5. Development of agriculture, forestry and fisheries of Ukraine in the conditions of the economic and economic needs of society

The process of improving the sectoral structure of agricultural enterprises involves the implementation of certain measures that precede the determination of the main directions and ways of developing and implementing a mechanism for ensuring the optimization of the production structure when using agricultural land.

It is impossible and impractical to determine the priority of one of the branches of agriculture. Since animal husbandry is based on plant products, the fodder base for which is the following products: hay, straw, green fodder, grain fodder and some other types of agricultural crops. In turn, animal husbandry wastes, namely manure, are used in crop production as organic fertilizers, which ensure the improvement of soil quality indicators and crop yields. At the same time, it should also be noted the undeniably important role of the plant industry in the social life of a person in general. This area provides the population with food products and raw materials for the processing industry, including food, pharmaceutical, light, woodworking, etc.

During the period 2000-2020, the area of agricultural land in Ukraine decreased. If in 2000 its volume was 41.8 million hectares, then in 2020 it will be 41.5 million hectares. Based on the data of the State Statistics Service of Ukraine, this trend was observed during the entire period of the study.

At the same time, the improvement of land productivity must be evaluated not only based on its total volume, but also on the use of mineral and organic fertilizers.

The dynamics of changes in the total volume of applied mineral fertilizers (nitrogen, phosphorus, potassium) in Ukraine during 2000-2020 (Fig. 1) shows about the growth of this indicator in 2020 compared to 2000 by 9.86 times.

It should be noted that compared to 1990 (4,414.2 thousand tons), the indicator of 2020 is 1.59 times lower, which indicates the absence of a policy to support the productivity of the land fund in the 1990s. This can be justified by the destruction of the chemical industry, in particular, enterprises that produced mineral fertilizers. The trend of stable growth of the total volume of applied nitrogen, phosphorus, potassium mineral fertilizers in recent years allows us to assert the existence of opportunities to increase the productivity of the use of land resources in the future.

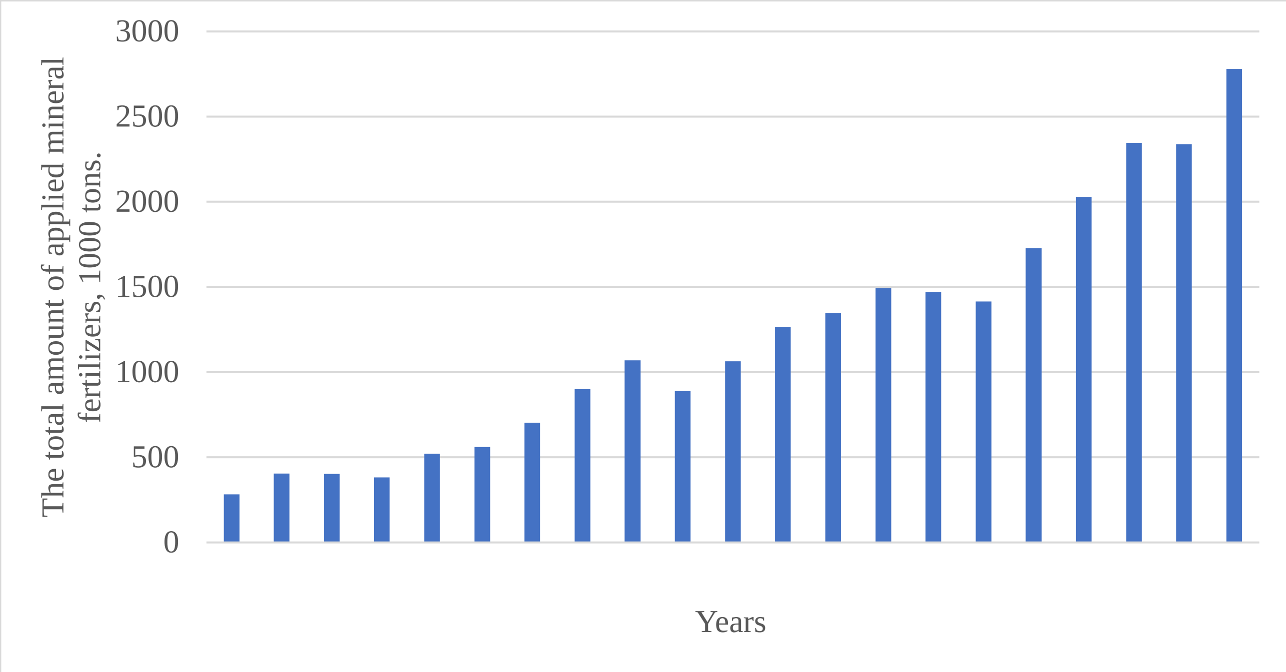

Figure 1. Dynamics of changes in the total volume of applied mineral fertilizers in Ukraine during 2000-2020, thousand tons.

(Compiled by the authors based on the data of the State Statistics Service of Ukraine)

It should be noted that compared to 1990 (4,414.2 thousand tons), the indicator of 2020 is 1.59 times lower, which indicates the absence of a policy to support the productivity of the land fund in the 1990s. This can be justified by the destruction of the chemical industry, in particular, enterprises that produced mineral fertilizers. The trend of stable growth of the total volume of applied nitrogen, phosphorus, potassium mineral fertilizers in recent years allows us to assert the existence of opportunities to increase the productivity of the use of land resources in the future.

Applying fertilizers is an important means of increasing the yield of crops and, accordingly, the efficiency of land use in agriculture. The effect of fertilization is achieved only with a balanced application of fertilizers, with an optimal combination of all components, maintaining the appropriate proportions between them. The level of fertilization of crops ultimately affects the revenue from the sale of plant products.

At the enterprise, a situation may arise when one of the components is preferred during fertilization. Yes, one of the elements most necessary for plants is nitrogen. It plays a significant role in improving soil properties and increasing their fertility.

Thanks to the introduction of nitrogen fertilizers, not only the yield of crops increases, but also the quality of agricultural products improves (the protein and gluten content in wheat increases, the sugar content in sugar beet increases, etc.) [90, p. 75]. Guided by such considerations, the enterprise can choose a ratio of fertilizers in which phosphorus and potassium fertilizers are provided. However, based on the fact that in the previous version, the applied amount of nitrogen fertilizers was not fully used, this ratio does not make sense, since the fertilizers are fully used only in the optimal ratio provided by the norm. The actual use of applied nitrogen fertilizers will be limited by the amount of applied phosphorus and potash fertilizers. This is explained by the effect of the law of the minimum, according to which the productivity of the field is directly dependent on the necessary component of nutrients that the soil contains in the smallest (minimum) amount [91, p. 9-10].

Phosphorus also plays an important role in the life of plants. The use of phosphoric fertilizers increases the yield of crops, improves the quality of products, and in addition, leads to the acceleration of plant maturation and increases their resistance to diseases [90, p. 75]. Phosphorus deficiency is characteristic of most soils.

Therefore, the use of phosphorus fertilizers is quite effective here. Potassium is also necessary for plant development. This element participates in the accumulation of proteins, stimulates the synthesis and accumulation of carbohydrates, and also increases the resistance of plants to lodging and damage by diseases. Potassium stimulates enzymatic processes in plants, increases their winter resistance and drought resistance [90, p. 75]. In some cases, potassium may be in short supply, so its application to the soil has a positive effect on fertility.

With the help of correlation-regression analysis, we will consider the dependences between different types of mineral fertilizers (nitrogen, phosphorus and potash), which are introduced to increase the fertility of agricultural lands. The peculiarity of this study is the construction of an inverse dependence, which will allow to assess the sufficiency (insufficiency) of potash and phosphorus fertilizers per unit area of agricultural land (Fig. 2).

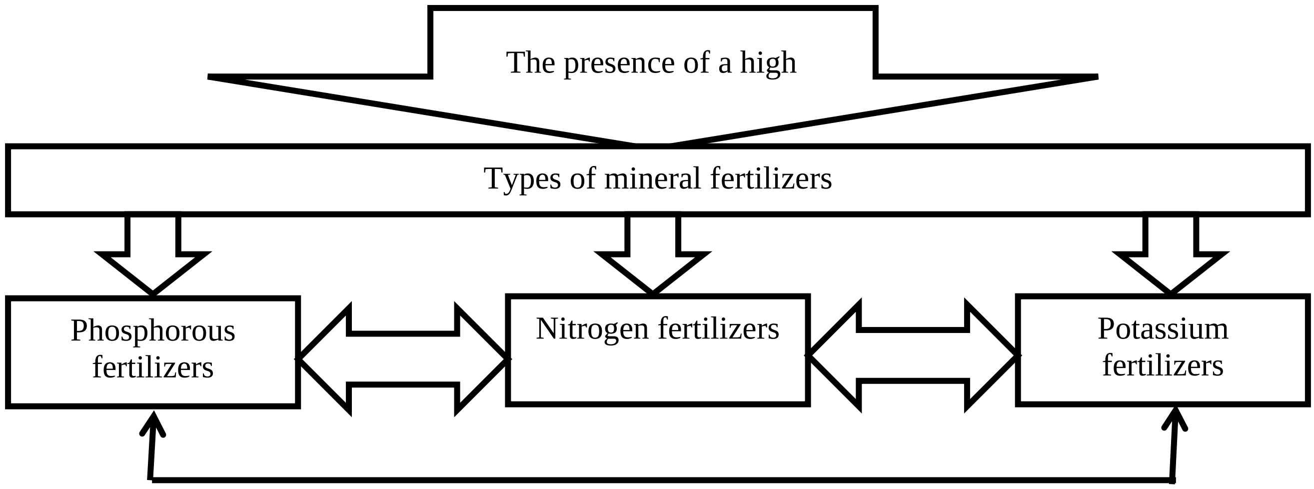

Figure 2. Scheme for assessing the sufficiency (insufficiency) of mineral fertilizers per unit area of agricultural land

(Built by the author)

The dependence of the application of nitrogen fertilizers per unit area of agricultural land on the amount of phosphorus fertilizers is characterized by growth trends.

Taking into account the high density of the connection, it is possible to say with one hundred percent certainty that the use of 1 kg of phosphorus fertilizers per 1 ha will lead to the use of 5.931 kg of nitrogen fertilizers.

The inverse dependence of this regression is the dependence of the application of phosphorus fertilizers per unit area of agricultural land on the volume of nitrogen fertilizers. In this case, there is a tendency to decrease the amount of phosphorus fertilizers per unit area of agricultural land in the case of nitrogen fertilizers.

If 1 kg of nitrogen fertilizers are applied per 1 ha of agricultural land, the lack of phosphorus fertilizers will amount to 0.2039 kg per 1 ha.

For a more detailed analysis of the sufficiency (insufficiency) of phosphorus and nitrogen fertilizers per unit area of agricultural land, we suggest considering both regression equations in the context of trends over the last twenty years (Table 1).

Table 1.

Assessment of the sufficiency (insufficiency) of nitrogen and phosphorus fertilizers per unit area of agricultural land

Regression equation	Evaluation of possible options
y=3,6479*x+2,2831	1. Phosphorous fertilizers are not applied (x=0). The minimum amount of nitrogen fertilizers applied in this case will be 2.2831 kg per 1 ha (3.6479*0+2.2831=2.2831). 2. It is planned not to apply nitrogen fertilizers (y=0). The lack of phosphorus fertilizers will amount to 0.6259 kg per 1 ha (x = -2.2831/3.6479 = -0.6259).
y=0,2664*x-0,4703	1. Nitrogen fertilizers are not applied (x=0). The lack of phosphorus fertilizers will amount to 0.4703 kg per 1 ha (0.2664*0-0.4703 = - 0.4703). 2. It is planned not to apply phosphorus fertilizers (y=0). The minimum amount of nitrogen fertilizers applied in this case will be 1.7654 kg per 1 ha (0.4703/0.2664=1.7654).

There is a lack of phosphorus fertilizers in the range from 0.4703 kg per 1 ha to 0.6259 kg per 1 ha in the case of no application of nitrogen fertilizers. At the same time, the minimum need for applying nitrogen fertilizers per 1 ha in the absence of phosphorus fertilizers is in the range from 1.7654 kg to 2.2831 kg.

In this way, it is possible to overcome the lack of phosphorus fertilizers under the condition of sufficiency of nitrogen fertilizers in the case of applying the latter more than 1.7654 kg per 1 ha of agricultural land.

The relationship between the application of potassium fertilizers per unit area of agricultural land and the volume of nitrogen fertilizers, studied on the basis of statistical data for the last 20 years, is characterized by high density. The dependence of the amount of potash fertilizers applied per unit area of agricultural land on the application of nitrogen fertilizers has a decreasing trend, because in the case of applying 1 kg of potash fertilizers per 1 ha, the lack of potash fertilizers will amount to 0.2461 kg per 1 ha.

The inverse regression to this is the regression of the dependence of the volume of nitrogen fertilizers on the application of potash fertilizers per unit area of agricultural land. The regression equation shows the increasing trend of this regression. In the case of applying 1 kg of potash fertilizers per 1 ha of agricultural land, the required amount of nitrogen fertilizers will be 6.904 kg.

According to the conducted studies, in the first case, there is a need to constantly increase the volume of nitrogen fertilizers to cover their guaranteed reduction in the amount of 0.4715 kg per 1 ha. In the second case, even with a zero amount of potash fertilizers per 1 ha of agricultural land, 4.3134 kg will be applied.

Considering the inverse of these equations in relation to each other, consider the level of sufficiency (insufficiency) of potash and nitrogen fertilizers per unit area of agricultural land (Table 2).

Table 2

Assessment of the sufficiency (insufficiency) of potash and phosphorus fertilizers per unit area of agricultural land

Regression equation	Evaluation of possible options
y=4,3134*x+2,5906	1. Potassium fertilizers are not applied (x=0). The minimum amount of nitrogen fertilizers applied in this case will be 2.5906 kg per 1 ha (4.3134*0+2.5906=2.5906). 2. It is planned not to apply nitrogen fertilizers (y=0). The lack of potassium fertilizers will amount to 0.6006 kg per 1 ha (x=-2.5906/4.3134= -0.6006).
y=0,2254*x-0,4715	1. Nitrogen fertilizers are not applied (x=0). The lack of potassium fertilizers will amount to 0.4715 kg per 1 ha (0.2254*0-0.4715= -0.4715). 2. It is planned not to apply potash fertilizers (y=0). The minimum amount of nitrogen fertilizers applied in this case will be 2.0918 kg per 1 ha (0.4715/0.2254=2.0918).

There is a shortage of potash fertilizers in the range from 0.4715 kg per 1 ha to 0.6006 kg per 1 ha in the case of not applying phosphorus fertilizers. At the same time, the minimum need for applying nitrogen fertilizers per 1 ha in the absence of potash fertilizers is between 2.0918 kg and 2.5906 kg.

In this way, it is possible to overcome the lack of potash fertilizers under the condition of sufficiency of nitrogen fertilizers in the case of applying the latter more than 2.0918 kg per 1 ha of agricultural land.

The dependence of the application of potash fertilizers on the amount of phosphorus fertilizers per unit area of agricultural land is characterized by a high density of connection, and the equation y=0.8417*x-0.0516 indicates a tendency to decrease the amount of potash fertilizers by 0.0516 kg per 1 ha.

In turn, the introduction of any amount of phosphorus fertilizers per unit of agricultural land leads to an increase in the amount of potash fertilizers by 0.8417 times. Thus, taking into account the trend over the last 20 years, it can be concluded that the application of 1 kg per 1 ha of phosphorus fertilizers leads to the need to apply 0.7901 kg per 1 ha of potash fertilizers.

The inverse equation of this regression is the equation y=1.1762*x+0.1098, and therefore it characterizes the tendency of growth in the amount of potash fertilizers applied per unit area of agricultural land by 0.1098 kg per 1 ha.

As a result, in the case of applying 1 kg of potash fertilizers per 1 ha of agricultural land, 1.286 kg of phosphorous fertilizers are applied.

Considering the inverse of these equations in relation to each other, consider the level of sufficiency (insufficiency) of potash and phosphorus fertilizers per unit area of agricultural land (Table 3).

Table 3

Assessment of the sufficiency (insufficiency) of potash and phosphorus fertilizers per unit area of agricultural land

Regression equation	Evaluation of possible options
y=1,1762*x+0,1098	1. Potassium fertilizers are not applied (x=0). The minimum amount of phosphoric fertilizers applied in this case will be 0.1098 kg per 1 ha (1.1762*0+0.1098=0.1098). 2. It is planned not to apply phosphorus fertilizers (y=0). The lack of potassium fertilizers will amount to 0.0933 kg per 1 ha (x=-0.1098/1.1762= -0.0933).
y=0,8417*x-0,0516	1. Phosphorous fertilizers are not applied (x=0). The lack of potassium fertilizers will amount to 0.0516 kg per 1 ha (0.8417*0-0.0516= -0.0516). 2. It is planned not to apply potash fertilizers (y=0). The minimum amount of phosphoric fertilizers applied in this case will be 0.0613 kg per 1 ha (0.0516/0.8417=0.0613).

There is a shortage of potash fertilizers in the range from 0.0516 kg per 1 ha to 0.0933 kg per 1 ha in the case of no application of phosphorus fertilizers. At the same time, the minimum need to apply phosphorus fertilizers per 1 ha in the absence of potash fertilizers is in the range from 0.0613 kg to 0.1098 kg.

In this way, it is possible to overcome the lack of potash fertilizers under the condition of sufficiency of phosphorus fertilizers in the case of applying the latter more than 0.0613 kg per 1 ha of agricultural land.

We will estimate the sufficiency (insufficiency) of mineral fertilizers by calculating the average indicators (Fig. 3).

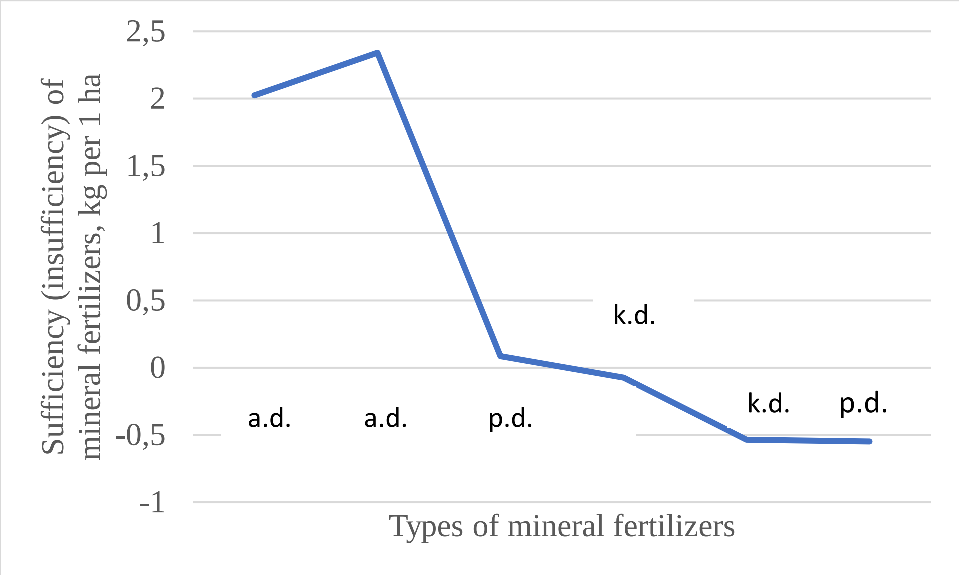

Figure 3. Average indicators of the dynamics of sufficiency (insufficiency) by types of mineral fertilizers (a.d. – nitrogen fertilizers, p.d. – phosphoric fertilizers, k.d. – potash fertilizers)

(Built by the author)

The conducted analysis allows us to conclude that in Ukraine there are all possibilities to achieve the minimum sufficiency of nitrogen fertilizers in relation to phosphorus fertilizers (average value 2.02425 kg per 1 ha) and potash fertilizers (2.3412 kg per 1 ha). In turn, the minimum sufficiency of phosphorus fertilizers in relation to potash is 0.08555 kg per 1 ha.

The shortage of potash fertilizers in Ukraine is the largest: in relation to phosphorus fertilizers - 0.07245 kg per 1 ha, nitrogen fertilizers - 0.53605 kg per 1 ha. The lack of phosphorus fertilizers in the context of the use of nitrogen fertilizers is 0.5481 kg per 1 ha.

Phosphorous fertilizers are the only type of mineral fertilizers, the use of which can provide both minimum sufficiency per unit area of agricultural land, and be insufficient in the calculation of two other types of fertilizers.

An example of the relationship between the volume of organic fertilizers and the application of nitrogen fertilizers per unit area of agricultural land is shown in fig. 4.

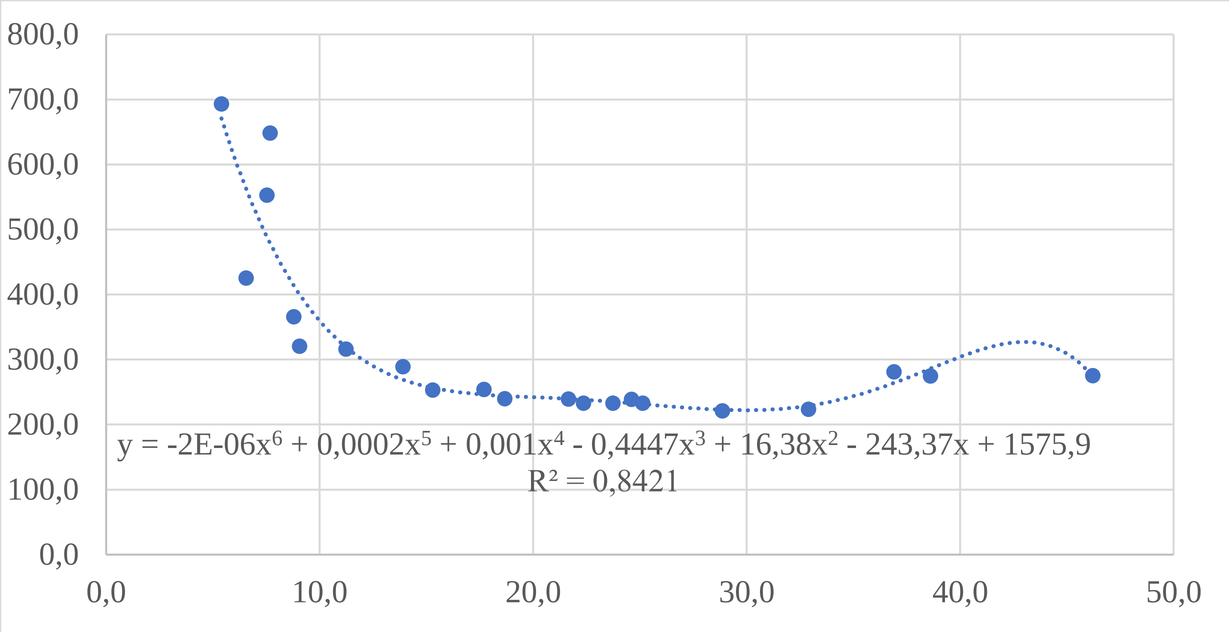

Figure 4. Dependence of the volume of organic fertilizers on the application of nitrogen fertilizers per unit area of agricultural land, kg per 1 ha
(Compiled by the author based on the data of the State Statistics Service of Ukraine)

The absence of a tight relationship when calculating a straight-line regression indicates a low dependence between the types of mineral fertilizers and organic fertilizers. Based on this, we propose to separately consider the importance and role of organic fertilizers in the development of land resources of the state.

You should pay attention to the form (regression equation) and features of the possible connection in the case of realizing the needs to comply with significant density.

In this case, the persistent instability of the development of the provision of organic fertilizers in the context of nitrogen fertilizers with a clearly expressed trend of decreasing their volume is characteristic.

By analogy with the calculations carried out, we will determine the amount of sufficiency (insufficiency) of mineral and organic fertilizers for crops: grain and leguminous crops (without corn), corn for grain, industrial crops, fodder crops.

The dependence of the volume of mineral fertilizers for corn crops per grain on the application of mineral fertilizers for grain and leguminous crops (without corn) is characterized by increasing trends of the regression line at a high connection density.

Thus, applying 1 kg of mineral fertilizers per 1 ha of grain and leguminous crops (without corn) provides a volume of 20.6406 kg of mineral fertilizers for corn crops per grain.

The inverse function to the given one has a decreasing character, characterized by the corresponding equation. Thus, the introduction of 1 kg of mineral fertilizers per 1 ha of corn crops for grain will lead to a shortage of mineral fertilizers for crops of grain and leguminous crops (without corn) in the amount of 10.8029 kg.

For a more detailed analysis of the sufficiency (insufficiency) of mineral fertilizers for sowing grain and leguminous crops (without corn) and corn per grain per unit area of agricultural land, we suggest considering both regression equations in the context of trends over the last twenty years (Table 4).

Table 4

Assessment of the sufficiency (insufficiency) of mineral fertilizers for sowing grain and leguminous crops (without corn) and corn for grain per unit area of agricultural land

Regression equation	Evaluation of possible options
y=1,1256*x+19,515	1. Mineral fertilizers are not applied to grain and leguminous crops (without corn) (x=0). In this case, the minimum amount of mineral fertilizers applied to corn crops per grain will be 19.515 kg per 1 ha (1.1256*0+19.515=19.515). 2. It is planned not to apply mineral fertilizers under corn crops for grain (y=0). The lack of mineral fertilizers for sowing grain and leguminous crops (without corn) will amount to 17.3374 kg per 1 ha (x=-19.515/1.1256= -17.3374).
y=0,8261*x-11,629	1. Mineral fertilizers are not applied under corn crops for grain (x=0). The lack of mineral fertilizers for grain and leguminous crops (without corn) will amount to 11.629 kg per 1 ha (0.8261*0-11.629= -11.629). 2. It is planned not to apply mineral fertilizers under crops of grain and leguminous crops (without corn) (y=0). In this case, the minimum amount of mineral fertilizers applied to corn crops per grain will be 14.077 kg per 1 ha (11.629/0.8261=14.077).

There is a shortage of mineral fertilizers for grain and leguminous crops (without corn) ranging from 11.629 kg per 1 ha to 17.33744 kg per 1 ha in the case of not applying mineral fertilizers for corn for grain crops. At the same time, the minimum need to apply mineral fertilizers for corn crops per 1 ha in the absence of mineral fertilizers for grain and leguminous crops (without corn) ranges from 14,077 kg to 19,515 kg.

In this way, it is possible to overcome the lack of mineral fertilizers for sowing grain and leguminous crops (without corn) under the condition of sufficiency of mineral fertilizers for sowing corn for grain in the case of applying the latter more than 14.077 kg per 1 ha of agricultural land.

The dependence of the volume of mineral fertilizers for crops of industrial crops on the application of mineral fertilizers for crops of grain and leguminous crops (without corn) per unit area of agricultural land is characterized by growth trends with a significant density of communication.

If 1 kg of mineral fertilizers are applied for grain and leguminous crops (without corn) per unit area of agricultural land, then based on the equation of the regression line, the amount of mineral fertilizers for technical crops will be 14.979 kg per 1 ha.

The function $y=1.2867*x-15.175$ is the inverse of the function $y=0.739*x+14.24$, and therefore, taking into account the negative value of the free coefficient (15.175), it has a decreasing character. Application of 1 kg of mineral fertilizers for crops of technical crops per 1 ha will lead to a shortage of mineral fertilizers for crops of grain and leguminous crops (without corn) by 13.8883 kg.

For a more detailed analysis of the sufficiency (insufficiency) of mineral fertilizers for sowing grain and leguminous crops (without corn) and technical crops per unit area of agricultural land, we suggest considering both regression equations in the context of trends over the last twenty years (Table 5).

Table 5

Assessment of the sufficiency (insufficiency) of mineral fertilizers for sowing grain and leguminous crops (without corn) and industrial crops per unit area of agricultural land

Regression equation	Evaluation of possible options
y=0,739*x+14,24	1. Mineral fertilizers are not applied to grain and leguminous crops (without corn) (x=0). In this case, the minimum amount of mineral fertilizers applied to crops of technical crops will be 14.24 kg per 1 ha (0.739*0+14.24=14.24). 2. It is planned not to apply mineral fertilizers under crops of technical crops (y=0). The lack of mineral fertilizers for sowing grain and leguminous crops (without corn) will amount to 19.2692 kg per 1 ha (x=-14.24/0.739= -19.2692).
y=1,2867*x-15,175	1. Mineral fertilizers are not applied to crops of industrial crops (x=0). The lack of mineral fertilizers for grain and leguminous crops (without corn) will amount to 15.175 kg per 1 ha (1.2867*0-15.175= -15.175). 2. It is planned not to apply mineral fertilizers under crops of grain and leguminous crops (without corn) (y=0). In this case, the minimum amount of mineral fertilizers applied for sowing technical crops will be 11.7937 kg per 1 ha (15.175/1.2867=11.7937).

There is a shortage of mineral fertilizers for crops of grain and leguminous crops (without corn) ranging from 15.175 kg per 1 ha to 19.2692 kg per 1 ha in the case of not applying mineral fertilizers for crops of technical crops. At the same time, the minimum need for the application of mineral fertilizers for the sowing of technical crops per 1 ha in the absence of the application of mineral fertilizers for the sowing of grain and leguminous crops (without corn) is in the range from 11.7937 kg to 14.24 kg.

In this way, it is possible to overcome the lack of mineral fertilizers for crops of grain and leguminous crops (without corn), under the condition of sufficient mineral fertilizers for crops of corn for grain, in the case of applying the latter more than 11.7937 kg per 1 ha of agricultural land.

The dependence of the volume of mineral fertilizers for fodder crops on the application of mineral fertilizers for grain and leguminous crops (without corn) per unit area of agricultural land is characterized by a downward trend with close connection. The equation y=0.5003*x-5.2882 characterizes the insufficiency of mineral fertilizers in the amount of 5.2882 kg per 1 ha, which has been laid in the last twenty years in the system of applying agricultural land under the conditions of this dependence.

Based on the regression equation, if 1 kg of mineral fertilizers are applied to crops of grain and leguminous crops (without corn) per unit area of agricultural land, then the lack of mineral fertilizers for crops of fodder crops will amount to 5.2882 kg per 1 ha.

The inverse of the equation y=0.5003*x-5.2882 is the regression y=1.9459*x+11.991, which has a tendency to increase the volume of mineral fertilizers for grain and leguminous crops (without corn) due to the introduction of mineral fertilizers for fodder crops per unit area of agricultural land. The minimum amount of increase in the amount of mineral fertilizers applied to crops of grain and leguminous crops (without corn) is 11,991 kg per 1 ha.

In the case of application of 1 kg of mineral fertilizers for sowing fodder crops per 1 ha of agricultural land, the volume of mineral fertilizers for sowing grain and leguminous crops (without corn) will be 13.9369 kg.

For a more detailed analysis of the sufficiency (insufficiency) of mineral fertilizers for sowing grain and leguminous crops (without corn) and fodder crops per unit area of agricultural land, we suggest considering both regression equations in the context of trends over the last twenty years (Table 6).

Table 6

Assessment of the sufficiency (insufficiency) of mineral fertilizers for sowing grain and leguminous crops (without corn) and industrial crops per unit area of agricultural land

Regression equation	Evaluation of possible options
y=1,9459*x+11,991	1. Mineral fertilizers are not applied under fodder crops (x=0). In this case, the minimum amount of mineral fertilizers applied to grain and leguminous crops (without corn) will be 11.991 kg per 1 ha (1.9459*0+11.991=11.991). 2. It is planned not to apply mineral fertilizers under crops of grain and leguminous crops (without corn) (y=0). The lack of mineral fertilizers for sowing fodder crops will amount to 6.1622 kg per 1 ha (x= -11.991/1.9459= -6.1622).

Continuation of table 6

y=0,5003*x-5,2882	1. Mineral fertilizers are not applied to grain and leguminous crops (without corn) (x=0). The lack of mineral fertilizers for sowing fodder crops will amount to 5.2882 kg per 1 ha (0.5003*0-5.2882= -5.2882). 2. It is planned not to apply mineral fertilizers under fodder crops (y=0). In this case, the minimum amount of mineral fertilizers applied to grain and leguminous crops (without corn) will be 10.57 kg per 1 ha (5.2882/0.5003=10.57).

There is a lack of mineral fertilizers for sowing fodder crops in the range from 5.2882 kg per 1 ha to 6.1622 kg per 1 ha in the case of not applying mineral fertilizers for sowing grain and leguminous crops (without corn). At the same time, the minimum need for applying mineral fertilizers for crops of grain and leguminous crops (without corn) per 1 ha in the absence of application of mineral fertilizers for crops of fodder crops is in the range from 10.57 kg to 11.991 kg.

In this way, it is possible to overcome the lack of mineral fertilizers for sowing fodder crops under the condition of sufficiency of mineral fertilizers for sowing grain and leguminous crops (without corn) in the case of applying the latter more than 10.57 kg per 1 ha of agricultural land.

The dependence of the amount of mineral fertilizers for technical crops on the application of mineral fertilizers for corn crops per grain per unit area of agricultural land is characterized by growth trends under conditions of high bond density, since for 0.6345 of the amount of mineral fertilizers applied for corn crops, 3.453 kg per grain is added on 1 ha.

If 1 kg of mineral fertilizers are applied to corn crops per grain, then the amount of applied mineral fertilizers to technical crop crops will be 4.0875 kg per 1 ha.

The dependence of the volume of mineral fertilizers for corn crops per grain on the application of mineral fertilizers for crops of technical crops per unit area of agricultural land is inverted to the function y=0.6345*x+3.453, characterized by downward trends, since by 1.5047 mineral fertilizers for crops of technical crops a decrease of 1.0552 kg per 1 ha is observed.

If 1 kg of mineral fertilizers are applied to crops of technical crops, the volume of mineral fertilizers for crops of corn per grain per unit area of agricultural crops will be 0.4495 kg.

For a more detailed analysis of the sufficiency (insufficiency) of mineral fertilizers for sowing corn per grain and industrial crops per unit area of agricultural land, we suggest considering both regression equations in the context of trends over the last twenty years (Table 7).

Table 7

Assessment of the sufficiency (insufficiency) of mineral fertilizers for sowing corn for grain and industrial crops per unit area of agricultural land

Regression equation	Evaluation of possible options
y=0,6345*x+3,453	1. Mineral fertilizers are not applied under corn crops for grain (x=0). In this case, the minimum amount of mineral fertilizers applied for sowing technical crops will be 3.453 kg per 1 ha (0.6345*0+3.453=3.453). 2. It is planned not to apply mineral fertilizers under crops of technical crops (y=0). The lack of mineral fertilizers for corn crops per grain will amount to 5.442 kg per 1 ha (x= -3.453/0.6345= -5.442).
y=1,5047*x-1,0552	1. Mineral fertilizers are not applied to crops of industrial crops (x=0). The lack of mineral fertilizers for corn crops per grain will amount to 1.0552 kg per 1 ha (1.5047*0-1.0552= -1.0552). 2. It is planned not to apply mineral fertilizers under corn crops for grain (y=0). In this case, the minimum amount of mineral fertilizers applied for sowing industrial crops will be 0.7013 kg per 1 ha (1.0552/1.5047=0.7013).

There is a lack of mineral fertilizers for corn crops per grain ranging from 1.0552 kg per 1 ha to 5.442 kg per 1 ha in the case of not applying mineral fertilizers for technical crops. At the same time, the minimum need for the application of mineral fertilizers for crops of industrial crops per 1 ha in the absence of application of mineral fertilizers for crops of corn per grain is in the range from 0.7013 kg to 3.453 kg.

In this way, it is possible to overcome the lack of mineral fertilizers for sowing corn for grain under the condition of sufficiency of mineral fertilizers for sowing industrial crops in the case of applying the latter more than 0.7013 kg per 1 ha of agricultural land.

The dependence of the amount of mineral fertilizers for fodder crops on the application of mineral fertilizers for corn crops per grain per unit area of agricultural crops is characterized by a high density of connection and downward trends in the regression equation, since for any amount of mineral fertilizers applied for corn crops per grain, a decrease the volume of mineral fertilizers for fodder crops will be 10,994 kg per 1 ha.

In the case of application of 1 kg of corn per grain per unit area of agricultural land, the lack of mineral fertilizers for sowing fodder crops will amount to 10.5819 kg per 1 ha.

The dependence of the volume of mineral fertilizers for corn crops per grain on the application of mineral fertilizers for fodder crops per unit area of agricultural land is inverse to the previous one. It is characterized by growth trends, since in the case of applying any amount of mineral fertilizers for fodder crops per unit area of agricultural land, the amount of mineral fertilizers for corn crops per grain will increase by 33.185 kg per 1 ha.

If 1 kg of mineral fertilizers for fodder crops are applied per unit area of agricultural land, then the volume of mineral fertilizers for corn crops per grain will be 35.3683 kg per 1 ha.

For a more detailed analysis of the sufficiency (insufficiency) of mineral fertilizers for sowing corn for grain and fodder crops per unit area of agricultural land, we suggest considering both regression equations in the context of trends over the last twenty years (Table 8).

Table 8

Assessment of the sufficiency (insufficiency) of mineral fertilizers for sowing corn for grain and fodder crops per unit area of agricultural land

Regression equation	Evaluation of possible options
y=2,1833*x+33,185	1. Mineral fertilizers are not applied under fodder crops (x=0). In this case, the minimum amount of mineral fertilizers applied to corn crops per grain will be 33.185 kg per 1 ha (2.1833*0+33.185=33.185). 2. It is planned not to apply mineral fertilizers under corn crops for grain (y=0). The lack of mineral fertilizers for sowing fodder crops will amount to 15.1995 kg per 1 ha (x= -33.185/2.1833= -15.1995).

Continuation of table 8

y=0,4121*x-10,994	1. Mineral fertilizers are not applied under corn crops for grain (x=0). The lack of mineral fertilizers for sowing fodder crops will amount to 10.994 kg per 1 ha (0.4121*0-10.994= -10.994). 2. It is planned not to apply mineral fertilizers under fodder crops (y=0). The minimum amount of mineral fertilizers introduced in this case for corn crops per grain will be 26.678 kg per 1 ha (10.994/0.4121=26.678).

There is a lack of mineral fertilizers for fodder crops in the range from 10.994 kg per 1 ha to 15.1995 kg per 1 ha in the case of not applying mineral fertilizers for corn for grain crops. At the same time, the minimum need for applying mineral fertilizers for corn crops per grain per 1 ha in the absence of mineral fertilizers for fodder crops is in the range from 26,678 kg to 33,185 kg.

In this way, it is possible to overcome the lack of mineral fertilizers for fodder crop crops under the condition of sufficiency of mineral fertilizers for corn crops for grain if the latter are applied in excess of 26,678 kg per 1 ha of agricultural land.

The dependence of the amount of mineral fertilizers for fodder crops on the application of mineral fertilizers for technical crops per unit area of agricultural land is characterized by a high density of connection and downward trends, since the application of mineral fertilizers for technical crops leads to a decrease in the amount of mineral fertilizers for fodder crops on 13.268 kg per hectare.

In particular, in the case of applying 1 kg of mineral fertilizers for technical crops, the lack of mineral fertilizers for fodder crops will amount to 12,618 kg per 1 ha of agricultural land.

Dependence of the volume of mineral fertilizers for crops of technical crops on the application of mineral fertilizers for crops of fodder crops per unit area of agricultural land is the inverse of the regression y=0.65*x-13.268. It has a clear upward trend, since when mineral fertilizers are applied to forage crops, the volume of mineral fertilizers to technical crops will increase by 22,725 kg per 1 ha.

When applying 1 kg of mineral fertilizers for sowing fodder crops per unit area of agricultural land, the volume of mineral fertilizers for sowing technical crops will be 24.1771 kg per 1 ha.

For a more detailed analysis of the sufficiency (insufficiency) of mineral fertilizers for sowing technical crops and fodder crops per unit area of agricultural land, we suggest considering both regression equations in the context of trends over the last twenty years (Table 9).

Table 9

Assessment of the sufficiency (insufficiency) of mineral fertilizers for sowing technical crops and fodder crops per unit area of agricultural land

Regression equation	Evaluation of possible options
y=1,4521*x+22,725	1. Mineral fertilizers are not applied under fodder crops (x=0). In this case, the minimum amount of mineral fertilizers applied for sowing industrial crops will be 22.725 kg per 1 ha (1.4521*0+22.725=22.725). 2. It is planned not to apply mineral fertilizers under crops of technical crops (y=0). The lack of mineral fertilizers for sowing fodder crops will amount to 15.6497 kg per 1 ha (x= -22.725/1.4521= -15.6497).
y=0,65*x-13,268	1. Mineral fertilizers are not applied to crops of industrial crops (x=0). The lack of mineral fertilizers for sowing fodder crops will amount to 13.268 kg per 1 ha (0.65*0-13.268= -13.268). 2. It is planned not to apply mineral fertilizers under fodder crops (y=0). In this case, the minimum amount of mineral fertilizers applied for sowing industrial crops will be 20.4123 kg per 1 ha (13.268/0.65=20.4123).

There is a lack of mineral fertilizers for sowing fodder crops in the range from 13.268 kg per 1 ha to 15.6497 kg per 1 ha in the case of not applying mineral fertilizers for sowing technical crops. At the same time, the minimum need for the application of mineral fertilizers for crops of technical crops per 1 ha in the absence of application of mineral fertilizers for crops of fodder crops is in the range from 20.4123 kg to 22.725 kg.

In this way, it is possible to overcome the lack of mineral fertilizers for fodder crops under the condition of sufficiency of mineral fertilizers for technical crops in the case of applying the latter more than 20.4123 kg per 1 ha of agricultural land.

As a result of the analysis of the sufficiency (insufficiency) of mineral fertilizers for four types of crops, it was proved that the agricultural land is fully supplied with mineral fertilizers for technical crops (the sum of the average indicators of sufficiency is 36.7 kg per 1 ha). The sum of the average indicators of the sufficiency of mineral fertilizers for corn crops per grain is 63.5 kg per 1 ha, but the average value of the shortage in the context of technical crops is 3.2 kg per 1 ha.

The lack of mineral fertilizers for crops is most clearly manifested in two types (cereal and leguminous crops (without corn) and fodder crops) in the form of a shortage per unit area of agricultural land (kg per 1 ha). The sum of the average indicators for the lack of mineral fertilizers for sowing grain and leguminous crops (without corn) is 31.7 kg per 1 ha. In the case of the dependence of the amount of mineral fertilizers on this crop from fodder crops, the average indicator of the sufficiency of mineral fertilizers for crops of grain and leguminous crops (without corn) is 11.3 kg per 1 ha. The lack of mineral fertilizers for sowing fodder crops is the maximum compared to all other crops - the sum of average indicators is 33.3 kg per 1 ha.

The sufficiency (insufficiency) of mineral fertilizers by types of crops can be depicted by average indicators based on all analyzed cases of dependence (Fig. 5).

Using the scheme for assessing the sufficiency (insufficiency) of mineral fertilizers per unit area of agricultural land, we will conduct a similar study on organic fertilizers.

The dependence of the application of organic fertilizers under corn crops for grain on the amount of organic fertilizers under crops of grain and leguminous crops (without corn) per unit area of agricultural land is characterized by increasing trends in the amount of organic fertilizers applied under corn crops per grain in the case of the application of organic fertilizers under crops of cereals and legumes crops (without corn). At the same time, the low density of the relationship between the amount of organic fertilizers applied under crops of grain and leguminous crops (without corn) and under crops of corn for grain indicates the lack of interdependence in the field of increasing soil fertility.

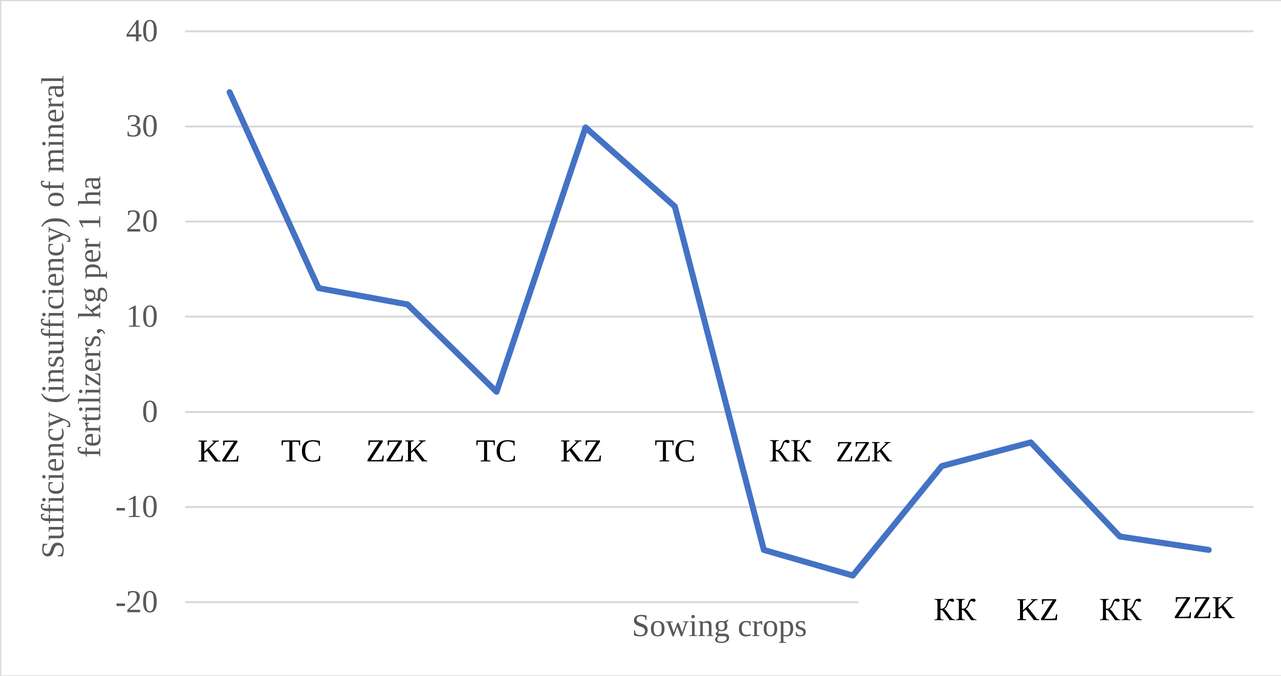

Figure 5. Average indicators of the dynamics of sufficiency (insufficiency) of mineral fertilizers by types of crops (KZ – corn for grain, TC – technical crops, ZZK – grain and leguminous crops (without corn), KK – fodder crops)

(Built by the author)

The dependence of the application of organic fertilizers for technical crops on the volume of organic fertilizers for grain and leguminous crops (without corn) per unit area of agricultural land is characterized by a high density of connection and downward regression trends, since the amount of organic fertilizers for technical crops will decrease by 1421 .4 kg per 1 ha of agricultural land for any indicator of the volume of organic fertilizers for grain and leguminous crops (without corn).

Based on the given regression equation, applying 1 kg of organic fertilizers for crops of grain and leguminous crops (without corn) will lead to a shortage of organic fertilizers for crops of industrial crops in 1415.925 kg per 1 ha of agricultural land.

The dependence of organic fertilizers for sowing grain and leguminous crops (without corn) on the volume of organic fertilizers for sowing industrial crops per unit area of agricultural land is the inverse of the function y=5.475*x-1421.4. In this case, there are increasing trends in the development of regression, since for any amount of industrial crops, the application of organic fertilizers under the sowing of grain and leguminous crops (without corn) will increase by 285.9 kg per 1 ha of agricultural land.

The application of 1 kg of organic fertilizers for sowing technical crops provides an increase in the volume of organic fertilizers for sowing grain and leguminous crops (without corn) by 286,056 kg per 1 ha of agricultural land.

For a more detailed analysis of the sufficiency (insufficiency) of organic fertilizers for sowing grain and leguminous crops (without corn) and technical crops per unit area of agricultural land, we suggest considering both regression equations in the context of trends over the last twenty years (Table 10).

Table 10

Assessment of the sufficiency (insufficiency) of organic fertilizers for sowing grain and leguminous crops (without corn) and industrial crops per unit area of agricultural land

Regression equation	Evaluation of possible options
y=0,156*x+285,9	1. Organic fertilizers are not applied to crops of technical crops (x=0). In this case, the minimum amount of organic fertilizers applied to grain and leguminous crops (without corn) will be 285.9 kg per 1 ha (0.156*0+285.9=285.9). 2. It is planned not to apply organic fertilizers to grain and leguminous crops (without corn) (y=0). The lack of organic fertilizers for crops of industrial crops will amount to 1832.69 kg per 1 ha (x= -285.9/0.156= -1832.69).
y=5,475*x-1421,4	1. Organic fertilizers are not applied to grain and leguminous crops (without corn) (x=0). The lack of organic fertilizers for crops of industrial crops will amount to 1421.4 kg per 1 ha (5.475*0-1421.4= -1421.4). 2. It is planned not to apply organic fertilizers under crops of industrial crops (y=0). In this case, the minimum amount of organic fertilizers applied to grain and leguminous crops (without corn) will be 259.62 kg per 1 ha (1421.4/5.475=259.62).

There is a lack of organic fertilizers for crops of industrial crops ranging from 1421.4 kg per 1 ha to 1832.69 kg per 1 ha in the case of not applying organic fertilizers for crops of grain and leguminous crops (without corn). At the same time, the minimum need to apply organic fertilizers for crops of grain and leguminous crops (without corn) per 1 ha in the absence of organic fertilizers for crops of technical crops is in the range of 259.62 kg to 285.9 kg.

In this way, it is possible to overcome the lack of organic fertilizers for sowing technical crops under the condition of sufficiency of organic fertilizers for sowing grain and leguminous crops (without corn) in the case of applying the latter more than 259.62 kg per 1 ha of agricultural land.

The dependence of the amount of organic fertilizers for forage crops on the application of organic fertilizers for grain and leguminous crops (without corn) per unit area of agricultural land is characterized by a fairly high density of connection (correlation coefficient - 0.77). The regression has an increasing character, because with any amount of organic fertilizers applied to crops of grain and leguminous crops (without corn), the amount of organic fertilizers to crops of fodder crops will increase by 3870.3 kg per 1 ha of agricultural land.

In case of application of 1 kg of organic fertilizers for crops of grain and leguminous crops (without corn), the amount of application of organic fertilizers for crops of fodder crops will be 3866.136 kg per 1 ha.

The dependence of the volume of organic fertilizers for crops of grain and leguminous crops (without corn) on the application of organic fertilizers for crops of fodder crops is the inverse of the regression y=-4.164*x+3870.3. It is also characterized by the presence of growing trends.

Application of 1 kg of organic fertilizers for fodder crops allows to obtain the volume of organic fertilizers for grain and leguminous crops (without corn) in the amount of 728.98 per 1 ha of agricultural land.

It should be noted that both regressions differ significantly from other dependencies in the form of the equation.

Their feature is the presence of a negative value of the angular coefficient, that is, the positive value of the effective indicator is limited to the amount of 3870.3 kg of organic fertilizers per 1 ha of agricultural land for the first equation and 729.12 kg of organic fertilizers per 1 ha of agricultural land for the second equation.

For a more detailed analysis of the sufficiency (insufficiency) of organic fertilizers for sowing grain and leguminous crops (without corn) and fodder crops per unit area of agricultural land, we suggest considering both regression equations in the context of trends over the last twenty years (Table 11).

Table 11

Assessment of the sufficiency (insufficiency) of organic fertilizers for sowing grain and leguminous crops (without corn) and fodder crops per unit area of agricultural land

Regression equation	Evaluation of possible options
y=-4,164*x+3870,3	1. Organic fertilizers are not applied to grain and leguminous crops (without corn) (x=0). In this case, the minimum amount of organic fertilizers applied to fodder crops will be 3870.3 kg per 1 ha (-4.164*0+3870.3=3870.3). 2. It is planned not to apply organic fertilizers under fodder crops (y=0). In this case, the maximum amount of organic fertilizers applied to grain and leguminous crops (without corn) will be 929.47 kg per 1 ha (x=3870.3/4.164=929.47).
y=-0,1418*x+729,12	1. Organic fertilizers are not applied to fodder crops (x=0). In this case, the minimum amount of organic fertilizers applied to grain and leguminous crops (without corn) will be 729.12 kg per 1 ha (-0.1418*0+729.12=729.12). 2. It is planned not to apply organic fertilizers to grain and leguminous crops (without corn) (y=0). The maximum amount of organic fertilizers introduced in this case for sowing fodder crops will be 5141.89 kg per 1 ha (729.12/0.1418=5141.89).

The optimal need for applying organic fertilizers for fodder crops is in the range from 3870.3 kg per 1 ha to 5141.89 kg per 1 ha in the case of not applying organic fertilizers for grain and leguminous crops (without corn). At the same time, the optimal need for the application of organic fertilizers for crops of grain and leguminous crops (without corn) per 1 ha in the absence of application of organic fertilizers for crops of fodder crops is in the range from 729.47 kg to 929.47 kg.

As the calculations show, the dependence between the application of organic fertilizers for fodder crops and the application of organic fertilizers for grain and leguminous crops (without corn) is characterized by the absence of a shortage (insufficiency) of organic fertilizers both for fodder crops and for grain and leguminous crops (without corn) per unit area of agricultural land. It should be noted that in case of exceeding the level of the maximum need for organic fertilizers, there will be a shortage (insufficiency) of both fodder crops and grain and leguminous crops (without corn).

The dependence of the amount of organic fertilizers applied to crops of industrial crops on the amount of organic fertilizers applied to crops of corn per grain per unit of agricultural land is characterized by a very weak relationship.

The correlation coefficient of 0.27 indicates that the application of organic fertilizers for crops of industrial crops does not depend on the application of organic fertilizers for crops of corn per grain per unit of agricultural land. Similarly, there is no inverse regression - the dependence of the amount of organic fertilizers applied to corn crops per grain from the amount of organic fertilizers applied to agricultural crops per unit area of agricultural land.

The dependence of the amount of organic fertilizers applied to fodder crops from the amount of organic fertilizers applied to corn per grain per unit of agricultural land is characterized by a very weak relationship.

The correlation coefficient of 0.03 indicates that the application of organic fertilizers for crops of forage crops does not depend on the application of organic fertilizers for crops of corn per grain per unit of agricultural land. Similarly, there is no inverse regression - the dependence of the amount of organic fertilizers applied to corn crops per grain from the amount of organic fertilizers applied to fodder crops per unit area of agricultural land.

The dependence of the amount of organic fertilizers applied to fodder crops from the amount of organic fertilizers applied to industrial crops per unit of agricultural land is characterized by an average density relationship.

The correlation coefficient of 0.63 shows that the application of organic fertilizers for fodder crops does not depend on the application of organic fertilizers for industrial crops per unit of agricultural land. The average relationship is not enough to identify the level of sufficiency (insufficiency) of organic fertilizers for crops. Similarly, there is no inverse regression - the dependence of the amount of organic fertilizers applied to technical crops on the amount of organic fertilizers applied to fodder crops per unit area of agricultural land.

Based on the results obtained regarding the sufficiency (insufficiency) of applying organic fertilizers to agricultural crops, it is possible to conclude that there is a high density of connection only for two cases:

– the relationship between the application of organic fertilizers for crops of grain and leguminous crops (without corn) and the volume of organic fertilizers for crops of technical crops;

– the relationship between the application of organic fertilizers for grain and leguminous crops (without corn) and the amount of organic fertilizers for fodder crops.

In contrast to the relationship between mineral fertilizers applied to crops of different agricultural crops, the relationship with organic fertilizers is mainly characterized by weak density. Thus, it is possible to conclude that there are no effective and well-founded measures for uniform supply of agricultural land with organic fertilizers in Ukraine.

As the obtained calculations show, there is a sufficient amount of organic fertilizers, however, in contrast to the use of mineral fertilizers, the lack of interdependencies between crops shows the lack of effective development of land resources due to the application of organic fertilizers to corn crops for grain. Moreover, the presence of an effective effect on the application of organic fertilizers is observed only for crops of grain and leguminous crops (without corn) (2 cases of interdependencies). For technical and fodder crops - one case each, which characterizes their attachment to the amount of organic fertilizer application exclusively for grain and leguminous crops (without corn).

The dynamics of waste generation in agriculture, forestry and fisheries (Fig. 6) shows the existence of stable growth trends during 2000-2020. The maximum volume of waste generation was reached in 2011 – 12,201.2 thousand tons. In the following years, it is observed reduction in the volume of waste generation in agriculture, forestry and fisheries, in particular in the last of the studied years, it amounts to 5315.4 thousand tons.

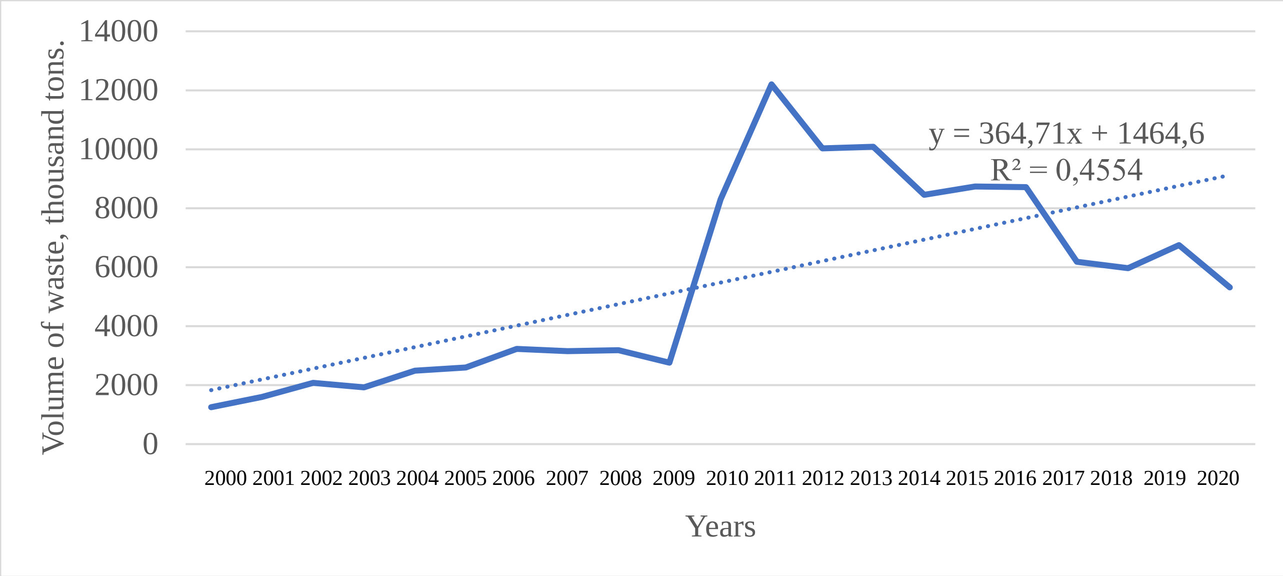

Figure 6. Dynamics of waste generation in agriculture, forestry and fisheries
(Compiled by the author based on the data of the State Statistics Service of Ukraine)

The density of connection (correlation coefficient – 0.67) characterizes the average influence of time (within twenty years) on the accumulation of waste. Nevertheless, the value of this coefficient is sufficient to assert with high probability a gradual decrease in the amount of waste.

Based on these dynamics, it is possible to conclude that there are three periods in the generation of waste in agriculture, forestry and fishing:

– gradual increase of waste (2000-2009);

– a rapid increase in the amount of waste (2010-2011), in particular compared to 2009, the amount of waste in 2010 increased by 3 times;

– gradual reduction of waste (2012-2020).

On the basis of the regression equation (y=364.71*x+1464.6), it can be stated that in the case of implementation of measures to eliminate this amount of waste in agriculture, forestry and fisheries, it is necessary to spend an additional four years.

The dynamics of waste generation in the supply of electricity, gas, steam and air conditioning for 2000-2001 (Fig. 7) is characterized by an insufficiently tight connection between the time period and the volume of waste. However, the correlation coefficient (0.57) is greater than 0.5, and therefore it is possible to assert the existence of a certain influence on the volume of waste from the activity of supplying electricity, gas, steam and air conditioning.

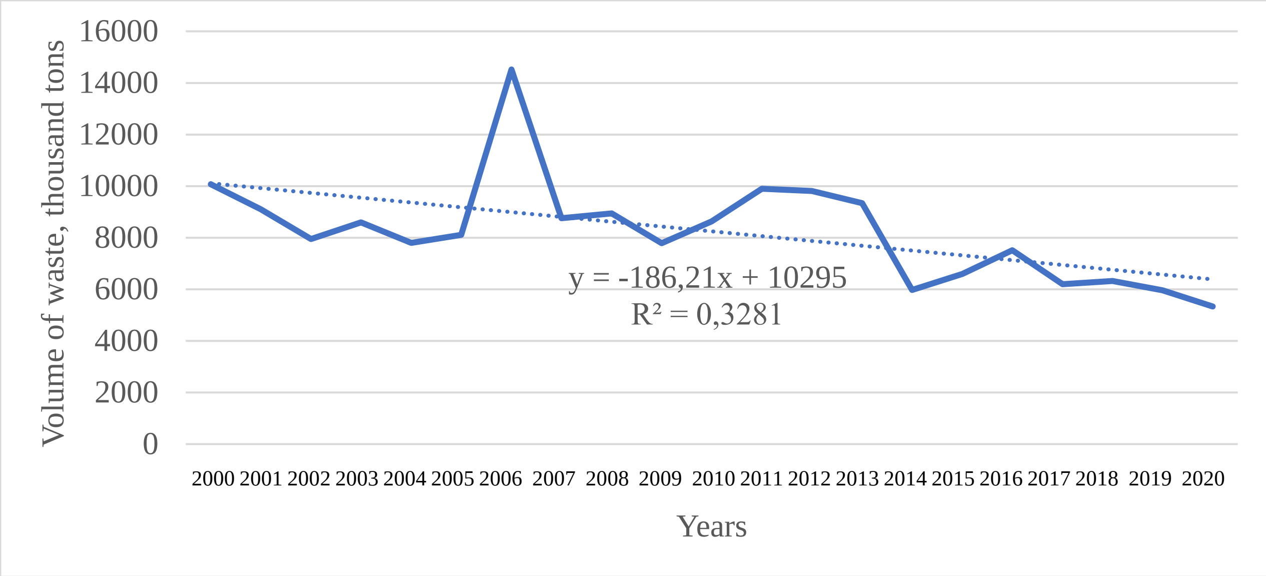

Figure 7. Dynamics of waste generation in activities related to the supply of electricity, gas, steam, and air conditioning

(Compiled by the author based on the data of the State Statistics Service of Ukraine)

The regression equation of the type y=-186.21*x+10295 indicates the possibility of complete elimination of this amount of waste no earlier than in 55 years.

Changes in the volume of waste generation in the activities of supplying electricity, gas, steam and air conditioning are characterized by a significant increase in 2006 compared to 2004 by 1.8 times. However, in the following year there was a return to the indicators of 2006 (8753.5 thousand tons).

In the period 2008-2020, there is a periodic increase in the amount of waste, in particular in 2011-2013 to the level of 10,000 tons. However, the general trend is a decrease in the amount of waste from activities related to the supply of electricity, gas, steam, and air conditioning. In the last of the studied years, it is 5333.7 thousand tons - the lowest indicator in the last 20 years.

The dynamics of construction waste generation is characterized by a weak correlation between the volume of waste and the time period between 2000 and 2020 (correlation coefficient equal to 0.44) (Fig. 8). Such a low value of this indicator indicates the absence of a stable model, which allows us to draw conclusions about the possibility of eliminating waste under these conditions. Based on the above, on the basis of the equation y=14.85*x+117.87, it is possible to draw conclusions about the need to spend approximately 8 years for the elimination of construction waste.

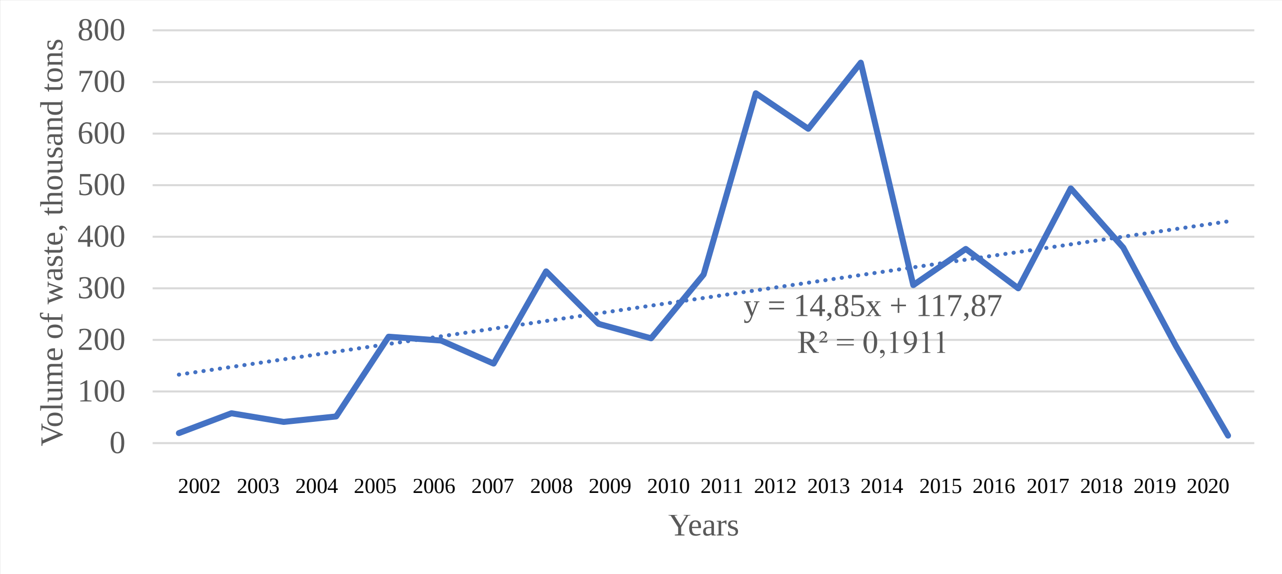

Figure 8. Dynamics of construction waste generation
(Compiled by the author based on the data of the State Statistics Service of Ukraine)

During the years 2000-2020, there is an increase in the volume of construction waste. If there is a gradual increase in the amount of waste from 2000 to 2010, then in 2011 the amount of waste amounted to 677.9 thousand tons (compared to 2010, the increase was 2 times). In 2013, the growth of the volume of construction waste reached its maximum - 737.3 thousand tons. However, already in 2014 there was a drop in the volume of waste compared to 2013 by 2.4 times.

In the future, growth trends were observed until 2017, and from 2018 there is a rapid decrease in the volume of construction waste, in particular, in the last of the studied years, this indicator amounted to only 14.5 thousand tons, which is the absolute minimum for the years 2000-2020.

The dynamics of waste generation in the mining industry and the development of quarries is characterized by a high correlation density (correlation coefficient equal to 0.78) (Fig. 9) between the amount of waste and the time period of 18 years (2002-2020). The regression equation y=12556*x+142063 shows that 11 additional years are required for the elimination of waste with the existence of this trend.

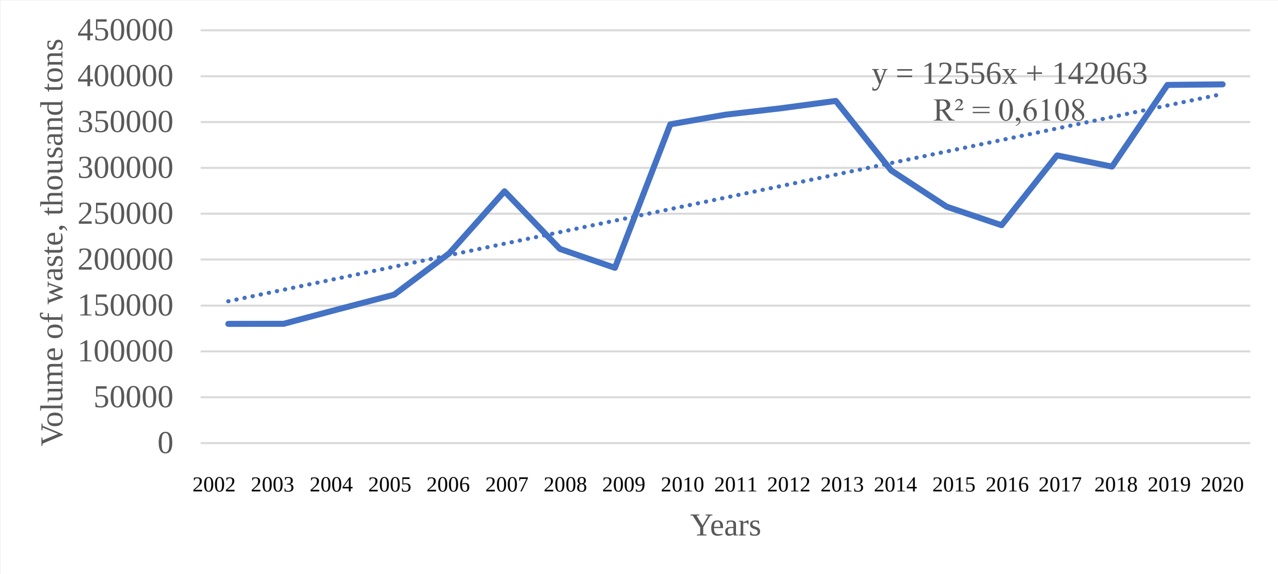

Figure 9. Dynamics of waste generation by mining industry and quarry development

(Compiled by the author based on the data of the State Statistics Service of Ukraine)

In 2010, there was a significant increase in the amount of waste compared to 2009 (the period 2002-2009 is characterized by a slight increase in the amount of waste) to 347,442.3 thousand tons (1.8 times). The period of 2010-2013 is the largest amount of waste from the extractive industry and quarry development since 2002.

From 2014 to 2016, there is a trend of a significant decrease in the volume of waste, but from the following year, a gradual increase led to the maximization of these indicators in 2019 and 2020 to the highest values for the entire period of the study.

The dynamics of waste generation in the processing industry is characterized by a sufficiently high density of connection (correlation coefficient equal to 0.7) (Fig. 10) between their volume and the time period of 2002-2020. The regression equation y=-1287*x+57864 shows that under these conditions, waste disposal is possible in 45 years.

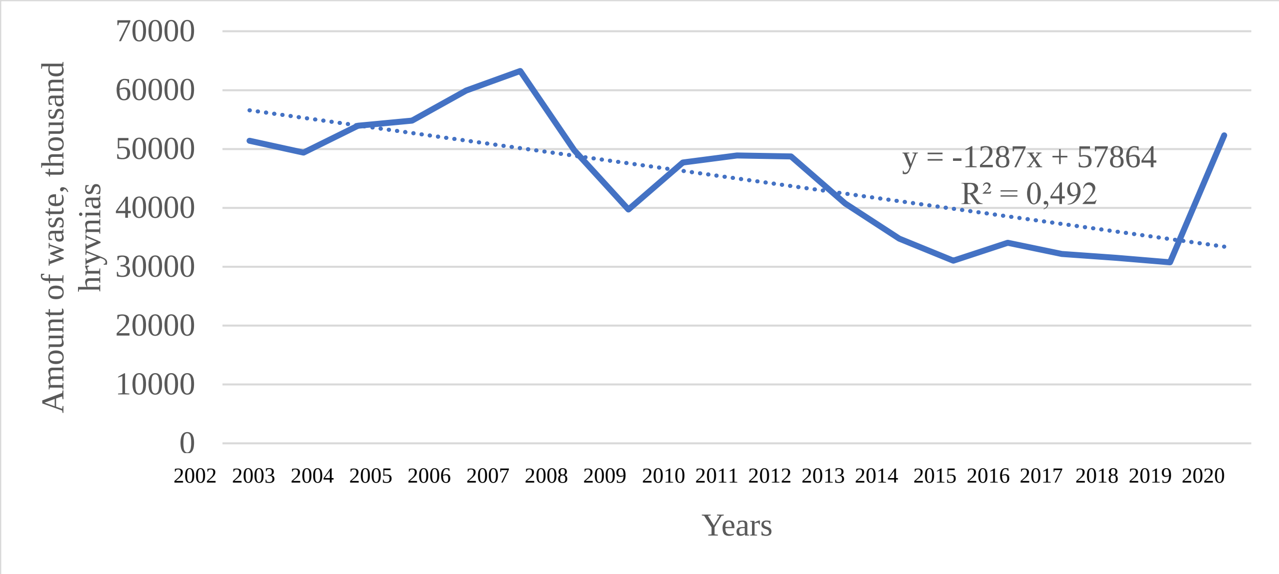

Figure 10. Dynamics of waste generation by processing industry
(Compiled by the author based on the data of the State Statistics Service of Ukraine)

There is a steady trend of a general decrease in the amount of waste in the processing industry for 2002-2020, with periods of partial growth. In this context, two periods can be distinguished:

– 2003-2009, where the maximum amount of waste amounted to 63,247.3 thousand tons in 2007;

– 2009-2015, where the maximum volume of waste amounted to 48,920.4 in 2011.

From 2019, a new cycle of growth in the volume of waste in the processing industry begins, as in 2020 it reached a value of 52,311 thousand tons, which is 1.7 times more than the previous year.

The dynamics of waste generation by other types of economic activity is characterized by a fairly low correlation coefficient (0.38) (Fig. 11), which indicates a weak connection between the amount of waste and the period of its generation in 2000-2020. The regression equation y=-168.35*x+5535.5 indicates the possibility of eliminating these wastes in 33 years under these conditions.

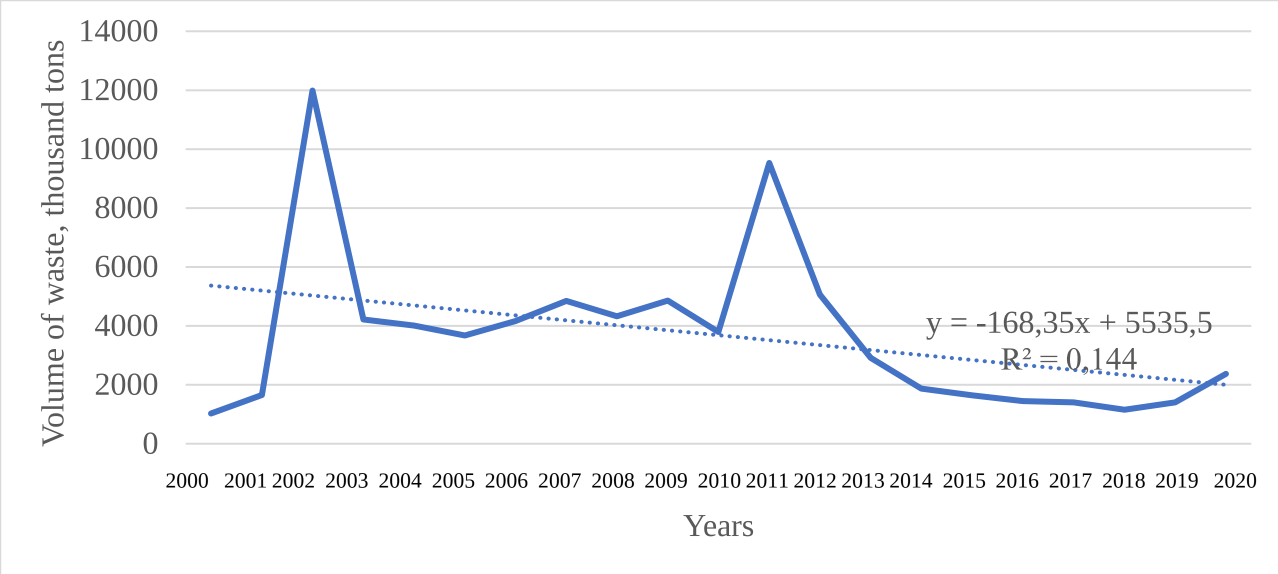

Figure 11. Dynamics of waste generation by other types of economic activity
(Compiled by the author based on the data of the State Statistics Service of Ukraine)

The maximum volume of waste from other types of economic activity was observed for the entire period under study in 2002 (11,987.8 thousand tons), which is 7.2 times more than in 2001. The period of 2003-2010 is characterized by moderate growth trends, and in 2011 a new maximum is reached - 9524.4 thousand tons, which is 2.5 times more than in 2010. Starting from 2012, trends in the reduction of the amount of waste in other types of economic activity determined the nature of the entire dynamics during the period under study.

Based on the study of waste generation, the following conclusions can be drawn:

– The dependence of the amount of waste on the time period during which it was accumulated is observed. In particular, the correlation coefficient is one of the highest in agriculture, forestry, and fishing compared to other types of economic activity: the connection is denser only in the processing industry and mining industry and the development of quarries. In no case was a strong connection found, however, the presence of an average allows us to state that for these three types of economic activity, the time factor of waste generation is quite influential.

– Of all the models of dependence in these branches of economic activity, two variations are observed: $y=a_0-a_1*x$ and $y=a_0+a_1*x$, which indicates the possibility of determining the number of years for waste elimination (the first equation) and the number of years that additionally required for waste elimination (second equation). In addition, in the case of the first model, the dynamics of waste generation has a pronounced decreasing character, in the case of the second model, it is increasing.

– The dynamics of all analyzed types of economic activity indicate the maximization of waste generation in certain years, in particular, in agriculture, forestry and fishing in 2011; for electricity, gas, steam and air conditioning in 2006; for construction in 2013; on the extractive industry and career development in 2020; on processing industry in 2007; on other types of economic activity in 2002.