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PRANA — GEOINFORMATION DECISION SUPPORT SYSTEM FOR REHABILITATION OF RADIOACTIVELY CONTAMINATED TERRITORIES

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Abstract

The Applied Geographic Information System (GIS) PRANA (1998), is a Decision Support System (DSS) for countermeasure analysis in agriculture in the long-term period of mitigation the consequences of a nuclear accident. This system has been introduced at the Chernobyl Department (Ministry of Agriculture) and at the Bryansk Centre of Agrochemical Radiology for practical needs as GIS-system for monitoring network support and analysis of countermeasure scenarios. Developed electronic maps, databases of attributive information, the main tasks of PRANA *implementation for assessing contamination of agricultural production, doses to the local population, results and effectiveness of countermeasure implementation along with examples of model assessments are pointed out. The tasks on local and regional analysis of various aspects under consideration within the PRANA and methods of their realisation are considerable different from other works/systems in this field of R&D.This work has been carried out by a group of Russian scientists and EU/Norway collaborators within the ISTC project #1224.*

1. INTRODUCTION

Geoinformation (GIS) decision support system (DSS) *PRANA* (**P**rotection and **R**ehabilitation of environment after **N**uclear **A**ccident) is a computer system for countermeasure (CMs) analysis in the long-term period after a nuclear accident. *PRANA DSS* comprises all the main aspects of estimating consequences (from contamination of agricultural production up to dose and risk assessing) and evaluating CMs effectiveness on the basis of radiological and economic parameters with the use of cost-benefit analysis. Different versions of *PRANA* are used for practical needs (GIS-DSS for rehabilitation of contaminated territory of Bryansk region), for research, as well as for training and education.

2. SYSTEM DESCRIPTION

PRANA *GIS-DSS* is an applied site-specific *DSS* for countermeasure analysis and decision-making support on rehabilitation of radioactive contaminated territories in the *long-term period* of liquidating the consequences of a nuclear accident [1]. The *PRANA DSS* is considerable different from all the DSSs intended for analysis of the consequences of an

accident due to, first of all, implementation of *local level* when assessing consequences and making decision on rehabilitation of contaminated territories.

The *PRANA DSS* is intended for solving the following main tasks:

— estimation of agricultural produce contamination;

— assessment of the structure of internal and external doses to the local population;

— radiological risk analysis;

— estimation of the results of countermeasure implementation;

— evaluation of countermeasure effectiveness with the use of radiological and economic methods;

— comparison of different protective strategies;

— decision-making support on management of contaminated territories.

The *PRANA DSS* consists of the system core and the set of applications (modules). The core is responsible for loading initial data, electronic maps, mathematical models and libraries of presentation and data access. Applications are intended for solving specific tasks, including analysis and presentation of source data, estimation of the consequences of land contamination, assessments of the results of CMs implementation and comparison of different intervention strategies.

The features of the *PRANA DSS* are the following characteristics:

— use of GIS-technologies; vector *map of landuse* and associated databases are key components of the system (see Fig.1);

— different levels of investigation and information detailing when estimating the consequences of land contamination, implementation of protective measures and evaluation of their effectiveness (district-farm-/settlements-arable lands-natural lands); at that the special attention is paid to the *local level analysis* of monitoring data and model estimates (for each field, settlement);

— particular attention is given to countermeasure analysis;

— evaluations of countermeasure effectiveness are based on the use of economic and radiological methods, including CBA-analysis.

3. DATABASES

Database is one of the components of the *PRANA DSS*. Input information is divided into several types.

Geographical data (GIS layers) include vector electronic maps of surface contamination density of territory by radionuclides (^{137}C), maps of landuse (settlements, arable lands, pastures, hayfields, forests, water systems, etc.), soil types, boundaries of the administrative division (farms, districts, regions).

"Tabular" information includes data on radiological parameters as well as agroecological, economic, demographic and other ones, including various transfer factors (for plant-growing and animal husbandry production) and countermeasure characteristics.

Databases associated with vector electronic maps (attributive information) comprise all the main information for each polygon and administrative/economic division, including:

— monitoring data (radiological, agrochemical, etc.) for each element of land use (fields, forests, etc.):

— the basic radiological, and demographic data for each settlement;

— agroeconomic and other data for each administrative district and for all farms of the given district;

— (available) data on countermeasures implemented earlier (for agricultural areas, settlements).

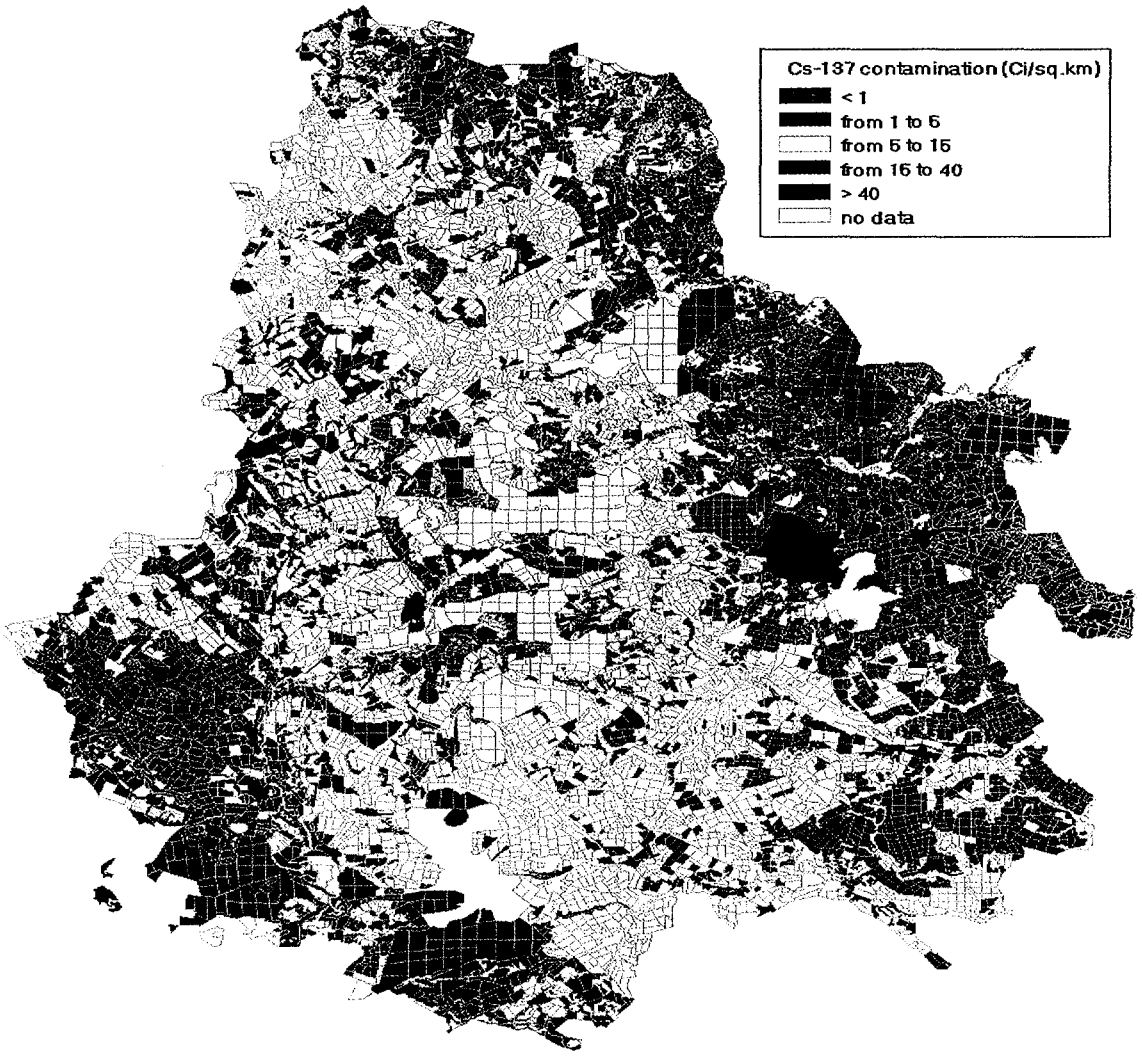


FIG.1. Map of surface density contamination (^{137}Cs, 1993) on the polygons of landuse map for Novozybkov, Klintsy and Gordeevsky districts, Bryansk region.

4. COUNTERMEASURES

A wide range of countermeasures which can be divided conditionally into agricultural, administrative and indirect ones has been implemented in the (specific application of) *PRANA DSSs*. Agricultural CMs include various measures for natural and arable lands, CMs in animal husbandry and management in agrosphere [2]. Administrative CMs comprise restriction/ban of local foodstuffs and restrictions of population activities (among them there is a possibility of intervention levels alteration that can change significantly the structure and scale of intervention measures and lead to the change of the structure of population doses).For estimations of agricultural production contamination the models of contamination of plant-growing and animal husbandry products are used. The feature of the dose models [3,4] is a significant use of cartographic data for connecting (rural) settlements with object of landuse (pastures and hayfields, arable lands, forests) and subsequent calculation of contamination of local diets, internal and external doses. Doses for the chosen year and dynamics of doses for each settlement are estimated. Using the dynamics of mean individual effective dose the risk analysis (radiogenic cancers) can be carried out [5].

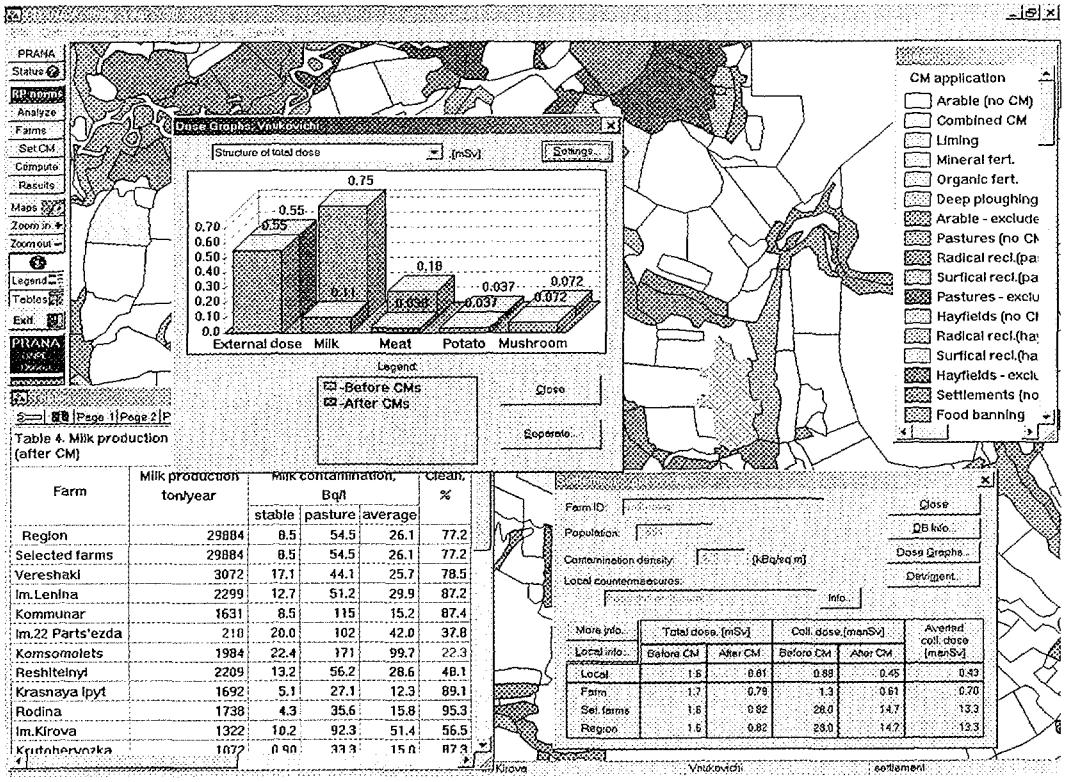
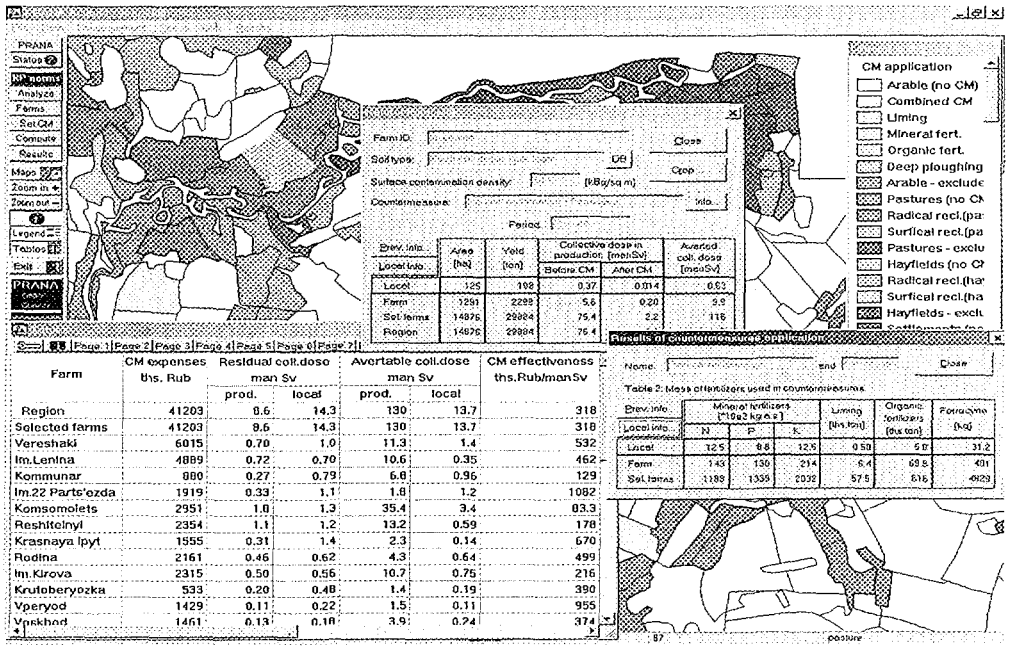


FIG. 2. Model estimates (example): the structure of dose to the local population before and after countermeasure implementation.

Evaluations of countermeasure effectiveness are based on the use of algorithms of estimating avertable collective and/or individual doses, algorithms of assessing countermeasure cost with implementation of cost-benefit analysis [2]. For the analysis of CMs or countermeasure combination the results of their application (contamination of production, population dose, the effectiveness of CMs) are presented as maps, tables, diagrams and graphs for the chosen levelThe interface of the *PRANA DSS* allows using possibilities of modules developed for visualisation of source data, carrying out different assessments and their analysis (zoning and ranking of lands, settlements and farms according to a chosen criterion), formation of various scenarios for analysis, the estimation of different CMs and subsequent decision making.

Presentation of output information comprises all the results on estimations of production contamination, structure of population doses (Fig.2) and countermeasure effectiveness as well as integration of estimates from initial areas (field, settlement) up to the farm or group of chosen farms and district/region as a whole (Fig.3). Operation in the regime of "local level" (at the level of separate farm) provides a more flexible use of *PRANA* possibilities on implementation and assessment of countermeasure scenarios and presentation of output information.



Farm	CM expenses ths. Rub	Residual coll.dose man Sv		Avertable coll.dose man Sv		CM effectiveness ths.Rub/man Sv
		prod.	local	prod.	local	
Region	41203	8.6	14.3	130	13.7	318
Selected farms	41203	8.6	14.3	130	13.7	318
Vereshaki	6015	0.70	1.0	11.3	1.4	532
Im.Lenina	4889	0.72	0.70	10.6	0.35	462
Kommunar	880	0.27	0.79	6.8	0.96	129
Im.22 Parts'ezda	1919	0.33	1.1	1.8	1.2	1082
Komsomolets	2951	1.0	1.3	35.4	3.4	83.3
Reshitelnyi	2354	1.1	1.2	13.2	0.59	178
Krasnaya Ipyt	1555	0.31	1.4	2.3	0.14	670
Rodina	2161	0.46	0.62	4.3	0.64	499
Im.Kirova	2315	0.50	0.56	10.7	0.75	216
Krutoberyozka	533	0.20	0.48	1.4	0.19	390
Vperyod	1429	0.11	0.22	1.5	0.11	955
Vpekhod	1461	0.13	0.18	3.9	0.24	374

FIG.3. Model estimates: analysis of countermeasure effectiveness.

5. FURTHER DEVELOPMENTS

The first version of *PRANA* (*PRANA*-1) was developed in 1997-1998. This system is used at the Chernobyl Department (Ministry of Agriculture) and at the Bryansk Centre of Agrochemical Radiology for practical needs. Practical use comprises monitoring network support, preparing different maps (contamination of fields and production, crop rotation, type of soil, etc.), as well as address recommendations on CMs implementation and corresponding estimates of cost, amount of substances (fertilisers), CMs effectiveness, etc.). However, its possibilities are limited by the questions of agriculture [1,2].

Conceptual requirements to GIS-DSSs, which are some considerable extension of the *PRANA*-1, were elaborated in contacts with interested parties in Russia. Realisation of the planned requirements and tasks are achieved through creating several GIS-DSSs (family of *PRANA* systems; each of them is intended for analysis of specific range of problems):

— GIS-DSS for practical use in Bryansk region (for introduction at appropriate local Centres, Authorities and Ministries);

— GIS-DSS for research and for scientific and practical estimations (including estimation of radionuclide fluxes, uncertainty analysis and optimisation of countermeasure structure);

— GIS-DSS for training and education;

— elements of distributed systems and remote access to components of GIS-DSS (for practical use, training and education).

This work is carried out by a group of Russian scientists (RRC KI, OINPE, RRC IB, IRH and BCAHR) within the ISTC project #1224.

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DISCUSSION AFTER THE PRESENTATION OF B.I. YATSALO

Y.V. PUTYATIN (Belarus): With regard to the penultimate table shown by you, were those just calculated values for the effectiveness of countermeasures or did a validation process take place, with agreement between the calculations and practical results?

B.I. YATSALO (Russian Federation): In that case they were calculated values for a given day.

In November, a joint study will be carried out with the Chernobyl Department of the Ministry of Agriculture using real data relating to each contaminated farm in the Bryansk region. We expect the study to be finished late in November or early December.

Y.V. PUTYATIN (Belarus): We have carried out such countermeasure studies, but so far without success, despite the very low cost of fertilizer in Belarus.