official position of the authors, their affiliated institutions and of the funding agency on their legal status, and are presented here in a purely geographic sense, following internationally accepted databases on administrative borders.

Table 1

Long-term (1982—2006) NDVI decline by main land cover/use types

Country	Area of NDVI decline in km^2 and in percentages for the corresponding land cover							Total
	Cropland	Mosaic vegetation-crop	Forested land	Mosaic forest-shrub/grass	Shrub land	Grassland	Sparse vegetation	
Belarus	3776 (3 %)	128 (0 %)	1600 (1 %)	0 (0 %)	0 (0 %)	192 (3 %)	64 (5 %)	5760 (3 %)
Estonia	1984 (14 %)	N/A	448 (1 %)	0 (0 %)	0 (0 %)	832 (15 %)	64 (1 %)	3328 (8 %)
Latvia	3328 (15 %)	N/A	3328 (5 %)	0 (4 %)	0 (0 %)	512 (11 %)	192 (2 %)	7360 (12 %)
Lithuania	3200 (7 %)	N/A	512 (1 %)	64 (0 %)	0 (0 %)	1600 (28 %)	128 (1 %)	5504 (9 %)

End of table 1

Country	Area of NDVI decline in km^2 and in percentages for the corresponding land cover							Total
	Cropland	Mosaic vegetation-crop	Forested land	Mosaic forest-shrub/grass	Shrub land	Grassland	Sparse vegetation	
Poland	36672 (16 %)	N/A	2816 (2 %)	128 (3 %)	0 (0 %)	1152 (12 %)	2624 (3 %)	43392 (14 %)
Russia	562048 (27 %)	183296 (27 %)	4074176 (24 %)	482944 (22 %)	116416 (6 %)	162176 (17 %)	1401792 (19 %)	698284 8 (43 %)

Source: [15].

Note: (1) Land cover data extracted from Globcover data in 2005—2006 with the original resolution at 300 m, (2) The total area in the table is retrieved from the World Bank Development indicators for 2010/2012.

Most of these land degradation hotspots in the region are masked by atmospheric and chemical fertilization. The land degradation hotspots shown in Figure 1 have been also found to potentially affect the livelihoods of significant number of people residing in the degraded areas. Agriculture being a relatively smaller source of livelihoods in the region, the direct income impact on the people residing in the degraded areas in the Baltic region might be smaller. However, the indirect impact through reduced provision of ecosystem services is still important (Table 2).

Table 2

The population residing in the areas with long-term (1982—2006) NDVI decline

Country/ Territory	Population residing in the areas with NDVI decline		Including the share in the areas with,		
	Total	Share of total, %	NDVI decline detected from the remotely sensed data	NDVI decline likely, masked by CO_2 effects	NDVI decline likely, masked by chemical fertilization
Belarus	1 447 586	14.8	0%	2%	13%
Estonia	181 745	14.5	0%	14%	0%
Latvia	171 627	7.5	1%	4%	2%
Lithuania	402 310	11.2	0%	4%	7%
Poland	14 692 077	38.4	1%	10%	28%
Russia	15 750 863	11.6	1%	10%	0%

Source: [15].

Note: (1) Land cover data extracted from Globcover data in 2005—2006 with the original resolution at 300 m, (2) The total area in the table is retrieved from the World Bank Development indicators for 2010/2012.

Results

Land use and land cover dynamics in the region

During the period between 2001 and 2009, the region witnessed substantial land use and land cover changes (Tables 3—5). The major shift at the regional level involved a substantial increase in the forested areas and a decrease in all other land covers and uses, with the exception of croplands that have increased in several countries of the region, although also slightly declined regionally (Table 5).

Table 3

Land use/cover classification in 2001, in thousand ha

Country	Forests	Shrublands	Croplands	Grasslands	Woodland	Barren lands	Urban areas
Belarus	7 994	167	9 529	1 942	838	0	134
Estonia	2 927	87	674	454	153	1	19
Latvia	3 737	160	1 338	1 033	126	0	22
Lithuania	2 127	86	3 533	559	130	0	34
Poland	8 790	113	19 287	847	1 281	1	799
Kaliningrad, Russia	391	7	496	423	17	0	10
Pskov, Russia	3 835	55	634	548	223	0	8
Total	29 801	675	35 491	5 806	2 768	2	1 026

Source: based on MODIS satellite data

Table 4

Land use/cover classification in 2009, in thousand ha

Country	Forests	Shrublands	Croplands	Grasslands	Woodland	Barren lands	Urban areas
Belarus	9 927	126	9 560	682	172	0	134
Estonia	3 306	60	710	201	15	1	19
Latvia	4 122	47	1 755	458	12	0	22
Lithuania	2 516	30	3 690	188	12	0	34
Poland	11 061	99	18 306	403	448	1	799
Kaliningrad, Russia	433	9	792	98	2	0	10
Pskov, Russia	4 205	28	660	370	20	0	8
Total	35 570	399	35 473	2 400	681	2	1 026

Source: based on MODIS satellite data.

Table 5

Land use/cover classification, difference between 2001 and 2009, in thousand ha

Country	Forests	Shrublands	Croplands	Grasslands	Woodland	Barren lands	Urban areas
Belarus	1 933	– 41	31	– 1 260	– 666	0	0
Estonia	379	– 26	37	– 253	– 138	0	0
Latvia	384	– 113	417	– 575	– 114	0	0
Lithuania	389	– 56	156	– 371	– 118	0	0
Poland	2 271	– 14	– 981	– 444	– 834	0	0
Kaliningrad, Russia	41	2	295	– 324	– 15	0	0
Pskov, Russia	370	– 27	26	– 178	– 203	0	0
Total	5 767	– 275	– 19	– 3 405	– 2 088	0	0

Source: based on MODIS satellite data.

Poland and Belarus saw a sharp increase of forested areas by 25 %. Regionally, forests increased by 19 %. On the other hand, the countries also experienced a massive drop in grasslands and woodlands, Belarus and Poland again leading in those declines. Although not very extensive in terms of area, in relative shares the Kaliningrad province of Russia had the highest rate of decline of grasslands: between 2001 and 2009, it lost almost 75 % of all the grasslands, which predominantly shifted to croplands. Across the region, grasslands and woodlands declined by 75 %, and shrublands by 60 %. There was practically no change in the total area under croplands. However, a more detailed analysis shows that the situation with croplands is more complicated in some cases. Specifically in Belarus, for example, where we observe sizable shifts from croplands to forests; then similar big shifts from grasslands to croplands, even though the total figure does not change much.

Economic impacts of land degradation

Costs of land degradation

The results show that the total annual costs of land degradation in the region due to LUCC only (excluding costs of productivity losses in degrading but static biomes) amount to about 8.6 billion USD between 2001 and 2009 (Table 6). In total, Belarus and Poland bear the biggest costs of land degradation: 3.0 and 1.5 billion USD, respectively. On the other hand, in terms of the share of GDP, the Kaliningrad and Pskov provinces of Russia suffer the biggest losses due to land degradation, reaching 11.8 % and 7.5 % equivalent of their GDP, respectively. Compared to its GDP, Poland has the lowest costs of land degradation, which stands at 0.3 %. The costs of action in the region against land degradation make up 20.1 billion USD over 6 years and 20.4 billion USD over 30 years.

Table 6

The costs of action vs. inaction in the region against land degradation (in billion USD)

Country	Annual cost of Land Degradation in 2009	As share of GDP in 2009	Cost of Action (6 years)	Cost of Action (30 years)	Cost of Inaction (6 years)	Cost of Inaction (30 years)	Ratio of cost of inaction/action, 6 years
Belarus	3.0	6.1 %	6.2	6.3	20.7	44.8	3
Estonia	0.6	1.5 %	1.5	1.5	4.2	9.1	3
Latvia	1.3	5.0 %	3.4	3.5	9.6	20.8	3
Lithuania	1.0	2.7 %	2.0	2.0	6.5	14.1	3
Poland	1.5	0.3 %	3.8	3.9	10.9	23.5	3
Kaliningrad, Russia	0.7	11.8 %	1.2	1.2	4.7	10.1	4
Pskov, Russia	0.5	7.5 %	2.0	2.0	4.3	9.3	2
Total	8.6	1.3 %	20.1	20.4	60.9	131.7	3

The costs level off after 6 years since most of the related establishment costs and opportunity costs of alternative land uses occur within the initial 3—6 years, whereas the costs of maintenance once the new higher value biome is established are relatively small. On the other hand, the costs of inaction keep growing over time, from 60.9 billion USD in 6 years to 131.72 billion USD in 30 years.

Every dollar invested into land improvement in the region yields between 2 and 4 USD over 6 years; over 30 years, the rate of return is twice as much. The calculations above include only the improvement of the degraded lands. On the other hand, over this period, there was also substantial land improvement in the region, most notably, through afforestation (both anthropogenic and via natural regeneration). As a result, the net balance of the total value of land ecosystem services in the region is, in fact, positive. The big exception is the Kaliningrad province of Russia, where the TEV of land declined by 20 % (Table 7). Primarily because grasslands and woodlands, which have higher total ecosystem values (including both provisional and non-provisional services), have been replaced by croplands. Croplands may have higher value of provisional services than grasslands and woodlands, but if one accounts for the non-provisional services as well, then their TEV is often smaller than that for grasslands and woodlands.

Table 7

The total economic value of land ecosystem services in the region by land use and land cover type (in billion USD)

Countries/ Territories	Forest TEV		Shrublands TEV		Cropland TEV		Woodland TEV		Grassland TEV		TOTAL		Rate of change of Total TEV
	2001	2009	2001	2009	2001	2009	2001	2009	2001	2009	2001	2009	
Belarus	24 087	29 910	265	199	8 260	8 287	1 331	274	5 574	1 957	39 517	40 627	+ 3 %
Estonia	8 819	9 960	138	96	584	615	243	24	1 303	576	11 087	11 272	+ 2 %
Latvia	11 261	12 419	255	75	1 159	1 521	200	19	2 966	1 314	15 841	15 348	– 3 %
Lithuania	6 408	7 580	137	48	3 063	3 198	207	19	1 604	538	11 419	11 383	– 0.3 %
Poland	26 483	33 325	180	157	16 718	15 867	2 035	711	2 431	1 157	47 848	51 218	+ 7 %
Kaliningrad, Russia	1 179	1 304	11	14	430	686	27	4	1 213	283	2 861	2 290	– 20 %
Pskov, Russia	11 554	12 670	87	44	549	572	354	31	1 574	1 062	14 118	14 380	+ 2 %
Total	89 791	107 168	1 073	633	30 763	30 746	4 397	1 082	16 665	6 887	142 691	146 518	+ 3 %

Conclusions

Despite being less recognized, land degradation is a major environmental problem in many countries of the Baltic region. The annual costs of land degradation in the region amount to about 8.6 billion USD, or 1.3 % equivalent of the gross regional product. In some areas of the region, specifically, in the Kaliningrad province of Russia, the costs of land degradation as a share of the province's GDP are much higher, standing at 11.8 %. On the other hand, the costs of inaction against land degradation over the next 6 and 30-year period may make up 61 billion USD and 132 billion USD, respectively. Meanwhile, the costs of actions, on average, are up to 3 to 6 times lower for the same time periods. This means that every dollar invested into improving degraded lands may yield 3 dollars in return in the region over a 6-year period, and 6 dollars over a 30-year period. This consideration is a strong economic justification for taking action to address land degradation.

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The authors

Prof. Joachim von Braun, Director of Economic and Technological Change, University of Bonn, Germany.

E-mail: jvonbraun@uni-bonn.de

Dr. Alisher Mirzabaev, senior researcher at the Center for Development Research (ZEF), University of Bonn, Germany.

E-mail: almir@uni-bonn.de

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