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Agro-ecological assessment of the vegetation cover of Poland's soils

Adam Harasim

Department of Systems and Economics of Crop Production
Institute of Soil Science and Plant Cultivation – National Research Institute
ul. Czartoryskich 8, 24-100 Puławy, Poland

Abstract. Indicators presented in the study – indices of vegetation cover and ecological stability – complement each other when used to assess the agro-ecological status of land surface coverage by vegetation. Vegetation cover index, especially that relating to farmland, is useful to evaluate the soil-protecting function of vegetation at a country, region, province (= voivodship) and farm levels. Vegetation cover index should be used to evaluate a crop rotation or a cropping structure. When the management of land surface is evaluated for its merits in relation to environment protection the ecological stability index is an indicator to be used.

Assessed at a country level, farmed lands were found to receive good soil protection from vegetation coverage and land surface showed low to medium-high level of ecological stability. It was found that as surveys went down from the country to region and to farm level the values of agro-ecological indicators became more diversified. In an evaluation comprising both tests the southern region of Poland showed the best performance whereas at a province level, the provinces of Lubuskie, Małopolskie, Podkarpackie, Podlaskie and Warmińsko-Mazurskie had the best indicators.

key words: soil cover, ecological indices, ecological stability

INTRODUCTION

Over the recent years there has been a surge of interest in the issue of stable development involving economic viability, social acceptance and environmental security as viewed from perspectives involving different scale of detail (continents, countries, regions, farms, production systems) (Majewski, 2008). Many investigators have attempted to develop and propose indicators to measure different areas of stability (Borys, 1999; Faber, 2001; Gil, Śleszyński, 2000; Majewski, 2008; Zegar, 2005; Woś, 1992). The use of universally accepted indicators creates the possibility to make reliable comparisons on an international or inter-regional level. It is also important to develop original indicators which would take account of features and their regional variation peculiar to a given country. It should also be noted that the concept of stable development is identified with the idea of sustainable development (Faber, 2001; Krasowicz, 2005, 2006; Kuś, 2006; Runowski, 2000; Woś, 1992). Likewise, in some studies and government documents a joint formula covering both the stable and sustainable development is frequently adopted.

In the evaluation of a farming system ecological indicators such as vegetation cover index are gaining increasing importance (Duer et al., 2002; Fotyma, Kuś, 2000; Harasim, 2000, 2004b; Vereijken, 1997). From the viewpoint of environment protection, farming activities should be accompanied with endeavours to keep soil under continuous vegetation cover for as much time as possible. If not covered by vegetation for long enough, the soil will undergo physical, chemical and biological degradation as a result of the destructive impact of precipitation, wind and sunshine exposure (Dębicki, 2000) Therefore, indicators that take account of the soil-protective function of vegetation are proposed to be used for the evaluation of the farming environment at a regional and local level (Fotyma, Kuś, 2000; Harasim, 2000, 2004b; Hronec, 1999; Vereijken, 1997).

The objective of the study was to analyze the status of vegetation cover and ecological stability of Poland at a region and province (= voivodship) level.

MATERIAL AND METHODS

The subject matter for the study was provided by the statistical data of Poland's Central Statistical Office (GUS). Evaluation of the soil-protective function of crops on arable lands was performed using the mean weighted vegeta-

Corresponding author:
Adam Harasim
tel.: +48 81 8863421 ext. 234, fax +48 81 8864547
e-mail: ahara@iung.pulawy.pl

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tion cover index of soil (VCI) calculated according to the formula (Harasim, 2004b):

$$VCI = \frac{\sum Pi \cdot Spi}{\sum Pi}$$

where:

$\sum Pi \cdot Spi$ – sum of products of area under crops multiplied by percentage of soil vegetation cover

$\sum Pi$ – total area under crops [ha].

For each crop or group of crops the data on cultivation area were obtained from source materials CSO (Produkcja…, 2008; Użytkowanie…, 2007). Percentage of soil vegetation cover was based on data listed in Table 1.

Evaluation of agricultural space management at the country or region level comprises a full array of constituent elements of agro-ecosystems or the entire land surface. With such an approach it is useful to use the ecological stability index of land surface (ESI) calculated according to the formula (Harasim, 2004b):

$$ESI = \frac{\sum PRs + \sum PNk}{\sum PRn + \sum PNn}$$

where:

$\sum PRs$ – total area of stable (beneficial) elements of farmland (meadows and permanent pastures, orchards, legume-grass mixtures and grass leys) [ha]

PNk – total area of beneficial non-agricultural elements of farmland (woodlands, tree plantings and shrubs, bodies of water, ecological sites) [ha]

$\sum PRn$ – total area of unstable elements of farmland (arable lands under annual crops, fallows and untilled lands) [ha]

$\sum PNn$ – total area of non-beneficial elements of non-agricultural land (built-up and urban areas, various other land uses, derelict lands) [ha].

Source data required to calculate the ecological stability index were derived from the statistical reports by GUS (Ochrona…, 2007). Some of the surface elements require defining: According to the methodology of GUS (Ochrona…, 2007) ecological sites comprise: natural water reservoirs, mid-field and mid-forest small water bodies, clumps of trees and shrubs, marshlands and peatbogs, sand dunes, patches of unused vegetation, old-river beds, rock outcrops, hillslopes, etc. Built-up and urban areas include residential areas, communication routes and mining sites. The meaning of the remaining elements is generally known.

Details on the methods used to calculate the agro-ecological indices were given in an earlier study (Harasim, 2004b). Scoring systems to estimate degree of coverage by plants during the year (soil-protective impact of vegetation) and ecological stability of land surface are given in Table 2.

Table 1. Degree of vegetation cover during the year.

Crops	Degree of soil cover [%]
Buckwheat	20
Fallow (cover an area)	70
Flax and hemp	20
Fodder root crops	25
Hops	30
Idle land	100
Idle land and fallow (total)	80
Legume-cereal mixtures	20
Legumes:	
for seeds	20
for green forage	15
Maize as a main crop	30
Meadows and pastures	100
Orchards	90
Perennial legumes and grasses and mixtures:	
seeding year (under crop)	70
full utilization year	100
last utilization year	70
Potatoes:	
medium	20
late	25
Spring cereal mixtures	25
Spring cereals:	
for grain	25
for green forage	15
Stubble crops	10
Sugar beets	30
Tobacco	30
Vegetables	25
Winter cereals:	
for grain	75
for green forage	50
Winter rape	75

Source: Harasim, 2004b.

The agro-ecological assessment of the vegetation cover of the soils of Poland was carried out at two levels: regional and provincial. It should be added that starting with January 1, 2008 Poland's territory was divided into spatial units hierarchically arranged at five levels and covering different areas, including 3 region-based (regions, provinces, sub-regions) and 2 local (poviats, rural municipalities

Table 2. Assessment scale of agro-ecological indicators.

Degree of soil cover	very good	good	mean	weak	wrong
Indicator [%]	81–100	61–80	41–60	21–40	0–20
Level of ecological stability	very high	high	medium	low	very low
Indicator [points]	>2,0	1,51–2,0	1,01–1,5	0,5–1,0	<0,5

Source: Harasim, 2004b.

(gminas)); (Rozporządzenie…, 2007). The classification of territorial units is applied for policy-making purposes by the EU countries and is indispensable, among other things, to carry out analyses concerning the variation of socio-economic development among the regions.

RESULTS

The indicators describing annual coverage of soil by vegetation and ecological stability of land surface were used to make region- and province-based estimations of the vegetation cover of Poland's soils (Table 3). The values of vegetation cover index of farmlands were higher than those of croplands. Such a relationship is decided mainly by the share of fully soil-protective permanent grasslands (meadows and pastures) in total farmland. Vegetation cover index of farmlands in Poland is 63.4% (Table 3) testifying to good soil-protective properties of vegetation cover (Table 2). In an alongside analysis, vegetation coverage of arable land under crops was found to be satisfactory (50.5%).

Variation in vegetation cover of soils is greater from province to province than from region to region (Table 3). The indicator of soil protectiveness of farmland was favourable in the southern region – chiefly due to a high percentage of meadows and pastures (Table 4). Cropland showed the best soil protectiveness in three regions: north-western, south-western and northern. The highest values of vegetation cover of soils (68-71%) were found for the provinces: małopolskie, podkarpackie, warminsko-mazurskie and the lowest (below 60%) for the provinces: kujawsko-pomorskie, lubelskie and wielkopolskie. Evaluation of the vegetation cover of cropland furnished evidence that soil-protective function of crops was good (55%) in the provinces: dolnośląskie, lubuskie, opolskie, warmińsko-mazurskie and zachodniopomorskie (Table 3). The status of vegetation cover of cropland in those provinces was significantly influenced by the percentage of winter and perennial crops (r = 0.99). In other provinces the vegetation cover index was lower. From the standpoint of environment protection requirements soil degradation may occur in those areas, becoming particularly severe under conditions of long periods without vegetation cover.

On the regional basis, the structure of farmland (Table 4) and the cropping structure on arable lands are the prime

Table 3. Agro-ecological assessment of the vegetation cover indicators in Poland's soils (2007).

Specification	Indicators of soil cover during the year [%]		Share of winter and perennial crops with sowing of arable lands [%]	Ecological stability index
	agricultural lands	arable lands		
Poland	63,4	50,5	50,5	0,98
Regions				
Central	63,3	48,6	46,7	0,82
Southern	66,8	47,5	44,5	1,25
Eastern	63,2	46,4	42,2	1,08
North-western	62,2	53,1	55,8	0,96
South-western	62,8	54,7	59,7	0,74
Northern	63,9	53,2	55,6	1,06
Province				
Dolnośląskie	64,2	54,7	60,0	0,82
Kujawsko-pomorskie	58,2	52,4	54,0	0,63
Lubelskie	58,4	46,5	43,0	0,69
Lubuskie	66,3	54,2	55,1	1,64
Łódzkie	61,4	50,2	49,9	0,66
Małopolskie	67,9	46,2	41,7	1,39
Mazowieckie	64,3	47,7	44,8	0,91
Opolskie	60,5	54,7	59,4	0,60
Podkarpackie	68,7	46,8	43,4	1,61
Podlaskie	66,6	46,0	40,5	1,39
Pomorskie	62,7	52,6	55,0	1,18
Śląskie	65,0	49,2	48,3	1,10
Świętokrzyskie	62,7	46,0	41,7	1,01
Warmińsko-mazurskie	70,6	54,8	58,7	1,43
Wielkopolskie	59,8	52,5	54,4	0,67
Zachodniopomorskie	64,8	54,7	59,1	1,11

Source: Author's elaboration from CSO data (Ochrona…, 2007, 2008; Produkcja…, 2008; Użytkowanie…, 2007).

factors influencing soil coverage by vegetation. Vegetation cover index assumes higher values in areas with a relatively large share of permanent grasslands (meadows and pastures) and perennial crops (in the years of their full production) (Table 2). A greater share of permanent grasslands in total farmland area of some provinces (małopolskie, mazowieckie, podkarpackie, podlaskie, śląskie, warmińsko-mazurskie) is related to their physiographical situation (river valleys, lake districts, piedmont areas). On the other hand, the provinces kujawsko-pomorskie, opolskie, and wielkopolskie are distinguished for their greatest share of arable lands accounting for more than 80% of total farmland area (Table 4).

With a greater number of constituent elements of agroecosystems or with taking account of total land area the ecological stability index provides a more comprehensive assessment of the vegetation cover made across the country or region. The level of ecological stability for Poland's area is low approaching the average (index = 0.98, Table 3). The average values are shown by three regions of the country: southern, eastern and northern. The provinces, on the other hand, are characterized by a greater diversification of that indicator (Table 3, Fig. 1). The provinces lubuskie and

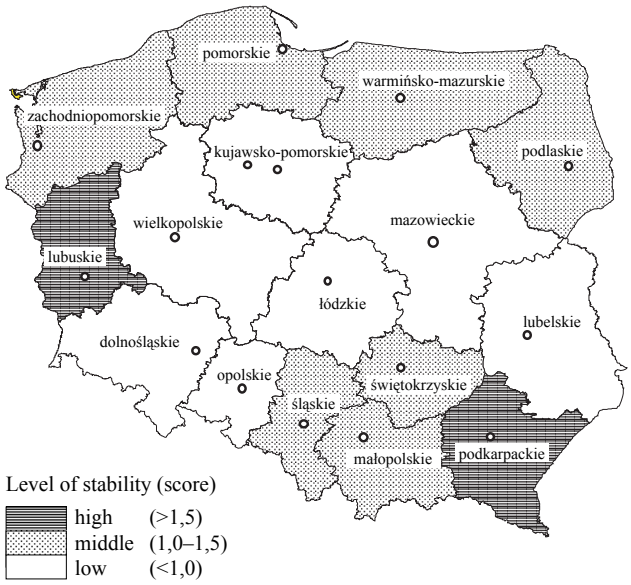

Fig. 1. Regional variation of ecological stability of land surface across Poland in 2007.
Source: Author's compilation.

Table 4. Structure of agricultural land in Poland (2007).

Specification	Arable lands with sowing	Idle land and fallow	Orchards	Meadows and pastures	Agricultural land out of cultivation*
Poland	70,8	2,6	2,1	20,2	4,3
Regions					
Central	67,3	2,7	4,3	21,6	4,1
Southern	58,9	3,5	1,7	29,2	6,7
Eastern	65,9	2,4	2,8	24,9	4,0
North-western	77,5	2,1	1,2	14,6	4,6
South-western	78,8	3,7	0,6	13,2	3,7
Northern	74,7	2,1	0,6	18,5	4,1
Province					
Dolnośląskie	75,6	3,2	0,8	15,2	5,2
Kujawsko-pomorskie	86,5	0,8	1,0	10,2	1,5
Lubelskie	75,4	1,8	4,0	16,1	2,7
Lubuskie	66,2	5,3	0,7	20,6	7,2
Łódzkie	74,5	2,1	3,6	16,2	3,6
Małopolskie	56,2	2,3	2,3	32,9	6,3
Mazowieckie	63,5	3,1	4,6	24,5	4,3
Opolskie	84,5	4,6	0,2	9,6	1,1
Podkarpackie	54,4	5,4	1,6	31,6	7,0
Podlaskie	60,8	1,6	0,4	35,0	2,2
Pomorskie	74,9	3,9	0,4	16,0	4,8
Śląskie	63,4	5,5	0,7	23,1	7,3
Świętokrzyskie	65,0	1,7	5,2	20,7	7,4
Warmińsko-mazurskie	63,3	2,0	0,4	28,0	6,3
Wielkopolskie	83,1	0,7	1,2	13,4	1,6
Zachodniopomorskie	73,2	2,9	1,5	13,8	8,6

* agricultural lands currently out of cultivation.
Source: Author's elaboration from CSO data (Użytkowanie…, 2007).

podkarpackie have a high level of ecological stability. The average stability is shown by 7 provinces i.e. małopolskie, podlaskie, pomorskie, śląskie, świętokrzyskie, warmińsko-mazurskie and zachodniopomorskie, the remaining ones scoring low for that indicator. Ecological stability index is highly significantly correlated with vegetation cover index of farmland soils (r = 0.88) and shows no significant correlation (r = 0.15) with the index of arable land coverage by crops.

DISCUSSION

Vegetation cover index of soils, especially when applied to farmland, is a useful tool in the assessment of the soil-protective function of vegetation made at different scales of detail: country, region, province or farm (Faber, 2001; Harasim, 2004a, 2004b; Harasim, Madej, 2008; Vereijken, 1997). If a crop rotation scheme or cropping structure is to be evaluated, an index measuring vegetation cover of arable lands is a suitable tool (Duer et al., 2002; Fotyma, Kuś, 2000; Harasim, 2000, 2002).

At a farm level, crop rotation and farmland structure are the factors that influence cropping structure and soil-protective function of vegetation. The favourable value of the vegetation cover index of arable lands is shown by the Norfolk-type rotation which includes a legume-grass mixture (Harasim, 2000, 2002). That type of crop rotation should be employed in operations specializing in organic farming. In organic farms cropping structure usually meets the correct crop rotation requirements with regard to fertilization and pest and disease management (Tyburski, 2005). Indices of soil coverage by winter crops and winter catch crops found in the majority of farms with substantial surpluses of nitrogen balance point to increased hazards related to leaching of nitrogen and to poor protection against erosion (Kuś, Krasowicz, 2001). Catch crops grown between two main crops may play a significant role in improving that indicator (Duer et al., 2002; Fotyma, Kuś, 2000; Vereijken, 1997). A survey carried out in 105 farms with different shares of permanent grasslands in the province podlaskie revealed that with an increase in the share of permanent grasslands in total farmland vegetation cover index for arable lands was significantly decreased (r = -0.40) whereas that for total farmland was increased (r = 0.82); (Harasim, Madej, 2008).

When management of land surface is evaluated for its merits relating to environment protection at a country or region level ecological stability index is a suitable indicator (Harasim, 2004a, 2004b; Hronec, 1999). Both indices presented in the study, vegetation cover of soils and ecological stability, are complementary to each other for the assessment of the agro-ecological status of coverage of land surface by vegetation.

CONCLUSIONS

1. Vegetation cover of soil and ecological stability of land surface can be classified among agro-ecological indicators to evaluate land surface resources, ecosystem equilibrium, and degree of implementation of sustainable production systems in agriculture.
2. At a country level, farmed land was found to show good soil protectiveness of vegetation cover whereas land surface showed low to medium high level of ecological stability
3. The southern region of Poland and the provinces lubuskie, małopolskie, podkarpackie, podlaskie and warmińsko-mazurskie received the most favourable appraisal when evaluated for both indicators jointly.

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