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The IIASA-LUC Project Georeferenced Database of the former USSR. Volume 3: Soil Degradation Status in Russia

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Contents

Abstract

The IIASA/LUC georeferenced database for the former USSR (in part only for Russia), was created within the framework of the project "Modeling of Land Use and Land Cover Changes in Europe and Northern Asia" (LUC). For Russia, essential information on relief, soil, vegetation, land cover and use, etc. for routine environmental analysis was lacking when the LUC project first started developing the database. In addition, the environmental data on the former USSR which was available occurred in formats (papers, tables, etc.) that in general could not be used with modern information technology, and in particular in model building. In creating the LUC project database, we have established a threefold task:

1) to obtain the relevant information for the LUC project modeling exercises;
2) to develop data which is applicable to modern information technology;
3) to contribute a series of digital databases which could be applied for a number of other specific analysis by the national and international scientific community. In defining the tasks it was agreed to create a set of digital databases which could be handled by a geographic information systems (GIS). This required that the data had to be georeferenced. The complete set of georeferenced digital databases was combined into the LUC project's GIS, using ARC/INFO. However, each individual item (physiography, soil, vegetation, etc.) was created as an unique specific digital database, allowing to be used separately, depending on user's needs.

The complete series of the unique georeferenced digital databases is described in several IIASA/LUC volumes:

Volume 1. Physiography (land forms, slope conditions, elevations).

Volume 2. Soil.

Volume 3. Soil degradation status (Russia).

Volume 4. Vegetation.

Volume 5. Land categories.

Volume 6. Agricultural regionalization.

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We appreciate the tremendous efforts of all the scientists and technical assistants from various organizations in Russia who prepared the inventory of soil degradation data for Russia.

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Introduction

Soil degradation is, in many cases, a manifestation of human intervention in the utilization of environmental resources and the result of human manipulation of land. In spite of the fact that exploitation of nature by people has deep historical roots, only during the last decades the condition and management of the land resources has increasingly become a matter of concern. Expanding populations and economic development have resulted in a growing demand for various land-based products leading to increasing pressure on soils, water resources and biodiversity. In several locations, both in developing and developed countries, this pressure has exceeded critical thresholds, and people face the problems of deteriorating land resources, declining productivity and consequently reduced income and amenities. Maintenance of the productive potential of land resources, and checking of land degradation, is a fundamental element of sustainable land use (Pieri et al., 1995).

The first attempt to combine soil degradation data collected by different ministries and institutes of Russia was undertaken by Dokuchaev Soil Institute in 1990 in the frame of the project on Global Assessment of Soil Degradation (GLASOD) (Oldeman, et al, 1991). Since then numerous publications concerning negative human impacts on soils have appeared in scientific and public journals describing types of degradation, their nature, severity, rate of change, extent, consequences, etc. The basic data was collected and published in Government (National) reports on the *Status and Use of Land in the Russian Federation* (1993, 1994 and 1995).

The GLASOD assessment for the Russian territory was based on data of varying quality, ranging from well documented sources (e.g., soil erosion) to assessments purely based on expert opinion (e.g., acidification). Also, the GLASOD project was limited to degradation of agricultural lands only. Thus, several other widespread forms of soil deterioration taking place in Russian forests and permafrost areas were not considered. Another disadvantage resulted from the fact that GLASOD aimed to compile a degradation map "manually". This caused a lot of cartographic restrictions, generalization and loss of collected information presented in tabular and paper formats. There was an enormous disproportion between the amount of soil degradation data, their acceptability and practical application and utilization.

The project *Modeling Land-Use and Land-Cover Changes in Europe and Northern Asia (LUC)*, established by IIASA in 1995, recognizes the importance of soil degradation as one of the driving factors in land resources alteration. The present georeferenced database on soil degradation for Russia is the result of collaborative efforts by the LUC project, the Dokuchaev Soil Institute, and the State Committee of Russian Federation on Land Resources and Land-Use Planning.

Spatial database component

A georeferenced digital database (Stolbovoi and Fischer, 1998) is composed of two basic elements: a) spatial information, and b) the attribute data. The spatial information consists of polygons taken from a newly compiled updated FAO soil map of Russia (Stolbovoi and Sheremet, 1995). Updating was contracted by FAO and done on the basis of FAO's Revised Legend of the *Soil Map of the World* (FAO, Unesco, 1988) and the latest *Soil Map of the Russian Federation* at scale 2.5 M (GUGK, 1988). This map was generalized to the scale of 1:5 M. In total, 1295 mapping units were created. The polygons were redrawn on stable material and digitized by scanning at FAO. Then essential checking, correction and linking of attributes was done at IIASA by the LUC project GIS group, using ARC/INFO. A detailed description is given in Volume 2 *Soils of Russia. Correlation with the Revised Legend of the FAO Soil Map of the World.* (Stolbovoi, 1998), and is omitted here.

Attribute database component

The attribute database describes various degradation characteristics. The attributes were defined following the *Guidelines for the assessment of the status of human-induced soil degradation in South and Southeast Asia (ASSOD)* (van Lynden, 1995).

Figure 1 illustrates the general design of the attribute database. As shown, the database comprises of information on soil degradation types, extent of degradation within soil polygon[1], effect on soil productivity, rate of degradation development, causative factors, and protection measures. Degradation types include water and wind erosion, secondary salinization, desertification, underfloods and compaction. For forest areas, two specific types of soil degradation were distinguished: disturbances of organic horizons caused by industrial wood harvest, and disturbances of organic horizons due to fires. To account for the specific forms of soil degradation in permafrost areas, the distribution of thermokarst and surface corrosion was inventorized. These two types of soil degradation are mainly caused by overgrazing of deer pastures and by industrial activities such as oil drilling, construction, vehicle moving, etc.

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[1] Several types of soil degradation might co-exist in parts of a polygon. An example: a polygon includes 4% of eroded and deflated lands, i.e., 66% of arable lands, 30% adjudged to be stable under natural conditions, and 30% of desertified lands, in total 130%. In this case the coincidence of desertification and arable lands is estimated as 30%.

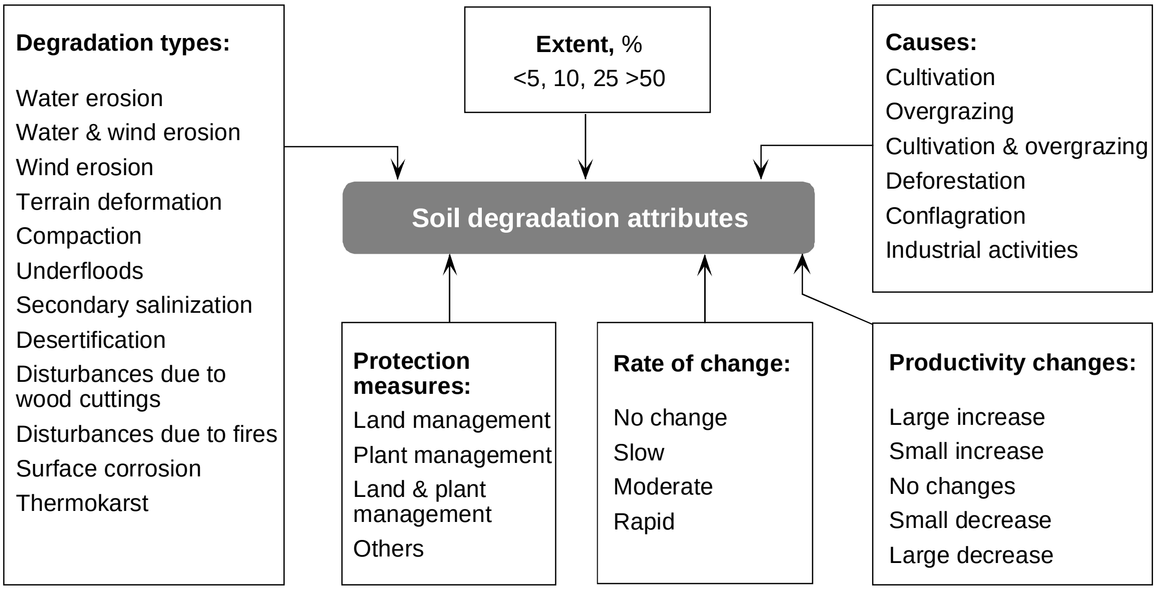

Figure 1. Composition of soil degradation attributes.

Data sources

Soil degradation attributes were created by compiling and coding of information from several unpublished paper map legends into digital format. Preparation of these maps had been contracted by the State Committee of Russian Federation on Land Resources and Land-Use Planning, and compiled by different authoritative organizations for the Government (national) reports on the *Status and Use of Land in the Russian Federation* (1993, 1994 and 1995). On the basis of a joint agreement between IIASA, Dokuchaev Soil Institute and the Committee, the maps were delivered to Dokuchaev Soil Institute for creating a digital database. These materials were transformed into an attribute database on soil degradation and was linked to the digital soil map of Russia. The following source materials were used:

- *Map of Recent Land Status of Forest Fund of Russia*, at the scale of 1:4 M, compiled by All Russian Research Institute of Forest Resources, 1993;
- *Map of Soil Water and Wind Erosion in Russia*, at the scale of 1:4M, compiled by Dokuchaev Soil Institute, 1992;
- *Map of Natural Grassland Degradation in Russia*, at the scale of 1:4 M, compiled by All Russian Research Institute of Fodder, 1992;
- *Map of Soil Salinization in Russia*, at the scale 1:4 M, compiled by Dokuchaev Soil Institute, 1992.

The estimation and georeferencing of degradation attributes was accomplished by overlaying the polygons from the soil map with each of the maps listed above.

Definition of attributes and terms

Compaction (Pc) - an increase of soil bulk density by more than 1.2 times as compared with levels of natural soil (Snaking, et al., 1992).

Degradation - a process that describes human-induced phenomena which lower the current and/or future capacity of the soil to support human life (van Lynden, 1995, and Oldeman, et al., 1991).

Desertification (Pa) - expanding areas of deserts as a result of natural (cyclic changes in climate) and anthropogenic causes (wood cutting, removal of herbaceous vegetation due to overgrazing) (Explanatory dictionary on environment conservation, 1995).

Deflation (Et) - loss of topsoil, disturbance of rocks and soils by wind, accompanied by removal and grinding of soil particles.

Permafrost - characterization of the upper layer of the earth crust, in frigid regions with permanent below-zero temperatures for a long period of time (from 2 to several thousand years) and presence of ice inclusions in underlying rocks.

Salt-affected soils - soils of various types combining: (i) soluble salt within the upper 2 m of the soil profile toxic for salt-tolerant plants, i.e., with

Cl > 0.3 meq/100, SO4 (Na+Mg) > 1.7 meq/100, HCO3 > 1 meq/100;

or (ii) the sum of soluble salts is higher than 0.2% in the case of sulfate salinity without gypsum. The threshold of plant salt tolerance refers to the lowest level of salt content which causes a decrease of crop yield due to soil salinization (Bazilevich, et al., 1971, and Ecological requirements, 1995).

Secondary salinization (Csi) – human-induced salt accumulation in the upper part of the soil profile, resulting from evaporation of irrigation groundwaters in capillary fringe due to rise of the groundwater table.

Soil bulk density - the ratio between the weight of soil dry matter of undisturbed soil consistence and the soil volume, in g/cm^3.

Surface corrosion (Sp) – displacement of soil material of permafrost soils (solifluction, mudboiling, hummocks, etc.).

Water erosion (Wt) - loss of productive topsoil and loose parent material due to the detachment of soil particles and their removal by water run-off and sedimentation in other locations.

Terrain deformation (Ed) – irregular displacement of soil material by wind action, causing deflation hollows, hummocks and dunes.

Thermokarst (T) – the formation of subsident relief forms and underground cavities resulting from defrostation of ice or frost deposits.

Underflood (Pw) – increase of the soil hydromorphizm due to the rise of groundwater table caused by human activities (Explanatory dictionary on environment conservation, 1995).

Causative factor – the kind of human action that can be considered responsible for the occurrence of the degradation type involved (van Lynden, 1995). Includes:

a – improper management, inefficient farming (insufficient or excessive use of fertilizers, shortening or absence of the fallow period, poor quality of irrigation waters, etc.);

f – deforestation, removal of woody vegetation from large stretches of land with the view of advancing agricultural production, road construction, urban development, etc., or clear-cut wood harvest;

e – over-exploitation of vegetation cover for the purposes of agriculture (plant cutting for fuel, fodder, etc.);

o – overgrazing;

i – industrial activities;

c – conflagration, fires resulting from human activities.

Impact on productivity – refers to productivity change as compared with the average productivity of the non-degraded (non-improved) soil, (van Lynden, 1995).

The following classes of productivity change have been distinguished:

A1 large productivity increase;

A2 small productivity increase;

A3 no productivity increase;

A4 small productivity decrease;

A5 large productivity decrease;

A6 unproductive.

Rate of soil degradation - degradation trend during the last 5-10 years (van Lynden, 1995). Three classes each have been distinguished for increasing and decreasing soil degradation, respectively:

3 rapidly increasing degradation,

2 moderately increasing degradation

1 slowly increasing degradation,

0 no change in degradation

-1 slowly decreasing degradation

-2 moderately decreasing degradation

-3 rapidly decreasing degradation.

Protection measures – activities and management practices which are applied to soils affected by degradation (van Lynden, 1995). The extent to which conservation/ protection measures are applied is given as a percentage of the soil polygon.

Four categories are distinguished:

V plant management (vegetative) practices: soil management, including agro-forestry, crop rotations, etc.;

L land management practices: contour tillage, minimum tillage, contour-strip-cropping;

S structural practices: construction of physical barriers to reduce or prevent excessive run-off and soil loss (terraces and banks, gully-filling, constructed flumes);

O Other practices oriented towards soil protection or rehabilitation, focusing not only at erosion but also at soil pollution and salinization.

Stable under natural conditions (Sn) – absence of human influence on soil stability, and largely undisturbed vegetation (van Lynden, 1995).

Stable without vegetation (Sw) – absence of vegetation cover and human influence on soil stability, e.g. deserts, high mountain zones (van Lynden, 1995).

Stable under human influence (Sh) – stable soil conditions under the presence of human influence; this influence may be passive, i.e., no special measures had or have to be taken to maintain stability, or active; i.e., measures have been taken to prevent or reverse degradation (van Lynden, 1995).

Database structure

All information is contained in datafile DEGRAD. Look-up tables exist for some parameters. The name of a look-up table is the same as that of the item name of the respective attribute in datafile DEGRAD.

Datafile DEGRAD includes records for all attributes, which were distinguished for each polygon. The possible attributes are presented in the following table:

	Parameter name	Item	Look-up table
0	Polygon unique number	POLY_ID	
1	Types of soil degradation	TYPE	TYPE.LUT
2	Extent of this soil degradation type in polygon		EXTENT
3	Causative factors	CAUSE	CAUSE.LUT
4	Degradation impact	IMPACT	IMPACT.LUT
5	Rate of degradation	RATE	RATE.LUT
6	Degradation Remarks	DEGR_REM	
7	Rehabilitation/ Conservation measures type	CTYPE	CTYPE.LUT
8	Rehabilitation/Conservation measures extent	CEXTENT	
9	Conservation remarks	CONS_REM	

If no record is present for a polygon, this means that none of the degradation types were identified in the polygon.

Some remarks on values

If the following values are empty causative factors (CAUSE), degradation impact (IMPACT), rehabilitation/conservation measures type (CTYPE) and some values are equal to the rate of degradation (RATE=0), rehabilitation/conservation measures extent (CEXTENT=0), it means that there are no information. Rehabilitation/Conservation measures extent:

Causative factors (CAUSE):

Field CAUSE can include several codes - comma separated values (for instance, CAUSE='o,a,i')

Degradation impacts (IMPACT):

Field IMPACT can include several codes - comma separated values (for instance, IMPACT='A3,A4')

Conservation measures (CTYPE):

Field CTYPE can include several codes - comma separated values (for instance, CTYPE='L,V')

Rate of degradation (RATE):

The case where RATE=0 means that there are no changes in degradation or there are no information about rate of degradation. If the following values are empty: causative factors (CAUSE), degradation impact (IMPACT), rehabilitation/conservation measures type (CTYPE) and rehabilitation/conservation measures extent are equal to (CEXTENT=0), it means that there is no information.

Files structure

File: DEGRAD.DBF

Number of data records: 2815

Field	Field Name	Type	Width	Description	Look-up table
1	DEGR_ID	Numeric	4	Polygon degradation number	
2	TYPE	Character	5	Degradation type	TYPE.LUT, item - TYPE
3	EXTENT	Numeric	3	Extent of this soil degradation type in a polygon	

4	CAUSE	Character	6	Causative factors	CAUSE.LUT, item - CAUSE
5	IMPACT	Character	5	Degradation impact	IMPACT.LUT, item - IMPACT
6	RATE	IMPACT	2	Rate of degradation	RATE.LUT, item - RATE
7	DEGR_REM	Character	5	Degradation remarks	
8	CTYPE	Character	6	Rehabilitation/ conservation	CTYPE.LUT, item - CTYPE
9	CEXTENT	Numeric	3	Rehabilitation/ conservation measures extent	
10	CONS.REM	Character	50	Conservation remarks	

File: TYPE.DBF - codes and descriptions of soil degradation types.

Types of soil degradation are represented by a two-letter code. The first capital character identificates the major degradation type, the second case character indicates the subtype. Sometimes type code includes the third lower case character.

Number of data records: 23

Field Name	Type	Width	Description
TYPE	Character	5	Degradation type. The same as in the table DEGRAD item TYPE.
DESC_TYPE	Character	70	Description

File: CAUSE.DBF - codes and descriptions of causative factors.

Field Name	Type	Width	Description
CAUSE	Character	1	Codes and descriptions of causative factors. The same as DEGRAD item CAUSE.
DESC_CAUSE	Character	50	Description

File: IMPACT.DBF - codes and descriptions of degradation impacts.

The degradation impact is represented in the database by a capital character and a single digit code. Letter means level of input/management improvements, digit means level of production increase/decrease.

Number of data records: 18

Field Name	Type	Width	Description
IMPACT	Character	2	Codes of degradation impacts. The same as DEGRAD item IMPACT
DSC_IMPACT	Character	60	Description of degradation impact
IMPROV	Character	1	Capital letter indicates level of input/management improvements
IMPR_LEVEL	Character	30	Value of level of input/management improvements
PRODUCT_LEVEL	Numeric	1	Indicates the level of production increase/decrease
RATE	Numeric	2	Code of degradation rate. The same as in DEGRAD item RATE.
DESC_RATE	Character	35	Description
CTYPE	Character	6	Code of rehabilitation/conservation measures. The same as in DEGRAD item CTYPE.
DESC-CTYPE	Character	40	Description

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