Urban land use planning within the system of sustainable urban development management

Boris Bondarev[1,*], *Sergey* Nosov[2], *Oleg* Antipov[3], and *Lusine* Papikian[2]

[1]Peoples' Friendship University of Russia, Agroengineering Department, 117198 Moscow, Russia
[2] Plekhanov Russian University of Economics, Project and Program Management Joint Department with Capital Group Company, 117997 Moscow, Russia
[3] State Budgetary Organization of Moscow City "General Architectural Planning Authority under Moscow City Committee on Architecture and City Planning", Department of Information Modeling Technologies Development and City Planning Analysis, 125047 Moscow, Russia

Abstract. Agricultural and forest lands near settlements are main reserve for expansion of urban areas. Thus, among 148.5 thousand hectares of lands added to Moscow city territory in 2012, 72.2 thousand hectares or 48% were occupied by agricultural and forest lands. Urban areas are characterized by excessively high intensity of land use, land depletion, deterioration in environmental quality and decline in sustainability of urban development. The paper presents the results of analysis of urban land use planning system in the interests of sustainable development of urban territories. The object of the study is the land that is part of Moscow, which is planned to be developed in the coming decades. The authors propose an algorithm for urban development of such areas, which takes into account the quality of land. Design calculations for areas under development were carried out for Shchapovskoye settlement in New Moscow as an example. In addition, the paper covers aspects of land management when developing agricultural land within cities. The authors developed a classification of agricultural land according to a criterion of "suitability for urban development". The suggested classification has been applied to achieve the objectives of planning urban land use development, determining the order of construction on agricultural lands within the system of sustainable urban development management.

1 Introduction

A large number of researchers are engaged in optimization of urban land use amid urbanization of territories in countries such as China [8, 9, 13], Russia [1-4, 14-16, 21-22], the USA [5], Japan [10], South Korea [17], etc. In recent years land use in Moscow has been carried out according to a strategy of mixed development, combining intensive and extensive development of territories. Intensive development implies increase in concentration of built areas within the old boundaries of Moscow. Extensive development means expanding the boundaries of the city and absorbing new, as a rule, agricultural and

* Corresponding author: zocenka@mail.ru nsi1960@mail.ru

forest lands of neighborhood territories. These productive lands, as the most prevailing in terms of area and usually located near settlements, are the main reserve for expansion of urban territories. This trend is observed in many countries [6-7, 11-12].

2 Materials and methods

Under conditions of urbanization an important issue is to improve approaches to formation of an effective model and methods for managing urban land use development. Scientists from different countries have studied various aspects of urban land use management and regulation. However, solutions to improve principles and methods of managing land use in a large city basing on evaluation by "suitability for urban development" of agricultural lands joined to the city remain unexplored, as well as the establishment of the order of their allocation for urban areas integrated development.

In this paper, it is proposed to solve this problem by:

- carrying out an analysis of the features of spatial and functional structure of a large city and its system of land use management;
- researching the features of various directions and options for long-term development of a large city and defining principles which complement the main city planning principles and serve as a recommended basis for planning efficient use of city land resources under conditions of development;
- developing methods for assessing agricultural lands within a large city which enable their classification according to the criterion "suitability for urban development", and a scale of indicators for determining the sequence of allocation of these lands for urban development, so that the most fertile land is preserved in its natural condition for agricultural production;
- justifying the sequence of developing a technical and economic justification for a first-priority integrated territorial development project, for informing the community, non-governmental and religious organisations and assuring their participation in decision-making (according to article 1, point 4 of The Land Code of the Russian Federation);
- suggesting enhancement of information support for land use management system as a tool for managing large cities development;
- conducting calculations on the effectiveness of managing agricultural lands use within territories joined to a large city and assigned for first priority urban development;
- evaluating economic effectiveness of public-private partnership in a project of integrated development of the joined territories.

The lands joined to settlements should be used on the principles of systematic and consequent (step-by-step) development. Construction on these lands is advisable to carry out in accordance with their quality ranked by classes (from the 1st to the 9th). The classes of land are identified by agricultural production grouping of lands according to their suitability for agricultural use [19, 20], the level of potential soil fertility and its limiting negative factors (erosion, salinization, flooding, etc.), the balance of humus containing in soils. Calculation of the balance of humus in soils is based on the assessment of their physical and chemical properties dynamics with the use of a method developed by the authors of this paper [18]. The scheme of land classification is shown in Table 1.

Table 1. The scheme of land classification according to suitability for agricultural use [4, 19].

Groups	Classes	Category	Crop yield, metric centners per hectare		Soil quality index (points)	
			average value	range	average value	range
I. Suitable for	1	1	61	60-66	98	95-100

Groups	Classes	Category	Crop yield, metric centners per hectare		Soil quality index (points)	
			average value	range	average value	range
arable land and any other agricultural land		2	59	58-60	93	90-95
		3	57	56-58	88	86-90
		4	55	54-56	83	81-86
	2	5	53	52-54	78	76-81
		6	51	50-52	73	71-76
		7	49	48-50	69	67-71
		8	47	46-48	64	62-67
	3	9	45	44-46	59	57-62
		10	43	42-44	54	52-57
		11	41	40-42	50	48-52
		12	39	38-40	45	43-48
	4	13	37	36-38	40	38-43
		14	35	34-36	35	33-38
		15	33	32-34	31	29-33
		16	31	30-32	26	24-29
	5	17	29	28-30	21	19-24
		18	27	26-28	16	14-19
		19	25	24-26	12	10-14
		20	23	22-24	7	5-10
II. Suitable for cultivating forage and fodder	6	21	29	28-34	21	19-24
		22	27	26-28	16	14-19
		23	25	24-26	12	10-14
		24	23	22-24	7	5-10
	7	25	21	21-22	3	2-5
		26	20	20-21	1	0-2
III. Unsuitable or inadequate for agricultural land in its natural state	8	27	potentially suitable		-	-
		28	unsuitable		-	-
IV. Unique lands	9	29	-		-	-

3 Results

Forest and agricultural lands included into a city area are developed in different ways. As a rule, lands occupied by forest vegetation are not built up and further perform the cities recreational functions, therefore, they are not considered by the authors of this paper from the point of urban planning. Thus, agricultural lands become the main reserve for urban development.

For urban areas sustainable development first the least fertile and infertile lands – mines, pastures, hayfields and arable lands (6-8 classes) – should be used for construction purposes. Lands of higher classes (3-5 classes) should be built up last. Land plots classified as 1st, 2nd classes (highly productive lands) and 9th class (unique lands) should not be built up or might be built up only as exception.

In this paper, the proposed algorithm for urban areas development implies development and use of a scale of suitability (inadequacy and unsuitability) of land of different classes for urban development. Agricultural land integration into urban areas and their consequent

development is relevant for most megacities in different countries around the world. The model proposed by the authors of this paper is one of the approaches to solve the issue.

In 2012, 148.5 thousand hectares of land were included into the Moscow city area, 72.2 hectares of which or 48% were used for agriculture and forestry. Urban areas are characterized by excessively high intensity of land use, land depletion, deterioration in environmental quality and, as result, decline in urban development sustainability. Thus, development of such lands requires a systematic approach.

As a case to study in this paper, the Shchapovskoye settlement, one of the 20 settlements in New Moscow, where agricultural enterprise "Shchapovo" functioned, was considered. The area of the settlement is 8693 hectares, 2294 hectares (26.4%) of which are agricultural lands. Predominant soils here are sod-podzolic with normal moistening, there are light-gray podzolized and some other soils.

To achieve the aim of this paper, a data base has been formed which reflects characteristics of land plots for agricultural use and includes the developed scale for classifying agricultural lands within the settlements of New Moscow, a soil map of agricultural lands, a scheme-map of the land plots and agricultural land groups in terms of suitability for urban development, as well as a table of land classes for agricultural land plots in the Schapovskoye settlement. The soil map will act as a cartographic basis for "finding" soil varieties from it and "linking" them to the land plots.

The scheme-map of agricultural land plots is formed on the basis of land plots within crop rotation fields of the former agricultural enterprise "Shchapovo". This land-type scheme-map shows land classes according to the level of suitability for agricultural use (based on the classification scale and soil map information). Further, using the developed scale for assessing and classifying agricultural lands of a settlement according to the degree of suitability for urban development suitability groups are indicated. The conducted calculations has demonstrated the distribution of agricultural lands soils in the settlement according to the land classes as it can be seen from Table 2.

Table 2. Distribution of agricultural land soils in the Schapovskoye settlement by land classes.

Suitability groups	Classes	Crop yield, metric centners per hectare	Area, hectares
I. Suitable for any agricultural use	1	55 - 61	-
	2	47 - 53	-
	3	39 - 45	1650.0
	4	31 - 37	245.0
	5	23 - 30	205.0
II. Inadequate for arable farming, perennial plantations, but suitable for growing forage and fodder	6	23 - 34	194.0
	7	20 - 22	-
III. Unsuitable or inadequate for agricultural use in its natural condition	8	-	-
IV. Unique lands	9	-	-
	Total	-	2294.0

The analysis results have revealed that in the Shchapovskoye settlement there are no land plots of the highest classes (1, 2), of the worst classes (7, 8) and no unique lands attributed to the 9th class.

The predominant class of land within the territory of the settlement is the 3rd class characterized by crop yield of 41-42 centners per hectare and soil quality index assessed as 50-52 points (see tables 1 and 2). This largest area accounts for 1650 hectares (see table 2). Lands referred to the 4th and 5th classes occupy 450 hectares, and the 6th class – 194 hectares.

Based on the classification of agricultural lands [4] within the Shchapovskoye settlement by suitability for agricultural use and the Scale for assessing and classifying agricultural lands of a settlement by suitability for urban development, the distribution of agricultural lands in the settlement according to suitability for urban development has been composed, which is shown in Table 3.

Table 3. Distribution of agricultural land soils in the Schapovskoye settlement by suitability for urban development.

Zones of agricultural land by fertility	Classes of land by crop yield	Suitability for agricultural production	Group	Level of suitability for urban development	Area, ha
Highly productive	1st and 2nd classes	Agricultural production; private farming (field plot)	5	Unsuitable (unfavorable)	none
	9th class	Suitable for cultivation of certain types of industrial crops, perennial plantations, berries, etc.			none
Productive	3rd class	Agricultural production; private farming (field plot), livestock husbandry (pastures and production of fodder)	4	Suitable (favorable) in the long term	1650
	4th and 5th classes	Agricultural production; private farming (field plot), livestock husbandry (pastures and production of fodder), gardening and horticulture	3	Suitable (favorable) in the medium term	450
Low-productive	6th and 7th classes	Agricultural production; private farming (field plot), livestock husbandry (pastures and production of fodder), gardening and horticulture, suburban construction	2	Suitable (favorable) for prior urban development	194
	8th class	Unsuitable or inadequate for agricultural use in its natural condition	1	Suitable (favorable) for prior urban development	none

Then, in accordance with the method of assessment developed by the paper's authors, land plots have been divided according to the sequence of use for development (construction) into three stages (queues). The distribution of agricultural land in the Shchapovskoye settlement according to the sequence of use for development (construction) is shown in Table 4.

Table 4. Distribution of agricultural land soils in the Schapovskoye settlement according to the sequence of use for development.

Zones of agricultural land by fertility	**Land class / group of lands**	**Suitability for agricultural production**	**Level of suitability for urban development**	**Area, ha**	**Sequence (order) of development (construction)**		
					I	**II**	**III**
Productive	3/2	Agricultural production; private farming (field plot), livestock husbandry (pastures and production of fodder)	Suitable (favorable) in the long term (more than 20 years)	1650	-	-	1650
	4, 5/3	Agricultural production; private farming (field plot), livestock husbandry (pastures and production of fodder), gardening and horticulture	Suitable (favorable) in the medium term (up to 20 years)	450	-	450	-
Low-productive	6/2	Agricultural production; private farming (field plot), livestock husbandry (pastures and production of fodder), gardening and horticulture, suburban construction	Suitable (favorable) for prior urban development (up to 5 years)	194	194	-	-
Total			ha	2294	194	450	1650
			%	100	8,5	19,6	71,9

The analysis of the data in Table 4 shows that the land plots intended for construction are distributed in a way that the more distant in time the development stage is, the larger the area of land. Thus, the problem of systemizing the processes of agricultural lands development and protecting more productive lands from prior withdrawal from agricultural use is solved. Meanwhile, the first stage of construction covers 194.0 hectares (8.5%) of the land area belonging to the 6^{th} class, the worst class within the territory of the settlement by the suitability for agricultural use.

4 Discussion

The suggested algorithm for urban areas development using the developed scale of suitability (inadequacy and unsuitability) of different classes of land for urban development

enables organization of urban land use planning based on the sequence of development of productive lands characterized by different quality, which ensures sustainability of urban areas development.

The leading role of information support for land use management in the interest of urban areas sustainable development should be given to the integrated information system proposed by the authors which includes land use planning, cadastre, registration of real estate rights and transactions, individual and mass valuation of land and other types of real estate, taxation and mortgage. Such system would contribute to urban areas sustainable development on the basis of systematic planning of cities' land use.

This integrated approach to urban land use planning in the interests of urban areas sustainable development is based on the algorithm of land differentiation by its quality realized with the use of a computer program which has been developed with participation of this paper's authors and has been certified through state registration procedure [20].

5 Conclusions

Development and introduction of principles and methods for effective land use management in a large city amid its territorial development based on economic valuation and consequent allocation of agricultural land for implementation of urban areas integrated development projects will ensure:

- justified economic assessment of added to a city agricultural land on basis of land plots classification by a criterion "crop yield" and differentiation of the joined land under development by a new criterion – "suitability for urban development";
- a fair and economically justified choice of land plots for prior development based on feasibility study of integrated development of territories of a large city;
- preservation of urban ecosystems in general, including agricultural and forest lands, lands of specially protected areas and of other uses, consideration of social aspects of urban areas development;
- enhancement of methodical and information support for land use management system for the new territories of large cities taking into account economic regulators, including public-private partnership in integrated development projects.

The publication has been prepared with the support of the "RUDN University Program 5-100" and Russian Foundation for Basic Research (RFBR) within the scientific project "Development of methodology for rural territories management based on identification of especially valuable land and development of tourism in digital economy" No. 19-010-00837.

References

1. O. A. Antipov, S. I. Nosov, Econ. and Entrepr., **12 p. 4,** 913-916 (2015)
2. O. A. Antipov, A. V. Sevostyanov, Land manag., cadastr. and land monitor., **9**, 76-81 (2014)
3. S. I. Nosov, B. E. Bondarev, Intern. Sc. and Tech. and Indus. J. "Earth Sc.", 4, 67-69 (2015)
4. A. K. Ogleznev, S. I. Nosov, B. E. Bondarev, et. al., *Reference book of agroclimatic appraisal zoning of subjects of the Russian Federation* (Maroseyka, Moscow, 2010)
5. D. N. Bengston, J. O. Fletcher, K. C. Nelson, Landsc. Urban Plan, **69**, 271–286 (2004)
6. H. Chen, Y. Wu, M. Ou, J. Nanjing Agric. Univ, **9**, 67–71 (2009)
7. J. M. Duke, L. Lynch, Land Econ., **82**, 189–213 (2006)
8. J. Freedmann, Int. J. Urban Reg. Res., **30**, 440–451 (2006)

9. J. Gao,; Y. D. Wei, W. Chen, K. Yenneti, Sustainability, **7**, 10281–10307 (2015)
10. B. Misra, S. Okita, et. al., *Japanese experience in physical development and land management. In Transferability of Development Experience (Regional Development Dialogue, Special Issue 1984)* (United Nations Centre for Regional Development, Nagoya, 1984)
11. A. C. Nelson, J. Am. Plan. Assoc., **58**, 467–488 (1992)
12. C. J. Nickerson, L. Lynch, Am. J. Agric. Econ, **83**, 341–351 (2001)
13. M. Timberlake, Y. D. Wei, X. Ma, J. Hao, Cities, **41**, 162–170 (2014)
14. V. I. Vasenev, E. A. Dovletyarova, V. G. Plyushchikov, R. Valentini, RUDN J., **4**, 7-9 (2016)
15. V. I. Vasenev, J. J. Stoorvogel, R. Leemans, R. Valentini, R. A. Hajiaghayeva, J. of Cleaner Produc., **170**, 902-914 (2018)
16. V. I. Vasenev, J. J. Stoorvogel, I. I. Vasenev Catena, **107**, 96-102 (2013)
17. C. Zhao, G. Jin, P. Zhou, Urban Probl., **1**, 90–96 (2007)
18. S. I. Nosov, B. E. Bondarev, et. al., *Physical and chemical properties of soils of agricultural lands and the balance of humus on arable lands of the Russian Federation* (Russlit, Moscow, 1996)
19. A. K. Ogleznev, S. I. Nosov, B. E. Bondarev, et. al., Quality assessment and classification of land according to their suitability for use in agriculture (Ltd. Publishing House "Russian Evaluation", Moscow, 2007)
20. Certificate on state registration of computer program “Software for calculating quality indicators and for classification of agricultural land”) No. 2015660854 dated October 12, 2015. Program developers: Nosov S.I., Bondarev B.E. et al.
21. D. V. Kovkov, N. D. Koryagin, S.Y. Eroshkin, T. A. Sukhorukov, A.I. Sukhorukov, Springer Geography, **24**, 199-205 (2019)
22. A. I. Sukhorukov, N. A. Kameneva, G. Shuhong, S. Y. Eroshkin, *Sustainable Management of Radiation-Hazardous Construction Projects* (MLSD, Moscow, 2018, 1-4)