Fondazione Eni Enrico Mattei

Land Cover Accounting in the Czech Republic

Jan Kolar

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

CSO   Czech Statistical Office
CUZAK   Czech Office for Surveying, Mapping and Cadastre
GIS   Geographic information system
OKEC   Branch classification of economic activities
SEEA   System of Environmental and Economic Accounting

1. INTRODUCTION AND THE PROJECT'S GOALS

The land cover structure – that is, landscape subjects and their spatial distribution - is an important indicator for assessment of the environment in its entirety. Value of a landscape is determined not only by the affluence and variety of natural resources (for example, soil quality, mineral resources, quality and accessibility of water) but also by the conditions, created and supported by a landscape, as for example, potency for socio-economic activities of a man.

The landscape structure has been continuously going through smaller or greater changes that shift the overall landscape value accordingly. Traditionally, nature was the main driving force causing landscape changes. However, civilisation has multiplied its energy potency to the extent that equals or even exceeds natural effects. Human activities substantially influence both the structure and quality of land cover, change environmental quality and thus, in reverse, influence again the human activities.

At present, it becomes more and more important to care about consequences of human impacts on a landscape in compliance wit the sustainable development concept. Environmental decision-making is a powerful tool that may significantly abate adverse anthropogenic impacts on a landscape. However, it can happen only provided that we truly understand the relationship between socio-economic activities and their impacts on the environment. Without that comprehension and without making decisions on sustainable development principles, people tend to see economic development in a clash with environmental protection concerns.

Goal of this project is to design and test methods of integration of two hardly comparable categories – economic performance and environment. Our approach is based on an assumption, that land cover provides relevant information on the state of the environment. The state of the environment both reflects previous human activities in a landscape and it also predetermines its future exploitation. A key element of this approach is finding and quantifying the relationship between land cover and economic parameters. Such a method is named "land cover accounting". It proceeds from the collection of physical and economic data to the development of a conceptual framework.

2. METHODOLOGY

Land cover accounting comprises two types of accounts: core accounts and supplementary accounts. The core account provides information on land cover composition, that is, what land cover categories occur and how large area they occupy in a particular place of the Earth surface. This standard volumetric statistics has been extended by geographic information system (GIS) technology with the spatial-based information (e.g. what are the neighbouring categories, spatial distribution of areas of different size, etc.). With regard to the purpose of the method, it is not the state of land cover, what really counts, but the land cover changes resulting from anthropogenic impacts. A very basic prerequisite for analysis of this kind is to compare data from at least two period of time. Thus a regular update of land cover inventory – similar to a very regular update of economic data and indicators – is an ensuing condition so that this method be used as a standard tool for decision-making.

There are myriad diverse potential impacts in both "society – environment" and "environment-society" directions. All parameters on neither side can be observed: the potential intersection of both domains is therefore observed only in a particular field with regard to the subject of interest - landscape stability, biodiversity, impact of particular economic activities, etc. The supplementary accounts are constructed right for exploring and making a relationship between environmental and economic statistics.

When constructing the supplementary accounts, defining the relationship between parameters of both domains is a major difficulty. Thus a crucial step lay right at the beginning of the work in defining appropriate land cover categories and categories of socio-economic activities. The selection of appropriate categories might reduce potential inaccuracies of the land cover – economy relationship (a typical puzzle to cope with was the multiple use of one land cover subject). This Module was structured in the following phases:

1. Definition of land cover categories

2. Construction of a basic account and analysis of land cover changes

3. Definition of categories of socio-economic activities; identification of parameters describing the socio-economic activities; analysis of the available data

4. Integration of land cover and economic categories; creation of matrix of coefficients

5. Construction of complementary accounts

6. Evaluation of results

3. LAND COVER ACCOUNTS

3.1. Core account

3.1.1. Land cover data

Land cover databases from 1997-98 and 1990-91 were used for construction of the core account. They are, in fact, digital thematic maps of land cover of the Czech Republic created by photo-interpretation of satellite imageries. A time series of two periods (over 12 years in this case) introduced a temporal dimensions of the framework. Land cover categories of the recent database (190-91) followed the categories of the former one to keep the consistency, despite the recent database could provide much more detailed nomenclature in order (see Table 1).

Class No	Nomenclature
11	Urban fabric
12	Industrial, commercial and transport units
13	Mine, dump and construction sites
14	Artificial non-agricultural vegetated areas
21	Arable land
22	Permanent crops
23	Pastures
24	Heterogeneous agricultural areas
31	Forests
32	Shrub and/or herbaceous vegetation associations
33	Open space with little or no vegetation
4	Wetlands
5	Water bodies

Table 1 - Land cover nomenclature used for the core account

3.1.2. Construction of core account

Core accounts were constructed for the both time periods. The temporal analysis was able to find changes of defined land cover categories in areas over the given period of time. A contingency table was made for analytical purposes (see Annex 1) to provide the main information on trends in land cover developments in the Czech Republic:

- land cover was changed on 269 357 ha over the given period of time (that accounts for 3.41 per cent from the total area of the Czech Republic)

- the most extensive changes (75 per cent of all changes) occurred in forests. Almost 60 per cent of forested areas were either damaged by emissions, logged (changes from class 31 to class 32) or afforested (changes from class 32 to class 31). However, the quality of forests was changed even more than the area

- the second most extensive changes (15 per cent of all changes) were detected in agricultural areas. Although the total area of agricultural land was not distinctly changed (Fig. 2), there were identified changes among agricultural classes - arable land, permanent crops and pastures (Fig. 1).

- a slight increase was detected in built-up categories (classes 11 and 12) and areas related to mining (class 13).
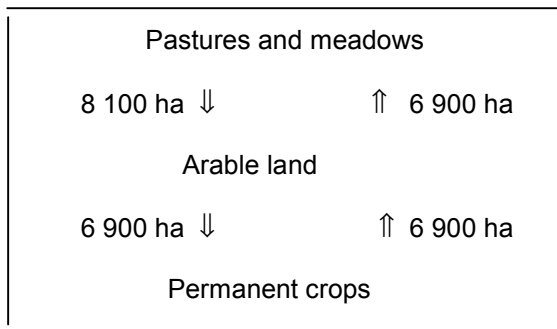
```
┌─────────────────────────────────────────┐
│         Pastures and meadows             │
│                                          │
│     8 100 ha ⇓            ⇑ 6 900 ha     │
│                                          │
│              Arable land                 │
│                                          │
│     6 900 ha ⇓            ⇑ 6 900 ha     │
│                                          │
│           Permanent crops                │
└─────────────────────────────────────────┘
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Fig. 1 - Changes in agricultural land

The dected changes were comparable with the similar data of the Czech Office for Surveying, Mapping and Cadastre - CUZAK (Tab. 2).

Land use				
	1978	1990	1990-1978 (ha)	1990-1978 (%)
arable land	3 326 502	3 232 229	- 94 273	2.83
hop plantation	10 394	11 436	1 042	10.03
vineyards	13 612	15 818	2 206	16.21
garden	149 229	157 450	8 221	5.51
orchards	53 839	51 083	- 2756	5.12
meadows	593 976	571 799	- 22 177	3.73
pastures	280 418	256 510	-23 908	8.53
agriculture land	4 427 970	4 296 325	- 131 645	2.97
forests	2 615 535	2 628 993	13 458	0.51
fishponds	51 495	50 789	- 706	1.37
other water bodies	92 890	105 274	12 384	13.33
build-up area	118 474	125 307	6 833	5.77
other	579 979	679 672	99 693	17.19
non-agricultural land	3 458 373	3 590 035	131 662	3.81
total	7 886 343	7 886 360	17	0.00

Table 2 - Data on land use by CUZAK

The spatial characteristic of identified changes was described by the visual assessment of changes presented in maps. The maps revealed that the most concentrated changes occurred in highly industrialised areas, around big cities and in frontier forested zones that suffered from long-term intensive air pollution.
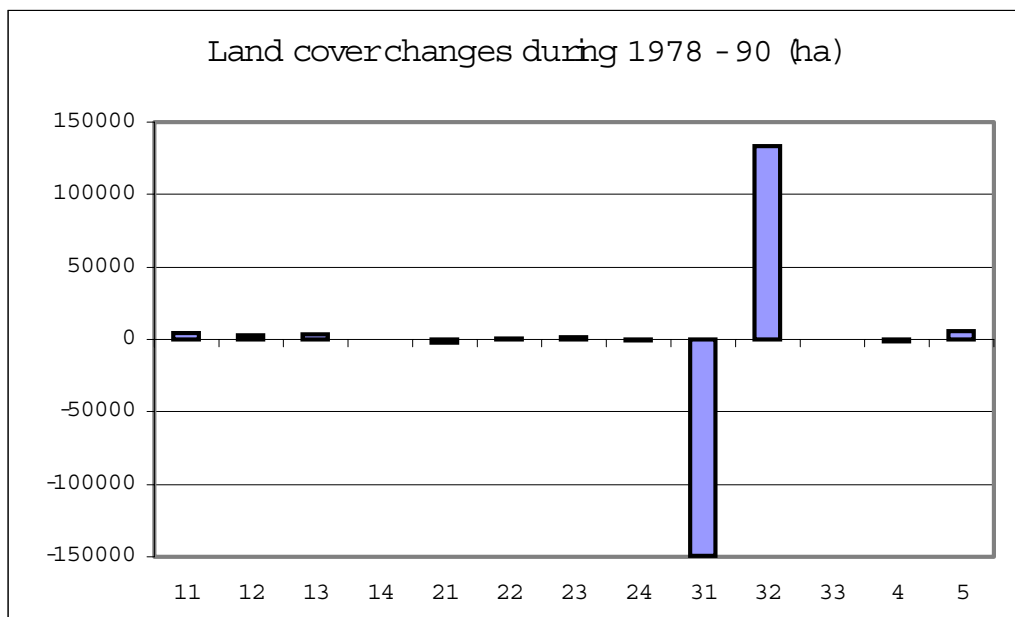
Fig. 2 - Changes of land cover categories during 1978–90

3.2. Supplementary accounts

3.2.1. Economic data

This supplementary account implicates effects of economic activities on a landscape. Selected categories of economic activities were to meet a criterion of including all human activities influencing land cover. In compliance with practice of the Czech Statistical Office - the official source of both environmental and economic data - we adopted the official "Branch classification of economic activities" (OKEC) for construction of supplementary accounts. Adopting this official classification will enable potential extension of a time series as well as linking with existing statistical nomenclature of the environment in the "System of Environmental and Economic Accounting" (SEEA). The only deviation was using the category "households" for all households without any difference, and also we introduced the category "Other or without use" for the landscape subjects without any economic exploitation. All categories of the supplementary account are shown in Table 3.

Category	Nomenclature
A01	Agriculture
A02	Hunting and forestry
B	Fishing
C	Mining and quarrying
D	Manufacturing
E	Electricity, gas, nuclear and water supply
F	Construction
G	Wholesale and retail trade
H	Hotels and restaurants
I	Transport, storage and communications
J-P	Public administration, defence, compulsory social security and other public and social services
	Private households
	Recreation
	Other or without use

Table 3 - Categories of socio-economic activities

A primary source of socio-economic data was so-called "balance of the national economy" and the Statistical Yearbooks of former Czechoslovakia and the Czech Republic published by the Czech Statistical Office.

Due to accessibility to data of the given period, we presented economic activities by statistical parameters "production" and "number of employees" of relevant economic branches. Presentation of economic activities was seriously hampered by difficulties to get a longer time series data. The data from 1978-90 were not available in comparative prices and the data in current prices did not allow the exact analysis of the economic development (they just indicated trends). Therefore, besides the above basic economic data, we further used some other data as volumes of raw material and wood exploitation, agricultural production, sowing acreage, number of inhabitants, housing etc.

Prospectively, some more data might be involved for all economic branches in constructing supplementary accounts: production, final consumption, added value, investments, number of employees, number of economic subjects, electricity consumption, etc.

3.2.2 The coefficient matrix

The linkage between land cover and economic activity is quantified by coefficient that indicates the share of economic activity in a particular land cover category. These coefficients were set for all the pairs created by land cover-economic categories. Due to some factors - high aggregation of classes in land cover nomenclature and the minimum size of mapped unit of 25 ha - there is some heterogenity in assigning economic exploitation to particular land cover categories. Since a single valued link between economic and land cover categories does not exist, several economic categories can relate to one land cover category and *vice versa*, an economic activity may relate to several land cover classes.

In order to express spatial demands of economic activities with regard to land cover classes, we designed a coefficient matrix that set the share (in per cent) of particular economic activities in the particular land cover category (see Annex 2). Since there has not been available any method, which would exactly set these coefficients, we set them with the help of expert judgement and the experience of the German Statistical Office.

This problem mainly concern the category of "built-up areas" (land cover class 11 and 12) that were very heterogeneous from the perspective of economic exploitation. No statistics, which would provide the information on built-up areas according their economic exploitation, has been available. Getting such information from the official land use statistics, which is based on registration of cadastres, would be very costly and timely. The coefficients for land cover classes 12, 13 and 24 were set with help of more detailed nomenclature of land cover database from 1990-91.

3.2.3 Construction of supplementary accounts

Pursuant to the coefficient matrix we were able to construct the supplementary accounts for 1978 and 1990 (see Annex 3 and 4). The supplementary accounts include economic parameters as well as spatial demands of each particular economic activity. The spatial demand is product of land cover parameter (as set in the core account) and the relevant coefficient. After constructing both supplementary accounts, we designed a supplementary account of changes for the period 1978-90 (Annex 5). The supplementary accounts - and the changes account, in particular - provide a sound framework for exploring potential relationships between parameters of the economic performance/magnitude and particular changes in land cover.

The underlying assumption for this kind of analysis is, firstly, that there exists such an interrelationship, and secondly, that the spatial demands of economic activities are determined by expert judgement. Last but not least, one must take into consideration the incomparability of monetary parameters in current prices for the both periods of time.

3.3. Analysis of supplementary accounts

A detailed analysis of supplementary accounts (see Annexes 3 - 5) follows by particular economic activity.

3.3.1 Agriculture

An agricultural sector showed a decline as well as an increase in some parameters (see Table 4) while the area of arable land slightly decreased. There was an evident transition from extensive to intensive type of farming. The impact of this sector manifested rather by changes in land quality than quantity (area).

Economic parameters		1978	1990	1990-1978	1990-1978 (%)
Production (t)	Cereals	7 289	8 947	1658	22.7
	Sugar beat	2 999	4 026	1027	34.2
	Potatoes	5 512	1 755	-3757	32
Yield (t/ha)	Cereals	4.1	5.46	1.36	33.1
	Sugar beat	34.84	34.01	-0,83	2.4
	Potatoes	20.71	16.06	-4,65	22.4
Livestock	Cattle	3 436	3 360	-76	2.2
	Pigs	4 858	4 609	-249	5.1
	Fowls	30 897	33 278	2381	7.7

Table 4 - Selected parameters of the agriculture production in 1978 and 1990 (Czech Statistical Office – CSO)

3.3.2. Forestry

Changes in forests were caused by changes in quality of forests what was fully in line with conclusions of the core account (Ch. 2). The main pressure of the changes was the air pollution produced by energy and chemical industry.

Forestry activities	1978	1990	1990-1978	1990-1978 (%)
Logging (1000m3)	13 004	13 332	328	2,5
Afforestation (ha)	25 648	33 615	7 967	31

Table 5 - Selected parameters of economic activities in forest in 1978 a 1990 (CSO).

3.3.3. Fishing

The supplementary account was not constructed because of lacking data from 1978. Also, due to land cover methodology mapping only units larger than 25 ha, the class 51 comprises only larger water bodies what would substantially bias the results.

3.3.4. Mining and quarrying

An increase of mining and quarrying areas corresponded with a rise of the brown coal production (Fig. 3) that was the most important raw material extracted in open pits. The quarrying was closely connected to recultivation subsequent to mining: during the recultivation phase there were founded new agricultural areas and water bodies.
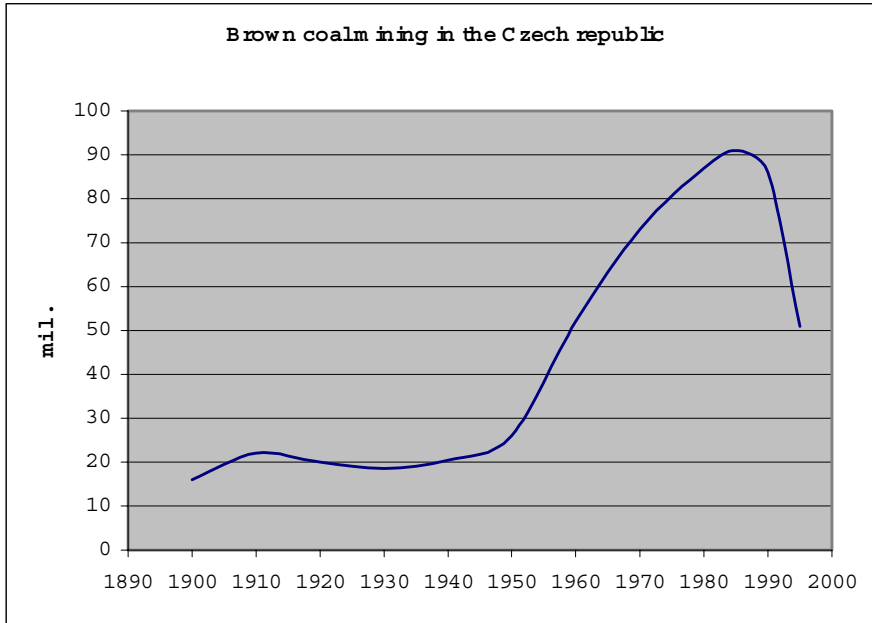
Fig. 3 - History of brown coal mining in the Czech Republic
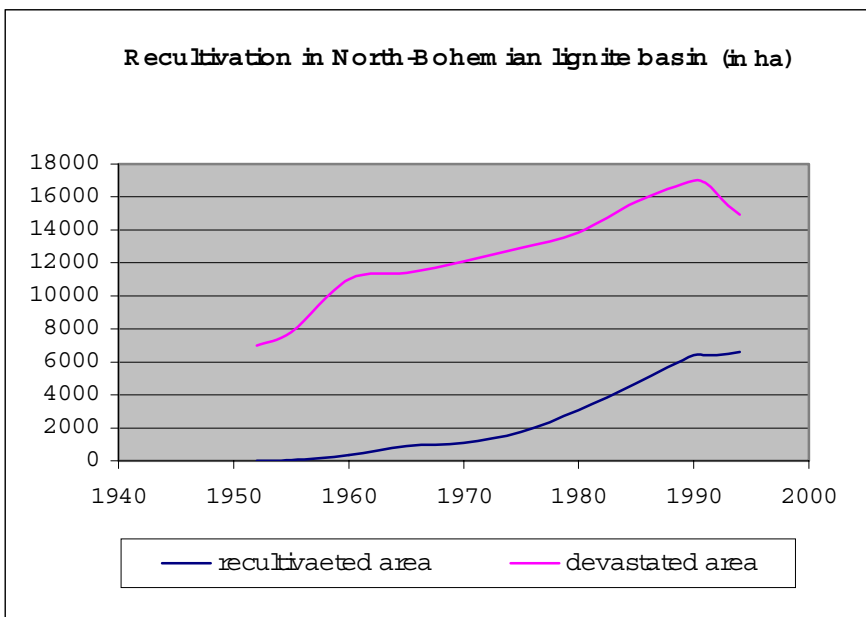

Fig. 4 - Recultivation in the North Bohemian brown coal basin

3.3.5 Manufacturing

Only the basic economic parameters were used for analysis of manufacturing sector - there was not any other specific parameter common for the whole sector. The GDP increase corresponded with enlargement of industrial and commercial areas (class 12). On the contrary, number of employees dropped.

GDP (CZK bn)	1980	1985	1988	1989	1990
1984 prices		465.6	487.8	509.9	503.7
Current prices	415.3	473.7	513.4	524.5	567.3

Table 6 - Gross domestic product during 1980-90

3.3.6. Households

An increase in built-up areas did not correspond with statistically registered drop in the number of houses. On the contrary, the official data on land use by (see Table 2) assigned much higher increase to built-up areas.

	1978	1990	1990-1978	1990-1978 (%)
Number of inhabitants	10 269 012	10 304 607	35 595	0.3
Number of houses	1 634 304	1 597 075	- 37 229	2.3
Number of dwellings	3 494 846	3 705 681	210 835	6.0

Table 7 - The housing statistics

3.3.7 Other and without use

Natural areas without any economic use and areas of damaged forest were assigned to this group of economic activities (large areas of heavily damaged forests without any economic activity in the sense of the OKEC classification).

4. CONCLUSIONS

Results accomplished in application of land cover accounting laid a good foundation for further developments.

The core account, which demonstrated magnitude and structure of land cover changes, was based on national databases of land cover as of 1978 and 1990. It identified significant changes in forest quality, an increase in built-up areas (both housing and industrial) and mining and quarrying areas. Although a total area of agriculture land just slightly dropped, there were identified major changes in land use on particular agricultural areas. The core account itself provided sufficient information for identification of those economic activities having the biggest share in driving the use of land. In supplementary accounts, the attempts to quantify the share and relate it directly to a particular land cover category was made.

The supplementary accounts evoked the issue of classification of economic activities and land cover as well as definition of their relationship. This problem was the bigger the less detailed information on land cover was available. The land cover nomenclature used for this project had only 13 classes (a detailed land cover nomenclature may include over 100 classes); this meant certain heterogeneity of classes and ensuing problems with defining the relations to economic activities. A coefficient matrix was made for relating land cover categories to the accordant economic activities.

When analysing the supplementary account of changes 1979-90 it is necessary to consider that the spatial share of particular economic activities was based on expert judgement. No statistical groundwork to make it more precise did exist. Moreover, the basic economic parameters were not published in official documents in comparable prices and full range. Also the extent, to which these financial parameters indicated the impact of economic activities on land cover, was not known and might be questioned. Therefore, some other socio-economic parameters were introduced for some economic activates (outputs, mining, and population).

In the future, the supplementary accounts will allow simulation of development trends. However, with regard to all above limitations, any modelling attempts would be rather untimely at the moment. For instance, any conclusions on mutual correlation of the two groups of parameters are not statistically relevant in this case, since only two time horizons were compared. Extension of the time series of both types of parameters is necessary. Similarly, it would need to build a more detailed land cover database or precise coefficients. Thus, we can accept conclusions of this module as the first attempt for land cover accounting. It may contribute to the overall goal to find objective tools for analysis and assessment of human impacts on a landscape that embrace both the economic and environmental dimensions.

5. ANNEXES

Annex 1 - Core account

Annex 2 - Coefficient matrix

Annex 3 - Supplementary account – state 1978

Annex 4 - Supplementary account – state 1990

Annex 5 - Supplementary account – change 1978-1990

Annex 5 - Supplementary account – change 1978-1990

| | economic activities | DIFFERENCES 1990 - 1978 | | | | | | | | | | | | | | | |
| | | parameters | | land cover (in ha) | | | | | | | | | | | | | |
		production mil CSK	employees	urban fabric	industrial, commercial and transport units	mine, dump and construction sites	artificial, non agricultural vegetated areas	arable land	permanent crop	pastures	heterogeneuous agricultural areas	forests	scrub and/or herbaceous vegetation associations	open spaces with little or no vegetation	wetlands	water bodies
A01	agriculture	29304	-40527		313			-2408	887	1236	-1048					
A02	hunting and forestry	-629	20100								-262	-111433	26907			
B	fishing		120													1215
C	mining and quarriyng		3768			2618									-128	
D	manufacturing	166058	-43276		1723											
E	elektricity, gas, nuclear and water suply		6034		313											1215
F	construction	20656	-8399			164										
G	wholesale and retail trade etc.	331	59069	233	313											
H	hotels and restaurant		13545	466												
I	transport, storage and communications	9282	32472		470											
J-P [1]	public administration and defence compulsory social security		222409	699												
	private households			3031							-175					
	recreation			233			90				-175	-29716				1215
	other or without use					491	90			137	-87	-7429	107627	-104	-1151	2429
total			265315	4662	3133	3272	179	-2408	887	1373	-1747	-148578	134534	-104	-1278	6074

total
-1020
-84789
1215
2490
1723
1528
164
546
466
470
699
2856
-28353
102004