USE OF GIS FOR ESTIMATION OF AGRICULTURAL SUITABILITY OF THE LANDS

Integrating Generations
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INTRODUCTION

LAND MANAGEMENT SITUATION IN BELARUS

- Transition to market relations
- More than half of land fund is involved in an agricultural production
- Modern priority is creation of sustainable and effective land use

PROBLEM

Long years the land was considered only as the main means of production:

- increasing of the agricultural areas
- forming of large open land parcels
- using of powerful agricultural machinery

RESULTS

- irrational land use (discrepancy of economic activities to natural, social and ecological conditions of concrete territories)
- simplification of landscape structures
- reduction of soil fertility
- pollution of the lands
- water deterioration
- development of erosive processes

RESEARCH PROBLEM AND OBJECTIVES

Land use optimization of agrarian areas is a very important problem in Belarus and the main research question is how to do it most effectively

The complex estimation and the spatial analysis of all landscape factors influencing agrarian land use is necessary for solving this problem

THE MAIN OBJECTIVE OF RESEARCH

to develop offers on optimization of agrarian land use of study area on the basis of the complex analysis of landscape factors of territory with application of GIS-technologies

RESEARCH TASKS

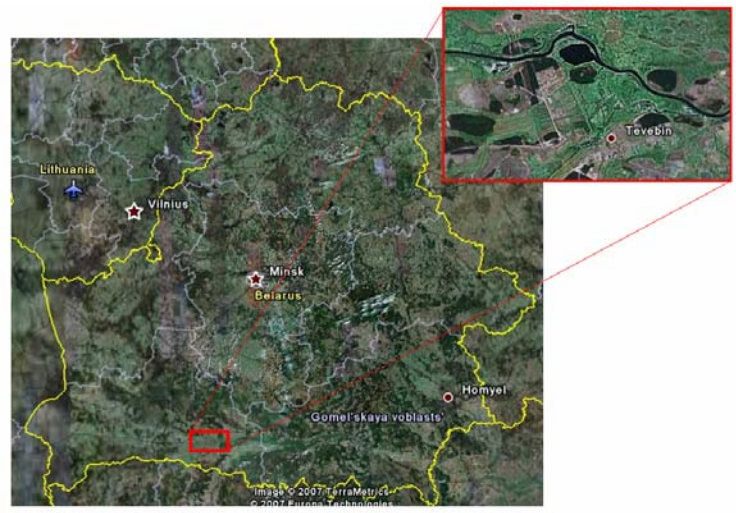
•to analyse the landscape factors influencing agrarian land use of study area

•to define the land suitability for agricultural activity

•to develop offers on optimization of land use

STUDY AREA

Agricultural organization "Lemeshevichi"
(part of geographical region of Belarusian Polesye)



Belarusian Polesye is unique region on the south part of Belarus

- large bogs areas named as "lungs of Europe"
- high level of using of the reclaimed agricultural lands
- fast development of land degradation processes

DATA

- Land information system (LIS) of Pinsky district
- Topographical map, 1:10000
- Aerial images, 1:10000
- Soil map, 1:10000
- Agro-chemical data about soils

SOFTWARE

- ArcGIS v.9.2
- ArcView v.3.2
- HydroTools v.1.0

METHODOLOGY

- Use of GIS
- Multi-criteria evaluation (development of optimal model of land suitability)

BASIC STEPS

- Creation of criteria layers
- Definition of suitability of criteria
- Layers reclassification
- Calculation of criteria weights (Analytical Hierarchy Process)
- Weighted overlay of layers
- Comparison of received model of suitability with actual land use

CRITERIA DEFINITION

Landscape factors influencing agrarian land use:
•climate
•relief
•soils

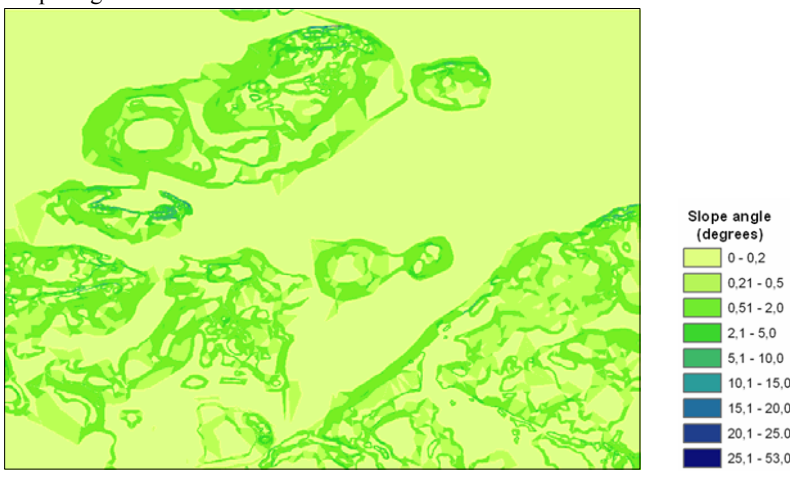
The climate determines temperature conditions and forms water mode of the lands. However on the level of agricultural organization we can only speak about microclimate which is mainly determined by relief of territory.

The relief is responsible for redistribution of heat and a moisture. At its analysis for the purposes of optimization of agrarian land use it is necessary to take into account slope angle, slope exposition, features of water accumulation and other characteristics.

The most important factor influencing agrarian land use is the soil cover. At the analysis of soils it is necessary to take into account soil type, agro-chemical quality, structure and other qualitative characteristics.

CREATION OF CRITERIA LAYERS

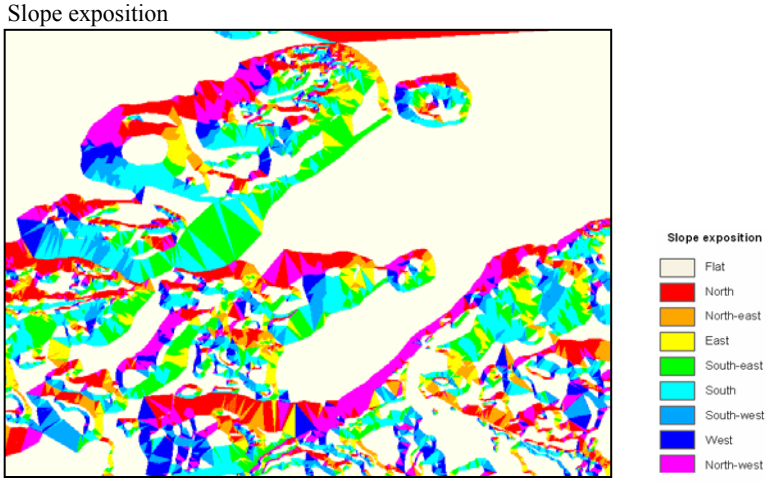
Slope angle



Slope angle influence degree of erosion processes.
In Belarusian conditions the erosion start to develop at value of slope angle more than 2^{o}.
This value is an original threshold of relief intensity.

CREATION OF CRITERIA LAYERS

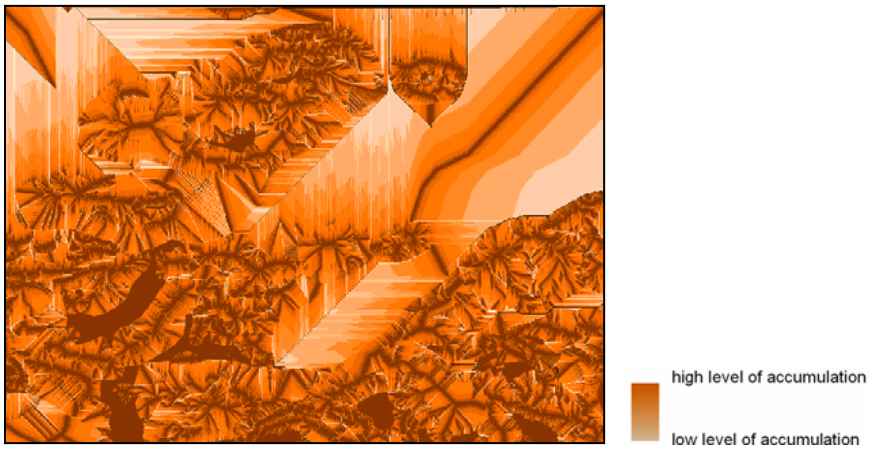
Slope exposition



Depending on exposition the slopes receive various dozes of a solar energy that influences soil moisture and air temperature

CREATION OF CRITERIA LAYERS

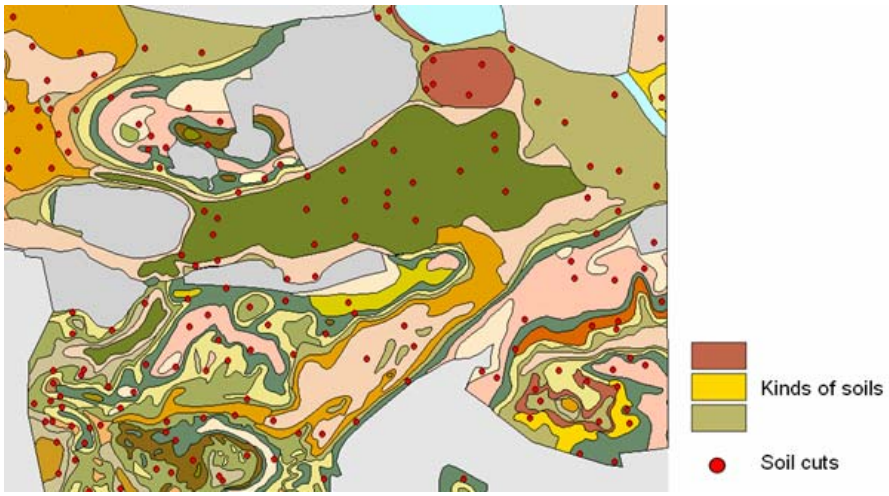
Water accumulation



This layer shows features of water accumulation of study area. The closed sites of dark color represent downturns of a relief in which water stands that results in oppression and destruction of agricultural crops on these sites.

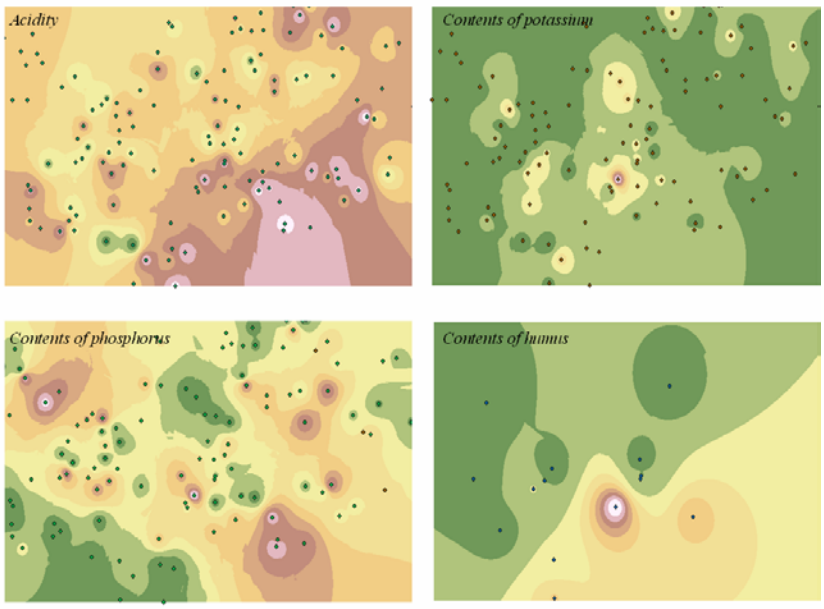
CREATION OF CRITERIA LAYERS

Soil types



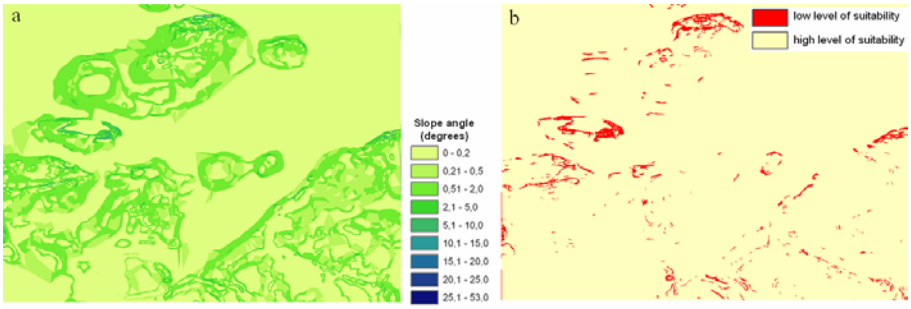
CREATION OF CRITERIA LAYERS

Agro-chemical characteristics of soils



LAYERS RECLASSIFICATION

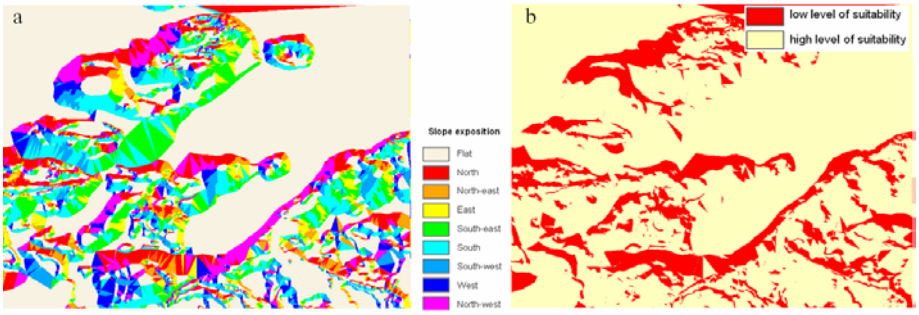
Slope angle



Areas with slope angle value less than 2° were classified as more suitable for agricultural use, and areas with value more than 2° were classified as less suitable

LAYERS RECLASSIFICATION

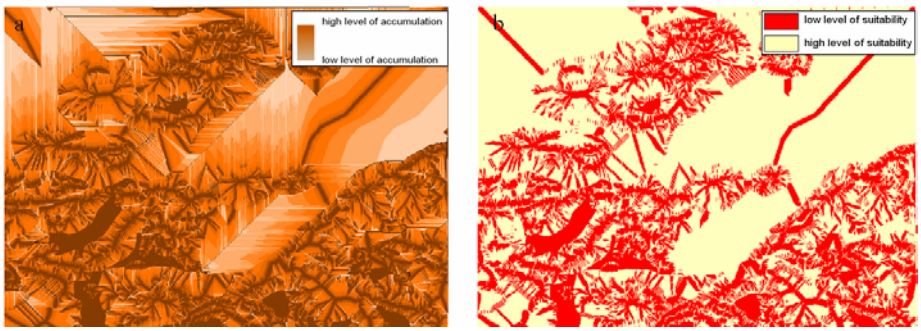
Slope exposition



Flat territories, and areas with slopes of southern, south-west, south-east and western expositions were classified as more suitable for agricultural activity, and areas with slopes of northern, north-east, north-west and east expositions were classified as less suitable.

LAYERS RECLASSIFICATION

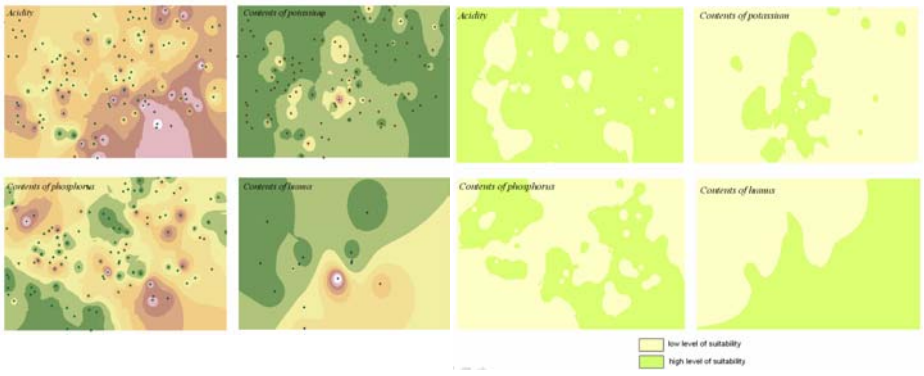
Water accumulation



The sites with an average level of flow accumulation, which provide optimum water supply for agricultural plants, were classified as more suitable for agricultural activity and sites with the maximal and minimal flow accumulation (surplus or lack of a moisture for plants), and also downturns were classified as less suitable.

LAYERS RECLASSIFICATION

Agro-chemical characteristics of soils



Classification of soil characteristics on agricultural suitability was carried out with use of optimal (for Belarus) quantitative parameters of each characteristic (Smejan 1989): acidity of soil (Ph in KCl) 5,6 - 6,5; the contents of humus 2,0 - 3,2 %; contents of phosphorus 5 - 32 mg / 100 g; contents of potassium 15 - 32 mg / 100 g.

CALCULATION OF CRITERIA WEIGHTS
(Analytical Hierarchy Process)

AHP steps:

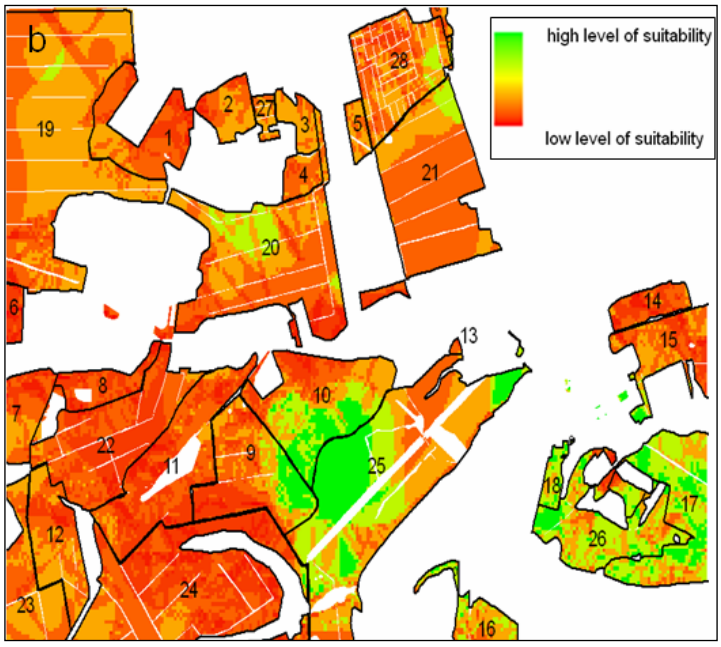
I) calculate the sum of the values in each column of the pair wise comparison matrix

II) divide each element in the matrix by its column sum

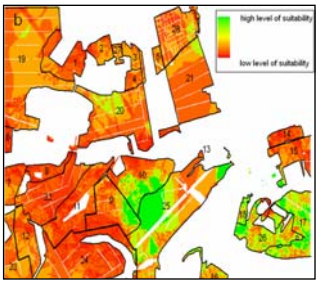
III) compute the average of the elements in each row of the normalized matrix

Step I								
Factors	SA	SE	FA	KS	Hum	Pot	Ph	Acid
Slope angle (SA)	1	2	2	0,25	0,25	2	2	2
Slope exposition (SE)	0,5	1	2	0,25	0,25	2	2	2
Flow accumulation (FA)	0,5	0,5	1	0,25	0,25	2	2	2
Kinds of soils (KS)	4	4	4	1	2	2	2	2
Contents of humus (Hum)	4	4	4	0,5	1	2	2	2
Contents of potassium (Pot)	0,5	0,5	0,5	0,5	0,5	1	0,5	0,5
Contents of phosphoru (Ph)	0,5	0,5	0,5	0,5	0,5	2	1	0,5
Soil acidity (Acid)	0,5	0,5	0,5	0,5	0,5	2	2	1
Sum	**11,5**	**13**	**14,5**	**3,75**	**5,25**	**15**	**13,5**	**12**
Step II								
Factors	SA	SE	FA	KS	Hum	Pot	Ph	Acid
Slope angle (SA)	0,087	0,154	0,138	0,067	0,048	0,133	0,148	0,167
Slope exposition (SE)	0,043	0,077	0,138	0,067	0,048	0,133	0,148	0,167
Flow accumulation (FA)	0,043	0,038	0,069	0,067	0,048	0,133	0,148	0,167
Kinds of soils (KS)	0,348	0,308	0,276	0,267	0,381	0,133	0,148	0,167
Contents of humus (Hum)	0,348	0,308	0,276	0,133	0,190	0,133	0,148	0,167
Contents of potassium (Pot)	0,043	0,038	0,034	0,133	0,095	0,067	0,037	0,042
Contents of phosphorus (Ph)	0,043	0,038	0,034	0,133	0,095	0,133	0,074	0,042
Soil acidity (Acid)	0,043	0,038	0,034	0,133	0,095	0,133	0,148	0,083
Sum	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**
Step III								
Factors	**Weight**							
Slope angle (SA)	(0,087+0,154+0,138+0,067+0,048+0,133+0,148+0,167)/8 = **0,118**							
Slope exposition (SE)	(0,043+0,077+0,138+0,067+0,048+0,133+0,148+0,167)/8 = **0,103**							
Flow accumulation (FA)	(0,043+0,038+0,069+0,067+0,048+0,133+0,148+0,167)/8 = **0,089**							
Kinds of soils (KS)	(0,348+0,308+0,276+0,267+0,381+0,133+0,148+0,167)/8 = **0,253**							
Contents of humus (Hum)	(0,348+0,308+0,276+0,133+0.190+0,133+0,148+0,167)/8 = **0,213**							
Contents of potassium (Pot)	(0,043+0,038+0,034+0,133+0,095+0,067+0,037+0,042)/8 = **0,061**							
Contents of phosphorus (Ph)	(0,043+0,038+0,034+0,133+0,095+0,133+0,074+0,042)/8 = **0,074**							
Soil acidity (Acid)	(0,043+0,038+0,034+0,133+0,095+0,133+0,148+0,083)/8 = **0,089**							
Sum								**1,000**

WEIGHTED OVERLAY



COMPARISON



Number on the map*	Actual use of the lands	Level of suitability	Offers on the organization of the lands
1	Arable	Low	Translation in wood or substantial increase of fertility
2	Arable	Below average	Increase of fertilizers
4	Arable	Low	Translation in wood or increase of fertility
6	Arable	Low	Translation in wood or meadow
7	Arable	Average	Increase of fertility
8	Arable	Low	Translation in wood
9	Arable	Average	East part without changes, western translation in meadow or wood
10	Arable	Above average	Northern part - translation in wood, the rest without changes
11	Arable	Low	Translation in meadow or wood
12	Arable	Average	Increase of fertility
13	Arable	Low	Translation in wood
14	Arable	Low	Translation in wood
19	Meadow	Above average	Part under arable in view of water-security zones of the rivers and channels
20	Meadow	Average	Northern part under arable
21	Meadow	Low	Northern part under long-term plants
25	Meadow	High	Under arable in view of a water-security zone of channels

DISCUSSIONS AND FUTURE RESEARCH

GIS and MCE can help to spatial planners to optimize land use of the agricultural organization.

Problem: the outcome of multi-criteria analysis first of all depends on the weights of evaluation criteria. The calculation of weights is always the subjective process dependent on features of concrete territory (in different places the criteria have various influence), planner experience, presence of the necessary data for the analysis, choice of multi-criteria decision rules and other conditions.

It is possible to solve this problem with the help of access of all interested groups to land use planning. This will lower subjectivity of process and will allow making the most effective decisions.

The objective of future research is conceptual design and further development of the prototype of web-based application for agrarian land use planning support.
This application will allow the users to communicate with each other, perform the analysis with their set of criteria weights and see the result interactively. And this will help groups of users to form their opinions on the process. Interested parties may access the underlying data and conduct their own analyses using their own assessments of the relative importance of the criteria.

THANK YOU!