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Review Article

Assessment of Soil Pollution Using Environmental Indicators

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Abstract

Consideration of environmental performance indicators (EPIs) is used to assess the state of the natural environment in Eastern Europe, Caucasus, and Central Asia. A system is proposed for assessing the condition of the natural envi¬ronment in Ukraine. This is based on a study of the ecological indicators that are already in use in particular regions and in the country as a whole.

Keywords: Environment; Environmental Performance; Environmental Performance Indicator; System Monitoring

Introduction

The agro-industrial complex comprises more than half of Ukraine's productive assets, generates about half of the gross domestic product, and, in turn, impacts the environment – not least by pollution of soil and water. In Eastern Europe, Caucasus, and Central Asia (EECCA), the environmental performance indicator (EPI) is the main tool for assessing the status of the environment [1]. Well-chosen indicators based on enough time series data can show key trends and help describe causes and effects, as well as enable us to monitor the implementation of environmental policy and to evaluate its effectiveness. Therefore, we propose a system of EPIs to assess the state of the environment (hereafter the EPI system). It will facilitate the tracking of trends in status of areas under surveillance and assess the impact of environmental management both across the Ukraine and in particular administrative districts. Furthermore, it will promote the development of the information base of the state environmental monitoring system which should be a basis for policy development, management decisions concerned environmental safety, and public information.

The EPI system should have the following applications

- A tool for estimating the state of the environment and the effectiveness of environmental policy;
- Providing information on environmental problems for managers and policy makers;
- Determination of the main factors impacting the environment;
- Information for planning economic development while minimizing the negative impact on the environment;
- Monitoring the effectiveness of implementation of environmental protection measures;
- Improving the public awareness of environmental problems according to Ukraine's obligations under international conventions and agreements in the field of environment protection.

Proposals

The EPI system is based on the recommendations of the UNECE Working Group on Monitoring and Assessment of Environment set out in the *Guidelines for EECCA* [2] and experience of the application of environmental indicators in Ukraine [3,4]. It should cover the main areas of environmental monitoring and the economic zones of industries that have a direct impact on the environment; and it should allow progressive improvements in the components of the system based on the practical experience of its application [5]. Table 1 lists 39 proposed EPIs under nine headings (directions).

The *Agriculture* dimension includes the following EPIs

- *Adding mineral and organic fertilizers* The amount of mineral and organic fertilizers applied per unit of arable land.
- *Pesticide* The amount of pesticide applied per unit of land area, which increases the risk of harmful effects.

Land and soil includes the following EPIs

- ***Withdrawal of land from production***: Index of land withdrawal for transport infrastructure, landfill, waste dumps, tailings, and waste rock dumps. Includes direct urban and industrial development.
- ***Areas affected by soil erosion:*** Total land area and the share of agricultural land affected by wind and water erosion.
- ***Structure of agricultural land***: Area of agricultural land, as well as the distribution of agricultural land under arable, hayfields, pasture, perennial crops, and fallow.
- ***Irrigated and drained lands:*** Total area of reclaimed land, including irrigated and drained lands.

Direction (i)	EPIs (j)
1	2
Air pollution	Emissions of pollutants into the air
	Air quality in urban areas
	Radioactive contamination of the atmosphere
	Use of ozone-depleting substances
Climate change	Air temperature
	Precipitation
	Greenhouse gas emissions
Water resources	Renewable freshwater resources
	Freshwater intake
	Household water consumption *per caput*
	Loss of water
	Reuse and recycling of freshwater
	Quality of drinking water
	Biochemical oxygen consumption and concentration of ammonia in river water
	Biogenic substances in freshwater
	Biogenic substances in coastal waters
	Contaminated wastewater
Biodiversity and forests	Natural areas under special protection
	Forests and woodland
	Protected species
	Trends in the number and distribution of selected species
Land and soil	Withdrawal of land from production
	Areas affected by soil erosion
	Structure of agricultural land
	Irrigated and drained land
Energy	Total energy consumption
	Gross domestic use of energy
	Energy capacity
	Energy consumption from renewable sources
1	2
Agriculture	Use of mineral and organic fertilizers
	Use of pesticides
Transport	Passenger traffic
	Freight traffic
	Motor vehicles by type of fuel
	Average age of the motor vehicles
Waste management	Waste
	Processing and recycling of waste
	Final waste disposal
	Transboundary movements of hazardous wastes

Table 1: Indicators of the state of the environment in Ukraine.

A methodology has been developed for integrated assessment of the environment in particular regions, which should facilitate the identification of key areas for action to improve the regional environment. This boils down to selecting the most informative environmental performance (EP) factors forming a part of each EPI, valuation of indicators, and their linear conversion with weighting factors. In general, the EPI for individual administrative units is formed by linear combination of the individual, weighted EPs in two steps:

First, standardized assessment of each EPI (A_i^j) should be carried out on the status of environment directions. To obtain the normalized evaluation of each EPI (A_i^j), we need to:

(1) Normalize all the EPs that are part of the EPI. Before continuing with the conversion of EPs into a single EPI, each EP should be normalized so that each will be measured on an N-point (dimensionless) scale. For this purpose, each EPI is calculated by the formula:

$$\left|\xi \tilde{A}_i^j\right| = \frac{\left|\xi A_i^j\right|_{\text{звіт.рік}}}{\left|\xi A_i^j\right|_{max}},$$

Where

i	means the number of directions, according to Table 1;
j	the number of EPIs the direction, according to Table 1;
$\left\|\xi A_i^j\right\|$	EP, which is required to determine the ***j***-of the EPI for the ***i***- the direction;
$\left\|\xi A_i^j\right\|_{\text{звіт.рік}}$	the value of ξ- EP for the year to determine the ***j***- of the EPI for the ***i***- the direction;
$\left\|\xi A_i^j\right\|_{max}$	the maximum value of ξ- EP, which is selected from the list of years for which the calculated ***j***- the EPI for ***i***- the direction;
10	the maximum value of N-point (dimensionless) scale.

Table a

Determination of the weighting coefficients ($w\ \xi b_i^j$) for the EP is carried out by an expert. Values of weighting coefficients for EPI are between 0 and 10 ($0 < \xi b_i^j < 10$).

In evaluating the EPI as a whole, all the EPs (ξA_i^j) that are needed for a specific EPI (A_i^j) are calculated by the formula:

$$\left|A_i^j\right| = \frac{\sum_\xi b_\xi \left|\xi \tilde{A}_i^j\right|}{\xi},$$

where

$\lvert A_i^j \rvert$	the EPI for ***i***- the direction;
$\sum_\xi b_\xi \lvert \xi \tilde{A}_i^j \rvert$	the sum of all ? - EPs that are needed to determine the ***j***- of the EPI for the ***i***- the direction;
ξ	the number of ? - EPs that are part of the ***j***- to the EPI.

Table b

The resulting EPI value is within the range 0-10. The greater the value of the EPI, the more critical the situation in the corresponding dimension.

In the second phase, a cumulative assessment of the environment along the dimensions (A_i) in the region is carried out. To carry out an integrated assessment of the environment in the region by dimensions, we need to do the linear conversion used in the first phase of the EPI dimension detection by the formula:

$$\lvert \widetilde{A}_\iota \rvert = \frac{\sum_j \xi \tilde{A}_i^j}{j},$$

Where

$\lvert \widetilde{A}_\iota \rvert$	an integrated assessment of the environment for ***i***- the dimension;
$\sum_j \xi \tilde{A}_i^j$	the sum of all ***j*** - EPI for ***i***- the dimension;
j	the number of ***j*** - EPs, which are part of ***i***- the dimension.

Table c

Thus, the integrated assessment of environment will be defined in the range from 0 to 10.

To plan for evaluation and action to protect the environment, dimension by dimension, we recommend a 10-point scale assessment for each dimension, as well grouping the calculated EPI values into classes (Table 2) which will represent the status of each of the dimensions based on the level of deviation from a standard value.

Class	Class status	Ecological status
F_1	$0 < F_1 = 2$	Norma
F_2	$2 < F_2 < 4$	Minor deviation from the normal state
F_3	$4 < F_3 < 6$	Significant violation of state
F_4	$6 < F_4 < 8$	Dangerous violation of state
F_5	$8 < F_5 = 10$	Critical condition

Table 2: Calibration according to the rating assessment for each dimension.

For example, a class F_5 deviation might be found in territory virtually unaffected by human activities, e.g. a nature reserve. Class F_5 deviation is the characteristic of areas with extreme man-made pressure on the system in the dimension of the EPI. Thus, the 10-point scale gives the opportunity to compare different regions (administrative areas) with one another.

Conclusions

Objective information is needed for the development and implementation of environmental protection measures, as well as for the effective management of natural resources. In Ukraine, information on environmental condition, the influence of various factors on it, and the use of natural resources are all based on environmental monitoring.

Currently, environment assessment in Ukraine is by no means comprehensive. The EPI system will enable a comprehensive evaluation of the environment and the effects of using natural resources at the national level and within particular administrative districts.

The practical value of the EPI system is to improve efficiency and environmental performance at different levels (national, regional, departmental, etc.), as well to raise public awareness about the environmental situation.

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