DYNAMICS OVER 50 YEARS OF AREA OF LANDS BY CATEGORIES OF THE INVENTORY OF THE VOLGA MUNICIPALITY OF THE REPUBLIC OF MARIY EL

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ABSTRACT

The waves of dynamics for 1970-2020 are revealed. by categories of land cadastre in the Volzhsky region of the RME. The first two terms out of eight forms Weibull's law, showing a decrease of 3292 hectares in the area according to Mandelbrot's law. Since 1970, the decline has been 3.60%. For 50 years, there have been two leaps in the reduction of the total area. After the first jump, 20 years have passed from 1978 to 1998, and after the second jump - 21 years from 1999 to 2020. For agricultural lands, the trend shows a steady decrease in area. This trend is noticeable for the country's municipalities. The first component of exponential growth reflects the desire to expand the habitat. And the second term, according to the law of the power function, gives the counteraction of nature to people. This fact shows that there is no ecological balance between agriculture and nature. In territorial planning and forecasting in the conditions of the Russian Federation, arrays of tabular data are urgently needed for all municipalities of the country since 1970. Agricultural lands have especially strong dynamics in 18 components in the form of fluctuations. In Finland, an ecological balance has long been formed, even at the farm level. In Russia, in the legalized minimum territorial unit (municipality) in the total area, strong fluctuations have occurred. A sharp surge in the land fund of the Volzhsky region occurred during the socio-economic crisis from 992 to 2005. This proves the lack of awareness of decision-makers in land policy. Next, you need a conscious behavior in the distribution of the land fund of municipalities of the Russian Federation by categories and types of land.

Keywords: *municipality, land, categories, area, dynamics over 50 years, patterns*

INTRODUCTION

"The earth is the most important part of the natural environment, characterized by space, relief, climate, soil cover, vegetation, bowels, waters, ..." [1]. In this part of the definition, the primacy of nature over man is fixed. And the second part "... which is the main means of production in agriculture and forestry, as well as the spatial basis for the location of Enterprises and organizations of all sectors of the national economy" already allows us to strongly doubt the primacy of nature.

For the municipalities of the Russian Federation, there is no data even for the categories of the land cadastre, although the level of municipalities is considered an elementary territorial unit of the country [2]. Due to the lack of official tabular data, it is necessary, for example, for the Volga municipal formation of one of the subjects of the federation - the Republic of Mari El, to use archival data to compile a tabular model for 50 years from 1970 to 2020. Such dynamics allow us to consider the behavior of land surveyors during the times in the USSR, during the transition period and in the post-Soviet period.

In article 1.9 of the law [2], there is "a differentiation of state ownership of land to the property of the Russian Federation, the property of the constituent entities of the Russian Federation and the property of municipalities, according to which the legal basis and the procedure for such a distinction are established by federal laws." Lands are lands that are systematically used or suitable for use for specific economic purposes and differ in their natural and historical characteristics [1], [2].

However, in the official data [3] there are land areas of the Russian Federation, federal districts [4] and subjects of the federation. But there is no data on municipalities. As a result, it is difficult to compare the territories of districts from different subjects of the federation. There are also no data tables in dynamics, for example, since 1970, even for the whole country.

All this hinders the study of lands, for example, in climatic geomorphology.

Outside of Russia, intensive research is being carried out on lands as part of the natural environment. For this, the consolidation of information from different sciences is carried out.

For example, geomorphic classification is a categorization and description of nature, origin and development of landforms. The fundamental basis of this classification is that a geomorphic unit can be classified collectively on the basis of its origin and development (process), from its general structure and shape (relief), from size and characteristics (morphometry), as well as the presence and overlay states (geomorphological generation). The first type of geomorphic process is considered the emergence and evolution of river networks [5].

The purpose of the study is to identify the patterns of dynamics of 1970-2019 land distribution by cadastre categories using the example of the Volga municipal formation from the Republic of Mari El (RME).

MATERIALS AND METHODS

From the annual reports on the structure of the land fund, data were written out on the area of the territory, as well as on 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.

We adhere to the concept of vibrational adaptation in nature and society. To detect fluctuations, land dynamics data of at least 50 years of series are needed to reveal the behavior of decision-makers.

On many examples of modeling, it was found that oscillations (asymmetric wavelet signals) are written by the wave formula [4] of the form

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

where y – is the indicator (dependent factor), i – is the number of the component of the model (1), m – is the number of members in the model (1), x – is the explanatory variable (influencing factor), $a_1 \ldots a_8$ – are the parameters of the model (1), 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).

DYNAMICS OF ALL LANDS

After structural-parametric identification (1), the components were obtained, the parameters of which are given in Table 2 (Fig. 1 and Fig. 2).

Table 2. *Parameters (1) of the dynamics of the Volzhsky district area for 1970-2020*

Number 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	91315.506	0	0	0	0	0	0	0	
2	3291.8604	0	0.091494	1	0	0	0	0	0,9812
3	-0.052884	11.09664	1.60631	0.97955	6.82907	0.00039541	3.35307	-1.39915	
4	19.68937	5.90198	1.09985	1	0.010183	0.051563	0.83742	2.94403	0.8068
5	-0.00025907	6.58958	0.29896	1	-0.041829	1.09124	0.48228	5.60842	0.6858
6	-358.09544	0	0.434823	1	1.59887	-0.036815	1	0.51327	0.6506
7	-30.46909	0.40398	0.00018312	2.38707	3.20749	0.0021286	1.62585	0.75863	0.6513
8	1.15333e-121	122.6843	3.88055	1.04132	2.57343	0	0	-4.45910	0.7655

Two terms form Weibull's law, showing the limit and decrease by 3292 hectares of area according to Laplace's law (in mathematics), Mandelbrot (in physics), Zipf-Perl (in biology) and Pareto (in econometrics). Since 1970, the decline has amounted to 100 3291.86 / 91315.5 = 3.60%.

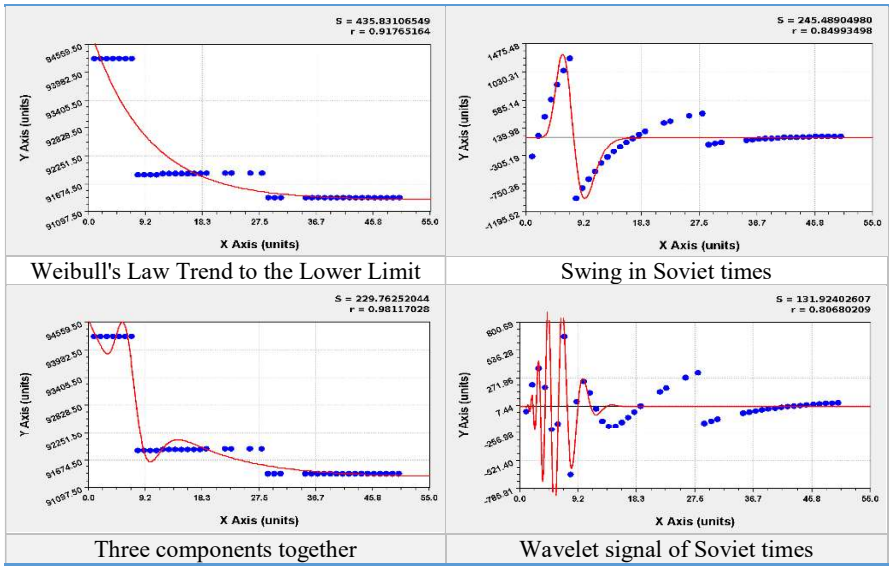
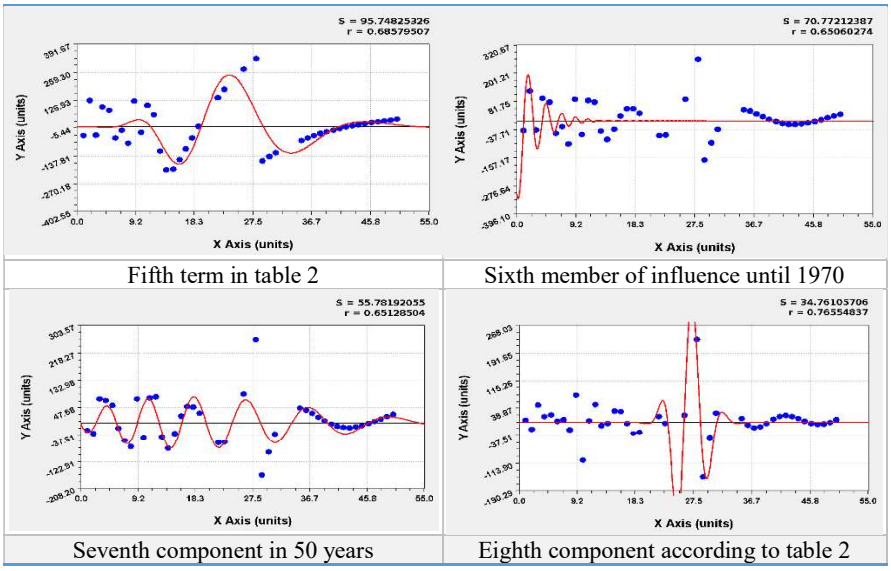


Fig. 1. *Dynamics of the distribution of all lands in the Volzhsky district of the Republic of Mari El*

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

For 50 years, there have been two leaps in the reduction of the total area. Each jump shows the work on the land inventory. After the first jump, 20 years passed from 1978 to 1998, and after the second jump - 21 years from 1999 to 2020.



Fifth term in table 2	Sixth member of influence until 1970
Seventh component in 50 years	Eighth component according to table 2

Fig. 2. *Additional graphs of the dynamics of the land fund of the Volzhsky region*

Even in the legalized minimal territorial unit (Volzhsky municipality), strong fluctuations occurred in the total area. The fifth and seventh wavelets show that the dynamics of the land area was not influenced by socio-economic changes (from 1970 to 1991 Soviet times, from 1992 to 1998 the transition period, and from 1999 to 2020 post-Soviet times). The basic principles of land use have remained unchanged

However, a sharp surge occurred during the socio-economic crisis in the period 1992-2005. Apparently, such a perturbation in the land fund was historically the last. Next, we need a conscious behavior in the distribution of the land fund of all municipalities of the Russian Federation in seven categories and 13 types of land. The residuals after the eighth term give the modeling error (Fig. 3).

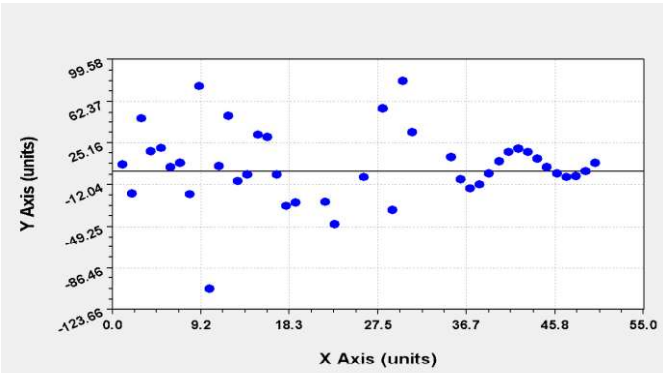


Fig. 3. *Remains after the eighth component*

The relative modeling error Δ is calculated by the formula

$$\Delta = 100\varepsilon_8 / y_f, \qquad (2)$$

where ε_8 – is the absolute error (residuals) after the eighth component (they show that other, but smaller, wavelets are also possible), y_f – are the actual values of the area of the district's land fund. The maximum error is -0.11% for 1980.

A small error in the decomposition of the dynamics of the land fund of the municipality into quanta of behavior shows that oscillatory adaptation is inherent not only for the total area, but also for the dynamics over 50 years of the area for certain categories of the land cadastre.

DYNAMICS OF THE AREA OF AGRICULTURAL LAND

The first category turned out to have the largest number of 18 components (Fig. 4, Table 3).

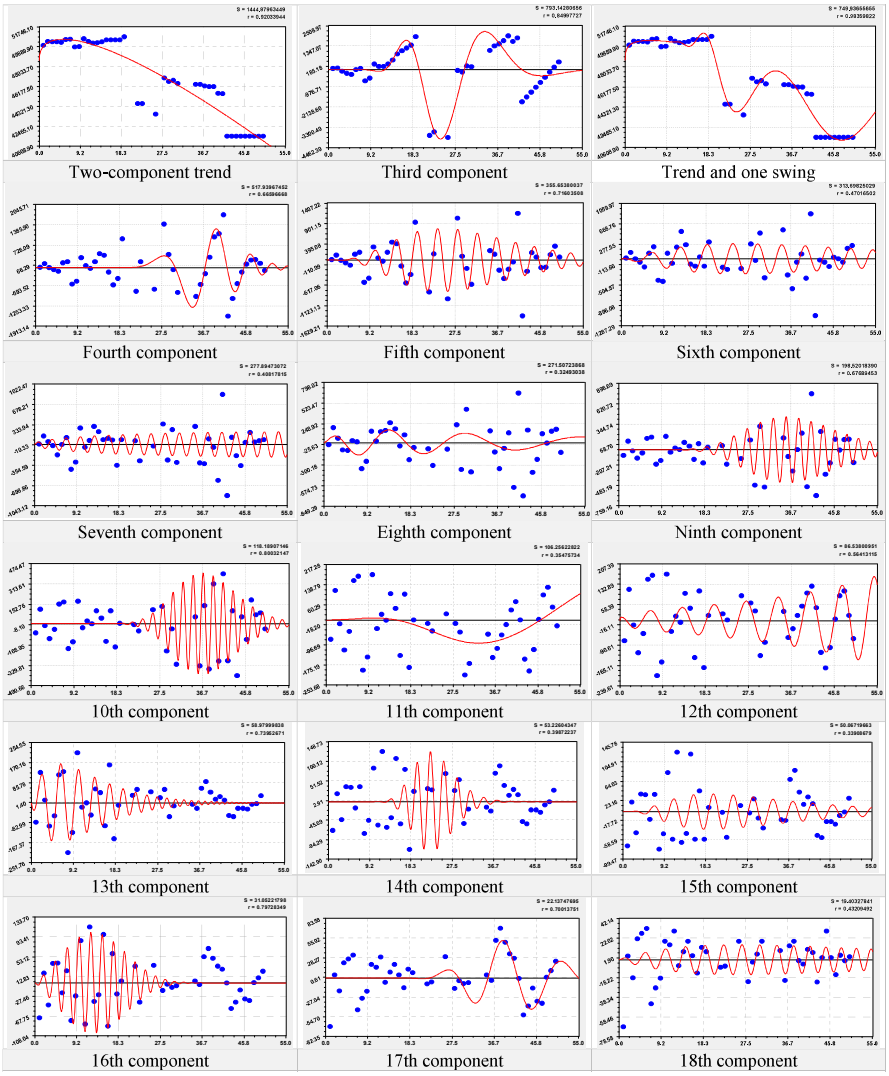


Fig. 4. *Dynamics of agricultural land in the Volzhsky region*

Table 3. *Parameters (1) of the dynamics of the area of agricultural land*

Number 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	48605.154	0	-0.068670	0.49573	0	0	0	0	0.9836
2	-2057.1628	0.58454	0	0	0	0	0	0	
3	1.07320e7	35.75245	51.92701	0.26637	0.48543	0.014150	1.32616	4.70353	
4	-1.05652e-32	29.69545	0.42318	1.14424	28.50149	-1.12339	0.75158	-4.10578	0.6660
5	0.12378	3.96909	0.16114	1	2.68892	-0.069322	0.51090	0.48493	0.7160
6	13.30661	1.37972	0.054277	1	13.28174	-8.87503	0.042751	-0.76643	0.4702
7	-45.92247	0.47778	0.0066244	1	1.54110	0	0	-1.64850	0.4082
8	-2.89811e6	3.02723	11.04307	0.17983	5.52788	0.020222	1.26775	3.92816	0.3249
9	5.06179e-14	14.37291	0.43211	0.98595	1.55625	-0.00047032	1.46711	0.75304	0.6769
10	-1.26778e-31	29.70062	0.81135	1.00085	1.11429	-0.00020152	1.28213	-4.55356	0.8003
11	-0.36756	1.22677	-0.033215	1	19.69619	0.00029996	2.60563	-2.31461	0.3548
12	20.09584	0.30405	-0.00083484	1.73894	3.41353	0	0	-0.30562	0.5641
13	-81.94109	0.89394	0.14977	1	2.23998	-0.010230	1.24441	-0.016226	0.7395
14	-2.48651e-21	57.70709	31.14591	0.45245	1.47803	0	0	0.92905	0.3987
15	-54912.385	8.64364	15.10267	0.26284	2.19944	0	0	-6.00482	0.3391
16	-7.91802	1.16215	0.00027135	2.86581	1.32601	-0.00012881	1.99985	1.15404	0.7973
17	9.33025e-23	19.91563	0.35329	1.07698	5.80799	0.010796	0.93198	0.84538	0.7001
18	-1.70827	0.96517	0.036703	1	2.35418	-0.0079353	1	-1.73565	0.4321

The two-term trend shows a steady decline in the area of agricultural land over the years. This trend is noticeable for all municipalities in the country. The first term is a modified Mandelbrot's law of exponential growth, and it reflects the desire to own an increasingly larger area. But the second term of the trend is negative for a person and, according to the equation of the power function, characterizes the opposition of the natural environment to the desire of people to expand their habitat.

DYNAMICS OF LANDS OF OTHER CATEGORIES

The rest of the dynamics models for 50 years have been identified according to the trend

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

where $y-$ is an indicator, $x-$ is a variable, a-$g-$ are parameters (2) detected in CurveExpert-1.40.

The stock lands received one asymmetric wavelet signal. Table 4 and Figure 5 show the results of model identification (2). Note that the trend is formed from the

oscillation (1) under the condition of multiple excesses of the oscillation period over the measurement period.

Table 4. *Parameters (2) of area dynamics for other land categories*

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	
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

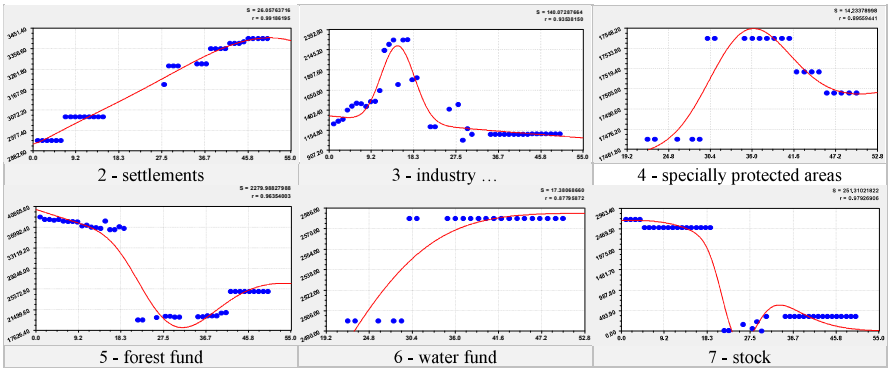


Fig. 5. *Graphs of the dynamics of the categories of the land fund of the Volzhsky region from 1970 to 2020*

The first term of formula (2) is physically natural, and the second term shows the stressful arousal of decision-makers. For example, the lands of settlements according to the first component of the trend are decreasing according to the modified Mandelbrot law, and this is opposed by the unlimited desire of people to expand the territory of their settlements. Over time, this category of land, according to the graph in Figure 5, will even decrease.

In the third category, in 1978-1991, an industrial boom was outlined and additional land areas for industrial construction were allocated more than twice in relation to 1991. The general trend according to Mandelbrot's law is decreasing. Only this fact indicates that they do as they want with the land fund. The area of specially protected areas has been sharply decreasing since 2010. According to Weibull's law, the area of the water fund has slightly increased, but since 2000 it has not changed at all.

The area of the forest fund naturally decreases according to Mandelbrot's law, but a sharp decline (due to the negative sign there was a strong crisis) occurred in three years from 1989 to 1992. (from 36756 to 19563 hectares, that is, a 1.9-fold decrease). This fact means that the forest management system did not function in

any way in the Volzhsky region. A slight increase in the forest area in 2012 occurred due to the transfer of the fallow overgrown with trees to the forest fund. As a result, the 50-year dynamics of the land was unconscious and not economic.

CONCLUSION

In territorial planning and forecasting in the conditions of the Russian Federation, there is an urgent need for arrays of official tabular data for all municipalities of the country, and for at least 50 years since 1970.

On the example of the Volga region of the Republic of Mari El, it can be seen that the land reforms carried out in our country have even aggravated the confusion in the understanding of environmental principles in the distribution of the land fund by categories of the land cadastre. Agricultural lands have particularly strong dynamics in 18 components in the form of a multitude of fluctuations. A strong struggle of opinions and official decisions are visible here.

There is no ecological balance between agriculture and the natural environment, as is achieved in Finland even at the farm level. In Russia, even in the legalized minimum territorial unit (Volzhsky municipality), strong fluctuations occurred in the total area. The basic principles of land use remained archaic.

A sharp surge in the eighth component of the general equation occurred in the entire land fund of the Volzhsky region during the socio-economic crisis in Russia from 1992 to 1998 and continued in the municipality until 2005. This proves the lack of awareness of the land policy. Next, we need a conscious behavior in the distribution of the land fund of all municipalities of the Russian Federation in seven categories and 13 types of land.

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