DYNAMIC COEFFICIENT FOR 50 YEARS OF AREA BY CATEGORIES OF THE LAND CADASTER OF THE VOLGA MUNICIPALITY OF THE REPUBLIC OF MARIY EL

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ABSTRACT

In territorial planning and forecasting in the conditions of Russia, it is necessary to take into account the coefficients of dynamism of the area of all lands and by categories of the cadastre. On the example of the Volzhsky district of the Republic of Mari El, it can be seen that agricultural lands have contradictory three fluctuations, which decrease in amplitude until 2070. The largest number of fluctuations over 50 years occurred for two categories of lands: 3 - industrial lands (9 wavelets), 7 - stock (8 fluctuations). The maxima in modulus of the dynamism coefficient are as follows: Category 1 - 0.0799 in 1992; 2 - 0.0177 in 1976; 3 - 0.2384 in 1998; 4 - 0.0018 in 2000; 5 - 0.2714 in 1992; 6 - 0.0160 in 1999; 7 - 6.4204 in 2020; all lands of the Volzhsky region of the RME - 0.0135 in 1977. The most dynamic are stock lands. For agricultural land since 1970, there has been a constant half-life of 5.09737 years. In Russia, the Soviet system of land use in agriculture was preserved, and it was aimed at increasing dynamism. In this case, the first and third fluctuations are directed against (negative sign) the growth of the dynamism coefficient. Not enough attention is paid to the dynamics of agricultural land. The third wave will slow down: 1970 with a period of 4.7 years, in 2020 - 4.3 years, and according to the forecast by 2070 - 3.9 years. Such an increase in vibration frequency is already dangerous. Wavelets # 1 and # 4 of stock lands dynamism become especially dangerous, as they strongly influence the future. Stock wavelets # 3, # 5-7 are a thing of the past. And the rest of the wavelets will continue after 2020. Therefore, stock lands require special attention

Keywords: *municipality, land, categories, area, dynamic factor, patterns*

INTRODUCTION

To understand the new parameter we are introducing - the dynamism coefficient - to describe the oscillatory behavior of land surveyors of the Russian Federation for 50 years from 1970 to 2020, and only at the level of a separate municipality, it is necessary to consider seven categories of the land cadastre in dynamics. These seven categories were accepted as the dominant land classification, although we did not find any indication as to why agricultural land (ACL) was accepted as the first category. In another classification, the sum of five types of agricultural land does not coincide with the area value of the first category of the land registry.

For a deeper understanding, within the framework of climatic geomorphology, you need to rely on the first part of the definition: “The Earth is the most important part of the natural environment, characterized by space, relief, climate, soil cover, vegetation, bowels, waters, ...” [1]. This enumeration of the objects of the natural and natural-anthropogenic environment surrounding a person makes it possible to introduce into the science of land use achievements from related sciences - geomorphology, climate, soil and vegetation, biology and zoology, river systems, open pit mines and much more.

But while in Russia anthropocentrism still prevails, when the entire land surface is declared an unconditional property of man: “Land resources on the territory of Russia are classified according to their suitability for various types of land use as follows: - by land categories; - by type of land; - in terms of quality and ecological status; - by administrative-territorial affiliation; - by forms of ownership ”[2]. There are no categories and types of land use, except for specially protected areas, necessary for the preservation of the descendants of the primitive natural environment.

From [3] it can be seen that Rosstat does not publish summary data for all municipalities of the country at all, although it is customary to consider them as elementary units of administrative-territorial affiliation. The tables contain federal districts [4] and subjects of the federation. With climate change, the challenges of protecting the natural environment are becoming more acute.

The environment is already being affected by significant changes in climate regimes around the world, leading to more complex and therefore more expensive biomass and bioenergy supply chains. The presented approaches should be taken into account in future research and practice to ensure sustainable forest management [5].

The purpose of the article is to identify the patterns of the dynamic factor in the distribution of lands by cadastre categories for 1970-2020 in the Volzhsky region of the Republic of Mari El (RME).

MATERIALS AND METHODS

From the annual reports on the structure of the land fund, data on the area of the territory of the region were written out according to seven categories of the cadastre (Table 1).

Table 1. *Dynamics of lands in the Volzhsky district, ha*

Year	Time, τ year	Land area by category							Total
		1	2	3	4	5	6	7	
1970	0	48597	2930	1121	-	38929	-	2694	94271
1971	1	50014	2930	1234	-	38893	-	2694	94271
…	…	…	…	…	…	…	…	…	…
1992	22	44569	-	1200	17469	19563	2498	18	91895
…	…	…	…	…	…	…	…	…	…
2018	48	41539	3404	1108	17502	24903	2578	352	91386
2019	49	41537	3404	1110	17502	24903	2578	352	91386
2020	50	41537	3404	1110	17502	24903	2578	352	91386

1– for agricultural purposes; 2 - settlements; 3 - industry ...;
4 - especially protected. territories ...; 5 - forest fund; 6 - water fund; 7 - reserve fund.
Since 1992, land registry categories 4 and 5 have been allocated.

Oscillatory adaptation in nature requires data with a series of at least 50 years to reveal the behavior of different decision-makers. The nature of behavior is determined by the dynamism coefficient K_D according to the formula

$$K_D = (S_F - S_T)/S_T, \qquad (1)$$

where S_F is the actual value of the total area and land by category (Table 1), ha; S_T – the calculated value of the area, hectares. The higher the value K_D, the more dynamic the distribution of land in the category over the years.

Models of dynamics for 50 years of values of the land area of each category were identified using a two-term formula of a clearly nonlinear trend

$$y = aexp(-bx^c) + dx^e\exp(-fx^g) \qquad (2)$$

where y – is a dependent indicator, x – is an influencing variable, a-g are model parameters (2) identified in the CurveExpert-1.40 software environment.

LAND DYNAMICS BY TREND

Table 2 and Figure 1 show the results of identifying the model (2) of a two-component trend to describe the dynamics of the area (Table 1) of lands.

Table 2. *Parameters (2) of the dynamics of the area by land categories of the Volzhsky district*

Category code	Trend $y = aexp(-bx^c) + dx^e\exp(-fx^g)$							Coef. correl. r
	Exponential law			Biotechnical law [4]				
	a	b	c	d	e	f	g	
All	3611.2284	0.10999	1	91345.928	0	0	0	0.9177
1	48588.7025	-0.031182	0.43270	-180.04340	1.15341	0	0	0.9203
2	2915.4126	0.0016487	1.73803	11.29123	1.50401	6.30277e-5	2.23242	0.9918
3	1331.1763	0.0041297	1	0.00067889	6.04352	0.0011693	2.78852	0.9354
4	17431.393	-7.54436e-5	1	4.53873e-46	41.55598	0.95853	1.04313	0.8956
5	40349.602	0.0071075	1	-2.20553e-10	13.17073	0.43332	1	0.9635
6	2582.2862	0	0	-227.2107	0	0.00034368	2.51678	0.8770
7	2676.7168	2.26292e-5	3.09067	-8.98135e-44	48.15864	1.95127	0.99707	0.9793

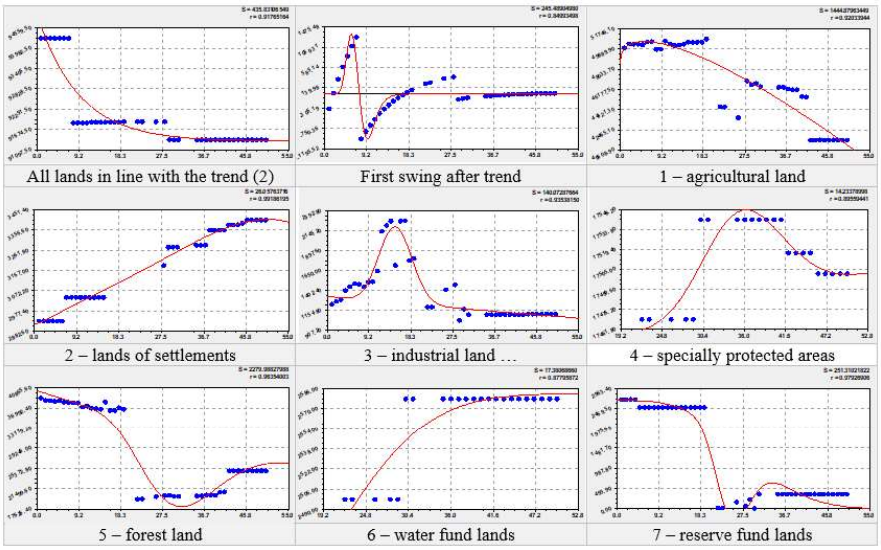

Fig. 1. *Graphs of the dynamics of the land fund of the Volzhsky region from 1970 to 2020.*

(in the upper right corner: S - standard deviation; r - correlation coefficient)

All lands of seven categories according to Table 2 change in dynamics according to Weibull's law until reaching the minimum area value of 91,346 hectares. For 50 years, the decline has occurred according to Laplace's law (in mathematics), Mandelbrot (in physics), Zipf-Perl (in biology) and Pareto (in econometrics). The dynamism is proved by the fact that, in addition to the trend, six more oscillations were obtained, and for agricultural lands there were 16 such wavelet signals. The dynamism coefficient makes it possible to abandon the identification of asymmetric wavelets and calculate it according to the trend using formula (1).

According to the first component of the trend, the lands of settlements are decreasing according to the modified Mandelbrot's law, this is opposed by the biotechnical desire of people to expand their habitat. This category of land according to the schedule (Fig. 1) will decrease.

DYNAMISM FACTOR FOR 50 YEARS

The results of calculations by formula (1) are given in table 3.

Table 3. *Coefficient of dynamism of land distribution in the Volzhsky region*

Year	Time, τ year	Area dynamic factor by category							Total
		1	2	3	4	5	6	7	
1970	0	0.0002	0.0050	-0.1579	-	-0.0352	-	0.0065	-0.0072
1971	1	0.0013	0.0028	-0.0692	-	-0.0292	-	0.0065	-0.0033
…	…	…	…	…	…	…	…	…	…
1992	22	-0.0779	-	-0.1119	0.0004	-0.2714	0.0063	-0.9945	0.0025
…	…	…	…	…	…	…	…	…	…
2018	48	-0.0035	0.0001	0.0148	0.0000	-0.0364	-0.0014	3.6004	0.0002
2019	49	0.0035	-0.0005	0.0209	0.0000	-0.0446	-0.0015	4.8130	0.0003
2020	50	0.0107	-0.0008	0.0251	0.0000	-0.0508	-0.0015	6.4204	0.0003

The maxima in modulus of the dynamism coefficient are observed: 1 category - 0.0799 in 1992; 2 - 0.0177 in 1976; 3 - 0.2384 in 1998; 4 - 0.0018 in 2000; 5 - 0.2714 in 1992; 6 - 0.0160 in 1999; 7 - 6.4204 in 2020; all lands of the Volga Municipal Formation RME - 0.0135 in 1977. The most dynamic are lands of the reserve fund (category 7).

The dynamism coefficient has a wave nature and therefore asymmetric oscillations (wavelet signals) are written by the wave formula [4] of the form

$$y_i = A_i \cos(\pi x / p_i - a_{8i}),\ A_i = a_{1i} x^{a_{2i}} \exp(-a_{3i} x^{a_{4i}}),\ p_i = a_{5i} + a_{6i} x^{a_{7i}}, \quad (3)$$

where y – is the indicator (dependent factor), i – is the number of the component of the model (3), m – is the number of members in the model (3), x – is the explanatory variable (influencing factor), $a_{1...}a_8$ – are the parameters of the model (3), which take numerical values in the course of structural-parametric identification in the CurveExpert-1.40 software environment, A_i – the amplitude (half) of the wavelet (axis y), p_i – the half-period of the oscillation (axis x).

CHANGE IN TIME COEFFICIENT OF DYNAMISM

After structural-parametric identification of formula (3), oscillations were identified, the parameters of which are given in Table 4.

The largest quantities of components were obtained for industrial lands (nine) and stock reserve lands (eight). Let us briefly consider the half-periods a_{5i} of oscillations in 1970 (Fig. 2).

For agricultural land since 1970, there has been a constant half-period of 5.09737 years, that is, the period of fluctuation is equal to two Soviet five-year plans. It turns out that the Soviet system of land use in agriculture has been completely preserved in Russia and it is aimed at increasing dynamism (positive sign).

Table 4. *Parameters (4) of the dynamics of the coefficient of dynamism (1) of the area of the Volzhsky district*

Category code	N i	Asymmetric wavelet $y_i = a_{1i}x^{a_{2i}}\exp(-a_{3i}x^{a_{4i}})\cos(\pi x/(a_{5i}+a_{6i}x^{a_{7i}})-a_{8i})$								Coef. correl. r
		Amplitude (half) oscillation				Wobble half period			Shift	
		a_{1i}	a_{2i}	a_{3i}	a_{4i}	a_{5i}	a_{6i}	a_{7i}	a_{8i}	
1	1	-4.44792e-10	8.39551	0.30343	1.01850	5.74377	0.075444	0.99345	3.84830	0.8809
	2	2.21350e-6	3.45101	0.077315	1.03386	5.09737	0	0	-1.11047	0.6787
	3	-3.15947e-7	4.66245	0.13862	1.05898	2.34334	0.0033574	1.09519	-1.57130	0.4826
2	1	0.0047864	0.73883	0.074069	1.00547	5.06078	0.0077458	0.93143	-0.67991	0.7449
3	1	-0.077831	1.35333	0.32117	1	9.64892	-0.55580	0.93081	-0.22971	0.4387
	2	1.11955e-16	13.23651	0.055541	1.54867	6.26564	0.0028069	1.80573	-2.59274	0.5364
	3	-2.73867e-7	7.48942	0.73882	0.84240	2.40005	-0.012834	1.18355	3.52907	0.7707
	4	-0.15765	0	0.95559	1	2.73256	0	0	0	0.6067
	5	4.46313e-13	10.62192	0.29327	1.06420	1.90841	-0.0041105	1.12346	-0.00267	0.4535
	6	-0.0050175	1.73751	0.67086	0.53369	1.56008	0.011292	1.38125	-1.41253	0.6604
	7	7.38770e-11	13.63608	1.09142	1.00978	1.19578	-0.00015858	1.95519	-0.17763	0.7068
	8	-1.21636e-10	7.67374	0.061574	1.39302	22.03094	0.0017644	1.22767	4.08453	0.5962
	9	1.87305e-8	6.27891	0.13903	1.18899	4.12497	0.0038884	1.86632	1.46845	0.5904
4	1	0.00018657	2.01828	0.20066	0.98864	5.27218	0.0011785	1.11309	-0.13546	0.4992
5	1	9.82985e-12	10.54189	0.23936	1.16226	4.42575	0.010090	1.44952	4.20309	0.8851
6	1	-0.00090592	2.30471	0.17738	1.01263	6.66338	0.00021626	2.08641	5.86615	0.6684
7	1	-2.52567e-8	2.97311	0	0	1.19473	0.70353	0.90971	-3.55120	0.9984
	2	5.18042e-5	3.47174	0.24644	0.63749	4.36298	0.022918	1.37327	2.58463	
	3	1.37030e-10	10.45961	0.82865	0.84579	0.94766	0.046449	1.01542	-2.07511	0.7482
	4	1.07840e-9	1.90544	-0.23937	1	4.27723	0	0	0	0.7065
	5	-0.00050453	6.06047	1.01210	0.98865	8.62759	-0.32370	1.00157	-3.27053	0.3758
	6	2.08113e-12	11.80506	0.54771	1.00515	2.27040	-0.012772	0.80501	-3.01453	0.5489
	7	1.74345e-24	22.58916	0.72998	1.03644	1.26530	0.00073494	0.50329	-3.93304	0.6864
	8	0.00044464	1.69814	0.015866	1.33491	13.69788	-0.15737	1.01679	-0.016866	0.7233
Bce	1	9.60716e-6	7.71389	1.01586	1.02418	4.53345	0.044079	1.36913	2.99546	0.8401

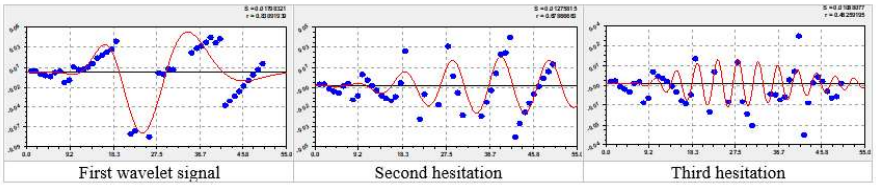

Fig. 2. *Dynamics of the distribution of the dynamic factor of agricultural land*

In this case, the first and third fluctuations are directed against (negative sign) the growth of the dynamism coefficient, but they calm down with an increase in the fluctuation period from $2 \times 5.74377 \approx 11.5$ years. In 1970, the first cycle of dynamism was equal to the average cycle of solar activity, in 2020 it was 19 years, and by 2070, according to the formula from Table 4 (if the land policy does not

change), it will already be slightly more than 26 years. Such is the relaxation in the dynamics of agricultural land.

The third wave will slow down the growth of dynamism: 1970 with a period of $2 \times 2.34334 \approx 4.7$ years, in 2020 - 4.3 years, and according to the forecast by 2070 - 3.9 years. Such an increase (Fig. 2) will already be dangerous.

However, all three oscillations decrease in amplitude. Apparently, the country has simply calmed down and is no longer paying attention to the ecological distribution of land.

THE DYNAMISM OF INDUSTRIAL LANDS

The largest number of wavelets was received by the category of lands for industry, transport, ... (Fig. 3). According to the maximum correlation coefficient of 0.2384 in 1998, the third category in terms of dynamism takes the third place after reserve lands and forest resources.

Of the nine wavelets, the fourth received a constant period of $2 \times 2.73256 \approx 5.5$ years, which is closer to the Soviet five-year plan or half of the solar activity cycle. The remaining periods for 1970 according to the hazard reduction rating: No. 7 - 2.4 years with a decrease; No. 5 - cycle 3.8 years with a decline; No. 3 - 4.8 years with a decrease in the period; No. 1 - 19.3 years with a reduction; No. 3 - 4.8 years with an increase in the period; No. 9 - 8.2 years up; No. 8 - 44.1 years with an increase.

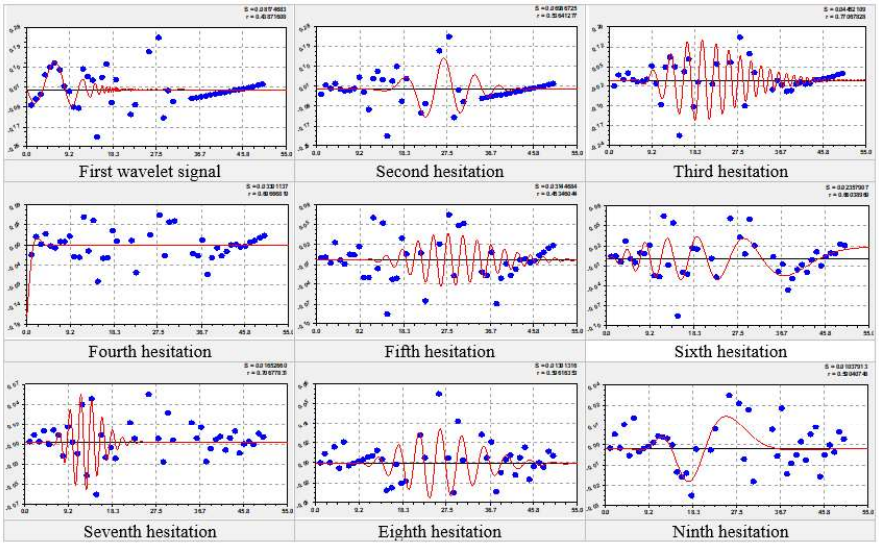

Fig. 3. *Dynamics of industrial and transport lands of the Volzhsky region from 1970 to 2020*

The fourth fluctuation is transitional from retrospective to 1970. At the same time, the amplitude of all fluctuations in the future decreases, that is, industrial lands

calm down. All asymmetric wavelets are finite-dimensional, and they appear only until 2020.

THE DYNAMISM OF THE LANDS OF THE RESERVE FUND

The category of the reserve stock (Fig. 4) refers, in our opinion, to the waste of land management that is undefined for its purpose.

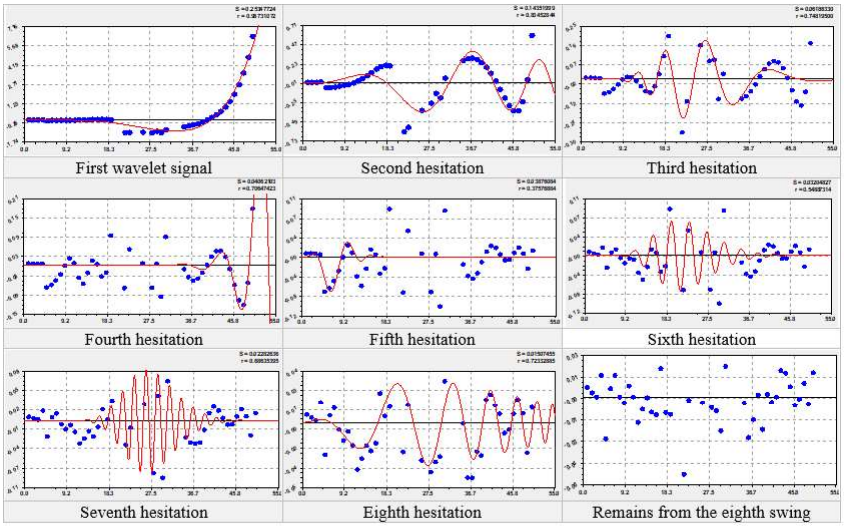

Fig. 4. *Dynamics of reserve lands of the Volga region of the RME from 1970 to 2020*

Wavelets # 1 and # 4 are becoming especially dangerous, as they strongly influence the future.

The amplitude of wavelet # 1 changes according to a power function, and that of wavelet # 4 according to the law of double growth (anomalous biotechnical law). Wavelets # 3, # 5-7 are finite-dimensional, as their influence is in the past. And the rest of the wavelets, although they are finite-dimensional, will continue after 2020. Therefore, reserve fund lands require special attention. It is known that in the best farms of municipalities the reserve lands are equal to zero.

THE DYNAMISM OF OTHER LAND CATEGORIES

Graphs for one waveform per category are shown in Figure 5.

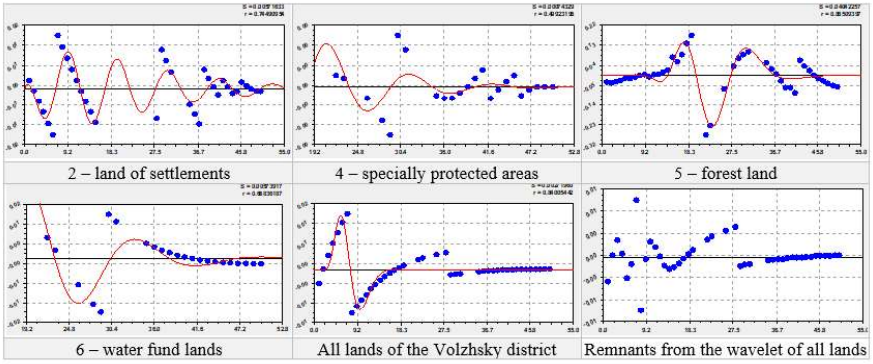

Fig. 5. *Dynamics of other land categories in the Volga region of the RME from 1970 to 2020*

All categories in Figure 5 have received fluctuations over 50 years, which most often appear due to the unconscious behavior of people in land use and land management. The periods of fluctuations grow with time and in 1970 they were equal: category 2 10.1 years, that is, settlements in Soviet times had a 10-year development cycle; specially protected areas - 10.6 years; forest land - 8.8 years; water fund lands - 13.4 years; all lands of the Volzhsky region - 9.1 years. Basically, in our country, the cycles of the past five-year plans clearly prevailed in land management and in the dynamism of the categories of the land fund.

CONCLUSION

In territorial planning and forecasting in the conditions of the Russian Federation, it is necessary to take into account the coefficients of dynamism of the area of all lands and by categories for all municipalities of the country, and not less than 50 years since 1970.

On the example of the Volga region of the Republic of Mari El, it can be seen that agricultural lands have contradictory three fluctuations, which decrease in amplitude until 2070. The largest number of fluctuations in 50 years occurred for two categories of lands: category 3 (industrial lands), nine wavelets, category 7 (lands of reserve stock) eight fluctuations.

The maxima in modulus of the dynamism coefficient are observed: 1 category - 0.0799 in 1992; 2 - 0.0177 in 1976; 3 - 0.2384 in 1998; 4 - 0.0018 in 2000; 5 - 0.2714 in 1992; 6 - 0.0160 in 1999; 7 - 6.4204 in 2020; all lands of the Volga region of the RME - 0.0135 in 1977. The most dynamic are lands of the reserve stock (category 7).

For agricultural land since 1970, there has been a constant half of the period of 5.1 years. It turns out that the Soviet system of land use in agriculture has been completely preserved in Russia and it is aimed at increasing dynamism. The first and third fluctuations are directed against the growth of the dynamism coefficient. For the third wave, the half-period will decrease (the oscillation frequency will

increase): 1970 with a period of 4.7 years, in 2020 - 4.3 years, and according to the forecast by 2070 - 3.9 years.

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