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The Solutions of the Agricultural Land Use Monitoring Problems

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ABSTRACT

Modern landscape – it's a holistic system of interconnected and interacting components. To questions of primary importance belongs evaluation of stability of modern landscape (including agrarian) and it's optimization. As a main complex characteristic and landscape inhomogeneity in a process of agricultural usage serves materials of quantitative and qualitative analysis of agro ecosystems. For this ones use different methods of remote sondage of soils, analysis of soil for agricultural purpose, GIS-technology and other. Usage of modern technologies for space imagery will allow to actualize information of agricultural lands monitoring and effectively solve arising tasks. Article is devoted to definition of indicators of lands condition of agricultural purpose. Accomplished analiys of methodical approaches to analysis of agricultural lands condition, that allows to determine the most prospective ways of usage, gives propositions about application of modern technologies. It is proposed to create a centralized governmental informational resources about lands of agricultural purpose and about these lands as a part of lands of other categories.

KEYWORDS
Agriculturalland, land-usechange, geographicalinformationsystem, RussianFederation, systematic land monitoring

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Governmental monitoring of agricultural lands implements in order to ungrounded outflow of agricultural lands, preservation of the minagricultural

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manufacturing (Gnedenko & Kazmin, 2015). Legitimate land evaluation allows to ensure with reliable information about state and fertility of agricultural lands and its factual usage (Bert et al., 2015).Received data solves problems of programs of saving and recovery soils fertility (Hartvigsen, 2014).

Since conducting first qualitative analysis of lands in former Soviet union (Armand, 1958), constantly had been improved thechnique of land classification, which also used in other post-communist countries (Cimprič, Lamovšek & Lisec, 2013). In it's basis laid an approach to lands typification, envisaging ten-step analysis of lands (Egorov et al., 1977).

Generalization of nature properties of separate areas and arrays from a position of agroindustrial usage it is expedient to reflect in division of lands on types and classes (Lopyrev, 1995). Representation about lands types, as territories with homogeneous nature conditions of agricultural manufacturing eventually evolved in representation about agroecological lands types, and made this system complete (Larionov, 1993).

In a system of landscape-agricultural typification of the RF, developed criterias and parameters of areas allocation (Lipski, 2015). In particular, due to relief conditions, offered 8 gradations of a slope abruptness (Gebeltová, Rezbová & Pletichová, 2014). For the first time, in classificational system of The RF soils, included antropogenetically transformed soils (Prishchepov et al., 2013).

For conditions of compound and erosionally dangerous relief, developed landscape and water-collecting approach, with the help of which determined 5 main types of peculiar agrolandscape (Kaz'min, 2016).

During determination of cadastral cost of agricultural areas on basis of agroecological analysis of lands, as a primary territorial unit stand out elementary areal of agrolandscape (EAA) (Bykowa & Sishchuk, 2015). Evaluative units in according to cadastral cost represent by itself the average weighted indications of analyzed indexes, included in them EAA (Marks-Bielska, 2013).

In the middle of 60's of XX century in USA for accounting and analysis was proposed geographical information system (GIS), which was concentrated on two issues: automated map making, and facilitating comparison of data on thematic maps(Coppock & Rhind, 1991). The first required high quality graphics, vector data models and powerful databases, the second is based on grid cells that can be manipulated by suites of mathematical operators collectively termed "map algebra" (Burrough, 2001). After more than 50 years of development, most standard GIS provide both kinds of functionality and good quality graphic display, but until recently they have not included the methods of statistics and geostatistics as tools for spatial analysis (Akinci, Özalp & Turgut, 2013). DevelopmentinGIS was limitedbyUSandCanadauntilthe 1980th, after that such approach was used in Japan, Great Britain, other countries (Theodoridou et al., 2012). Worldexperienceof GIF-technologies usage shows, that the majority of modern analysis systems of grounds is targeted on quantitative analysis of implementation of their main functions.(Bateman et al., 2002; Deshpande et al., 2004; Kamińska, Ołdak & Turski, 2004; Simoonga et al., 2009). Development of GIS-technology in analysis of landholdings in The RF is a perspective task (Akincietal, Özalp & Turgut, 2013).

Agricultural grounds monitoring of The RF implements on the basis of unification of program (informational, technical and technological) equipment (Makeeva, 2005), processes and methods of observation (Yakovlev et al., 2015), providing compatibility of his data with data of other types of monitoring of environment (Ratnikovetal, 2016).

In the concept of development of governmental monitoring The RF grounds till 2020 year, noted: "Specifics of agricultural lands accounting as a nature resource, which is used as a main tool of manufacturing in agriculture, requires another approaches and more wide list of indicators of such lands condition and their fertility (Ibrahimov, 2011).

Improving of systematic approaches to conducting monitorings, land analysis in The RF, pushes new requirements (Bukvareva et al., 2015) and focus an attention on actuality of standard development, which allows to detect changings of quality by every soil-climate zone of a country (Mirzabaev et al., 2015), by every used analysis index ofagricultural lands. (Mukhortova et al., 2015).

Analysis Problems of the RF Lands

Agricultural land covers about 38 % of the world's land area, arable land makes 11 % (Pomelov, Pasko & Baranova, 2015). The Russian Federation (The RF) possess (9%) of area of agricultural world ground sand 55% of black-soil grounds. At the same time, The RF produce just a little more, then 1% of GDP of world agriculture. In the calculation on 1 hectare of arable land, The RF produce agricultural production almost in 32 times less, then Netherland, in 10 times less, then FRG, and in 2,4 times less, then in USA (Lipski, 2015). One of the objective of transition in agriculture is to achieve productivity and efficiency improvement and thus begin to close the notorious productivity gap between The RF and the developed market economies (Lerman & Shagaida, 2007). Reliable information about condition and fertility of agricultural lands and its factual usage solves problems of development of programs upon saving and recovery soils fertility (Lerman & Shagaida, 2007).

Nowadays quantity of incoming requests from different authorities, as also from physical and legal persons on providing information about grounds monitoring results of The RF has a tendency to grow (Grədinaru et al., 2015).

During transition onto import substitution in Agro industrial Russian complex in modern conditions is extremely needed an organized system of monitoring realization of agricultural lands (Jakobson & Sanovich, 2010), including gathering, storage, processing and spreading of obtained information, that is based on usage of modern aerospace, terrestrial and geoinformation technologies (Zinchenkou et al., 2013).

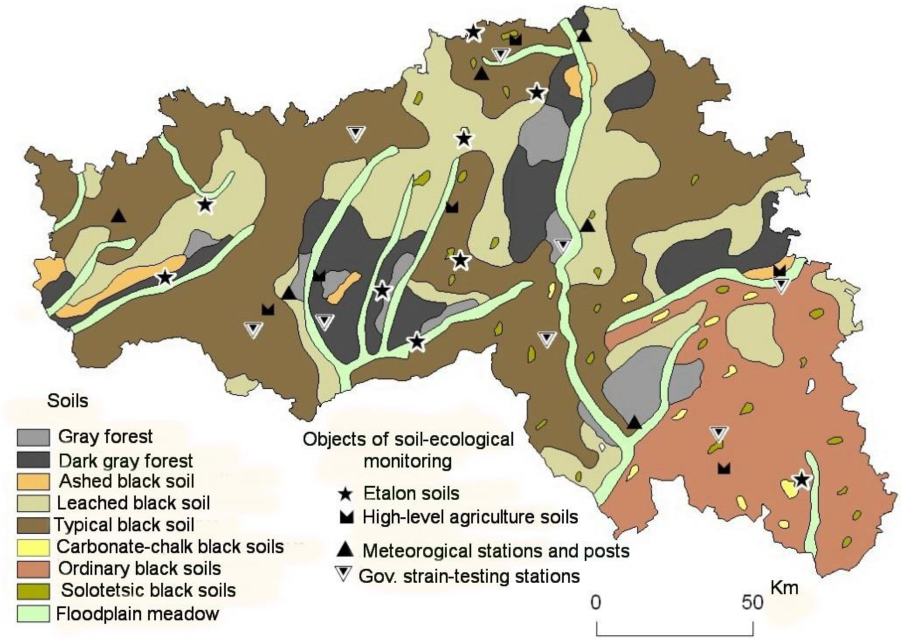
Agricultural holdings in constitution of agricultural lands have a priority in usage and are subject to especial protection (Shmidt, Tsarenko & Neyfeld, 2015). Lands transfer of land areas in constitution of such lands in other categories is allowed in unique cases (Schierhorn et al., 2013). Pointed lands transfer, mainly, implemented for widenin and building of settlements, and also for construction and widening territories of industrial enterprises and objects (Schepaschenko et al., 2011).

Established practice of main agricultural lands usage for areas of settlement building and other non-grounds aims may appear harmful for saving better quality soils (Engström et al., 2016). One of the important directions in modern land policy must become saving of a principle of purposeful usage of agricultural lands (Dziedzic et al., 2015).

For this purpose it is necessary to strengthen legislative mechanisms of agriculture lands protection, to insert restrictions on their transition into other categories. Withdrawal of valuable and especially valuable agricultural holdings must be prohibited, must be inserted personal responsibility for saving these lands, toughened agro technical requirements upon soils processing, that leads to deterioration and deprivation their productive properties (Podmolodina, Voronin & Konovalova, 2015).

Transition of areas , cadastral cost of which on 50% and more exceeds middle level of cadastral cost on municipal district (city district), and especially valuable productive agricultural lands, in other category for placing industrial objects, and also objects of social, communal-household purpose doesn't permitted (Bader & Van Ham, 2015).It is important from a viewpoint of following regime of denaturation, because cadastral cast, primarily, is focused on determination of taxable base and, alongside from indicators of soils fertility, it consist indexes of location and technological properties (Kravchenko & Litvinova, 2015).

Well, review the above mentioned factors on the example of The RF Belgorod region. Majority of soils in Belgorod region is related to zone of Ukrainian forest-steppe soil province. Significant part of soils in Belgorod region (31,7%) is related to black soils typical, which due to their qualities have nationwide value (fig.1).



Fugure 1. Basic objects of soil-ecological monitoring of Belgorod region

Special attention should be paid on soils-etalons, unique, rare and disappearing soils, information about which is in The Red book of Russia soils (Milanova et al., 1999).

Analyzing existing in Belgorod region net of objects for terrestrial inspection (fig.1), must be marked insufficiently developed monitoring system in areas of etalon soils and soils of advanced agriculture. That's why valuable types and kinds of soils should be reviewed as main objects of soil-ecological monitoring. Results of terrestrial inspections should be connected to data of distance sondage, that allows to conduct monitoring of soils in operational regime (Simoonga et al., 2009).

In order to organize rational soil us age it is necessary to conduct soil and agricultural inspections, systematic inspection of technogenically contaminated areas (Henry & Sundstrom, 2007). This, in it's turn, requires significant governmental support (Henry & Sundstrom, 2007).

Great importance in problems solving of arable lands not usage, related to their ecological condition. It's related to degradation and contamination of soils, in a result of which were excluded of usage significant areas of arable holdings (Ratnikov et al., 2016). In the past, degree of arable lands exploitation in several Russia regions (Belgorod, Voronezh, Kursk, Lipetsk, Oryol, Rostov, The Republic of Kalmykia and other regions) significantly exceeded ecologically permissible norms; area of arable lands until 1990'sconstitute 60-70% from whole area of these regions, that leads to negative ecological consequences (Ushachev, 2015). Areas of natural fodder lands due to high plushness with absence of soil saving measures were reduced to minimum and pushed in ravines and beams. Was abruptly disrupted balance of humus and deteriorated water regime of soils, wide areas, which exposed to processes of degradation, gradually became of little avail foe usage (Larionov, 1993).

Transition of low-productive lands in less intense using types of land holdings or other categories of lands, based on development of criterias of their analysis and allocation, when in the process of land-analysis works, aside from soil valuation, reviewed another one phase – qualitative analysis of soils (Semochkin, Ivanov &Semochkin, 2010).

Actual Factors of Land Analysis

For development of cartographical models for agro-ecological conditions distribution, it is needed to use new technological opportunities. They're must ensure integration of GIS-technologies, automated procedures of morphometric analysis of digital models, results of distance sondage of the Earth.

As a dimensional object of analysis should be considered agro ecological type of lands, instead of differentiation on diversities or groups of soils. Some diagnostic indicators of valuation may be taken into account in a result of agro ecological typization of a territory. As an important criteria's of land analysis considered thermo- and moisture provision of agro ecological land types, which is considered during determination of thermal regime and some agricultural crop yield in different locations of complex terrain.

For humidity coefficient calculation it is proposed to use formulas (Svetlitchnyi, Plotnitskiy & Stepovaya, 2003) for straight and concave slopes:

$$\text{Ch}=(\text{a}+0{,}16\cos A + 0{,}09\sin A)\text{Ca}, \quad (1)$$

$$a = \begin{cases} 1 - 0{,}2(l/l_{\max})^{0{,}5}, if\ 0 < l/l_{\max} \leq 0{,}167 \\ 0{,}77 + 0{,}43(l/l_{\max})^{1{,}47}, if\ 0{,}167 < l/l_{\max} \leq 0{,}833 \\ 0{,}77 + 0{,}70(l/l_{\max})^{4{,}0}, if 0{,}833 < l/l_{\max} \leq 1{,}0 \end{cases}$$

Where Ch – Coefficient of humidity, 1 – distance from slope border; l "max" - general slope length, A – angle of incline (in degrees) represent itself as incline aspect (degrees). Average mistake of data approximation for straight and concave forms of a slope ±0,05 or ±4,9% from average value coefficient of humidity Ch.

For slopes of concave form it is important to use such type formula (Stepovaya, 2001):

$$\text{Ch}=(\text{b}+0{,}14 \cos A + 0{,}10 \sin A - 0{,}02 \cos 2A)\text{Ca}, \quad (2)$$

$$b = \begin{cases} 1{,}04 - 0{,}22(l/l_{\max})^{0{,}93}, if\ 0 < l/l_{\max} \leq 0{,}833 \\ 0{,}86 + 18.0(l/l_{\max}\text{-}0{,}833)^{2{,}0}, if\ 0{,}833 < l/l_{\max} \leq 1{,}0 \end{cases}$$

Average mistake of data approximation for slopes of concave forms ±0,04 or ±3,8% from average value coefficient of humidity Ch.

Impact of slope exposition counts in a form of equalizing coefficients on agricultural crop yield: north – 1,06, south – 1,19, east – 1,08, west – 1,00 (Dabakhova, Dabakhov,&Titova, 2013).

Unsteady distribution of solar radiation upon slopes of different exposition and abruptness is one of the causes of emergence of microclimate differences in intersected locality (Simonov, 1956).

For purposes of rational usage of land holdings it is important to place correctly agricultural crops. For this is considered a level of their warmth supply. Calculation of a value of straight solar radiation for inclined surface also considers peculiarities of a terrain, and calculated by formula (Nikolaev, 2013):

$$S_{sl.} = C_S x S_{gor.}, \quad (3)$$

Where Sgor. –value of straight solar radiation for horizontal surface (due to reference data); CS – coefficient, calculated upon dependence: cos AS/tgho (AS – angle between vertical of the Sun and normal to a slope; ho-high of the Sun).

In table 1 represented an attitude of middle daily sums of straight solar radiation, falling in surfaces of north and south orientation with abruptness - 5º, to sum of radiation, falling on horizontal surface (CS) for territory of Belgorod region.

Table 1. Relation of average daily sums of straight solar radiation of Belgorod region (Rezk, Tyukhov & Raupov, 2015)

Months	III	IV	V	VI	VII	VIII	IX	X
				North slope				
-	0,88	0,93	0,96	0,98	0,98	0,95	0,91	0,85
				South slope				
-	1,12	1,06	1,03	1,01	1,02	1,04	1,09	1,15

One of the most important agro climatic indicators is a sum of temperatures high then 10 degrees. For territories with complicated terrain, where it is possible to include almost all Belgorod region, calculation of sums of active temperatures for slopes with different abruptness is possible to conduct by Sofronie-Enterzone formula with modifications (Urusov, Mayorov & Chipizubov, 2010):

$$\sum t_a = \frac{\sum t_{ac} \cos(\varphi + arctg(tg\alpha \cos\gamma \cos\eta))}{\cos\varphi_C} - C(H - H_c), \quad (4)$$

where ∑ta, ∑tac –sums of active temperatures in point of earth surface and on meteorogical station, accordingly; φ, φC –geographical attitude of a point and meteorogical station accordingly; α –angle of slope incline; γ – azimuth of a vector of drain line at a point; η – height of the Sun at true midday; H, HC – heights about sea level, points and meteorogical stations accordingle; C – empirical coefficient. Height of the Sun above horizon at true midday, calculates as arithmetic average of this index over vegetative period of plants development, i.e. from the beginning and to the end of transition of average daily air temperature to indicators, which exceed 10 ºC.

For quantitative accounting of joint influence of warmth and humidity within one agro-ecological contour we offer to use xenomorphic coefficient (Cx), which characterize changing of hydrothermal conditions for concrete area of terrain in comparison to horizontal surface (Svetlitchnyi, Plotnitskiy & Stepovaya, 2003):

$$C_x = C_i / C_h, \quad (5)$$

Where Ci – coefficient of insolation, reflecting inflow of straight solar radiation and real slope in comparison to horizontal surface; Ch – coefficient of comparative humidification, characterizing inflow of humidity in soil on this slope in comparison to horizontal surface.

Technically automatic allocation of agro ecological contours can be easily implemented in GIS with the help of cluster analysis: allocates all possible areals, appearing on zones intersection of hydrothermal conditions, clusters of brightness of image and allotments, contrast due to content of physical clay.

Method

With the help of science metrical bases of Scopus and Web of Science, conducted systematic analysis of bonification (valuation) problems of The RF lands, considering world practice. Ways of solving problems of agricultural lands analysis, reviewed considering existing techniques with usage of modern informational-communication technologies. During values determination is applying analysis of usage of basic agricultural lands, practice of their transition into other category. Nowadays in a sphere of agricultural lands by legislation regulated an activity for monitoring of lands fertility, and also monitoring of meliorated lands. Proposed a technique of territorial sondage of agricultural lands due to their level of suitability for usage in agriculture.

Data, Analysis, and Results

Governmental cadastral analysis of The RF lands must be conducted after full agro ecological monitoring. It is proposed to conduct it in four phases:

1) agro landscape mapping of territory;

2) substantiation of borders of micro climate in homogeneity and typization of slopes through morphometric analysis of terrain, using GIS-technologies;

3) quantitative analysis of warmth- and humidity endowment;

4) integral representation of a result, in the form of microclimatic typization of lands due to agro climatic resources.

Monitoring of agricultural lands must implements on the basis of unification of program (informational, technical and technological) instruments, methods and techniques of observation.

It will allows to make a transition of agricultural commodity producers to a system of precise farming. For that will be needed equipping of agricultural technique by GPS/GLONASS modules, equipping of automatized employees workplaces at agricultural enterprises, connection to web-services of geoportal.

Built in such way GIS monitoring of agricultural lands will be respond to all requirements, that is important to information systems in sphere of land resources management, such as (Rudenko, 2015):

- operativeness of receiving information;
- homogeneity of receiving data ;
- legitimacy of data;
- possibility of electronic documents circulation at all levels

For solving problems of agricultural lands analysis it is needed to create centralized governmental informational resources about these lands within lands of all categories.

Circle of users of mentioned information quite broad. It must be available for federal executive authorities, executive authorities of the Russian Federation subjects, local authorities, agricultural commodity producers, and also for other interested physical and legal persons.

Discussion and Conclusion

That's why from ecologic point of view, modern landscape – it's integrated system of interrelated and interacting components. The authors come to conclusion, that to questions of high-priority belongs analysis of modern landscape stability (including agricultural) and it's optimization. As a main complex characteristic and system analysis of landscape in homogeneity and it's changing in the process of agricultural usage serves materials of quantitative and qualitative analysis of condition of agro ecosystems, received obtained on the basis of modern technologies usage for different methods of analysis and monitoring of agricultural lands, GIS-technologies and methods of distance sondage of lands.

Fulfilled analysis of methodic approaches to analysis of agricultural lands condition, allowed not only determine the most perspective methods, but also gave propositions about usage of modern technologies during creation informational data bases about lands condition in monitoring system and it's actualization.

Usage of modern technologies of space imagery will allow to actualize information of monitoring agricultural lands and efficiently solve next tasks:

1) mapping of agricultural land holdings (determination of agricultural land holdings borders, inventorization, analysis);

2) mapping of soil cover characteristics

3) classification of agricultural crops;

4) monitoring of agriculture crops condition;

5) yield forecasting;

6) planning and monitoring of agro technical events;

7) soil sondage;

8) creation of a system of point land farming (using GPS equipment).

Disclosure statement

No potential conflict of interest was reported by the authors.

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