Systemic philosophical principles of research in agricultural practice

G. T. Telebaev[1,*], *D.* K. Abulkhairov[2]

[1]Al-Farabi Kazakh National University, Almaty, Kazakhstan
[2]Kazakh Agro Technical University named after S. Seifullin, Astana, Kazakhstan

Abstract. The article considers the possibilities of applying the systemic philosophical principles in practice. The philosophical systemic analysis applied in the study for the analysis of the given issue in agriculture makes it possible to demonstrate the integrity of the system, with the existence of links and contradictions between its elements. In this case, systemic analysis provides for the study of the considered production process as a system, with regard for all necessary internal interrelations of the process elements, relationship of the objects involved in the process with the environment, external interaction with other objects, towards achievement of a certain goal. The system is treated as a set of interrelated elements isolated from the environment and interacting with it as a whole.

1 Introduction

Currently, the Government of the Republic of Kazakhstan, proceeding from the ongoing global trends, has set a specific task to turn the agro-industrial complex into a highly profitable sector of the economy. At the same time, the importance of ensuring food security of the country is emphasised, in particular, the priority of development of the livestock industry which has a great export potential [1].

The programme for the development of agricultural production, developed by the Ministry of Agriculture of the Republic of Kazakhstan, envisages the stabilisation of the situation in the near future, with subsequent growth in the main types of crop and livestock farming products.

The main share in the structure of winter feed balance in Northern Kazakhstan cattle breeding is roughage in the form of hay obtained from annual and perennial herbs, as well as grain crops straw [2].

The transition to market relations resulted in a structural transformation of agricultural production in the Republic of Kazakhstan, with the appearance of collective, peasant farms and sole proprietorships distinguished by the concentration of bovine cattle, sheep and horse farms. Owing to such redistribution of livestock, significant changes in the structure of winter feed ration took place: the share of roughage in the form of hay from annual and perennial herbs increased, and the consumption of succulent feed and grain forage

* Corresponding author: gazizt@mail.ru

decreased. However, despite the extensive areas occupied by perennial herbs and grain crops, the stabilisation of roughage procurement in the necessary amount every year has not yet been possible. At the same time, the cost of procured fodder remains high, which hampers the increase in the number of animals. The livestock products' competitiveness depends to a great extent on the cost and payability of the feeding stuff. The thing is that in the conditions of price disparity, as concerns agricultural products and agricultural machinery, the cost of fodder is conditioned mainly by the costs of using machinery for its production. The article "Increasing productivity of machinery as a priority direction of technical policy in the agro-industrial complex" notes that the reduction of agricultural production costs depends on engineering science, and the solution to this issue is possible on the basis of dramatic increase in per-hour productivity (output) of machines [3].

2 Materials and methods

The efficiency of the mechanised hay procurement process can be achieved with regard for interaction of various factors, i.e. within the framework of the systemic approach based on the analysis of problem-containing and problem-resolving systems. The systemic analysis applied in the present research makes it possible to show the integrity of the system and the existence of links and contradictions between its elements. At the same time, systemic analysis treats the study of the considered production process as a system, with regard for all necessary internal relationships of the process elements, interrelation of the objects involved in the process with the environment, external interaction with other objects, towards achievement of a certain goal. The system should be understood as a set of interrelated elements isolated from the environment and interacting with it as a whole. According to the definition, a complex system represents a structure comprising subsystems that are to be studied individually and substantively within the framework of the set task with regard for the influence of other subsystems [4]. The problem of reaching efficiency of mechanised procurement of loose hay, considered in the article, appears to be a complex system. Therefore, using the principle of decomposition based on the fact that a complex system can be broken into a number of less complex elements, the authors proceeded to the research at different methodological levels.

Depending on the degree of generalisation, systemic research can be divided into generalised and detailed. Within generalised research, conceptual and operational levels are distinguished [5].

The purpose of conceptual research is the establishment of general development trends, development of concepts in respect of the main issues of system organisation with a high degree of generalisation of factors in an informal way, development of related goals and system functioning principles. The formalisation of system models is effectuated by the transition from verbal description of the system and the scheme of its functioning to mathematical description.

Operational research aims at a more detailed study of the system actualisation options within the framework of conceptual research. In this case, functional structures of operations and technical means leading to the solution of the set tasks are established on the basis of economic and mathematical modelling.

Detailed research is aimed at analysing the quality of subsystems and their elements; it is carried out at the appropriate methodological level. Thus, conceptual, operational and detailed studies, reciprocally complementing each other, form a coherent research system.

3 Results and discussion

A schematic representation of this systematic approach is shown in Figure 1.

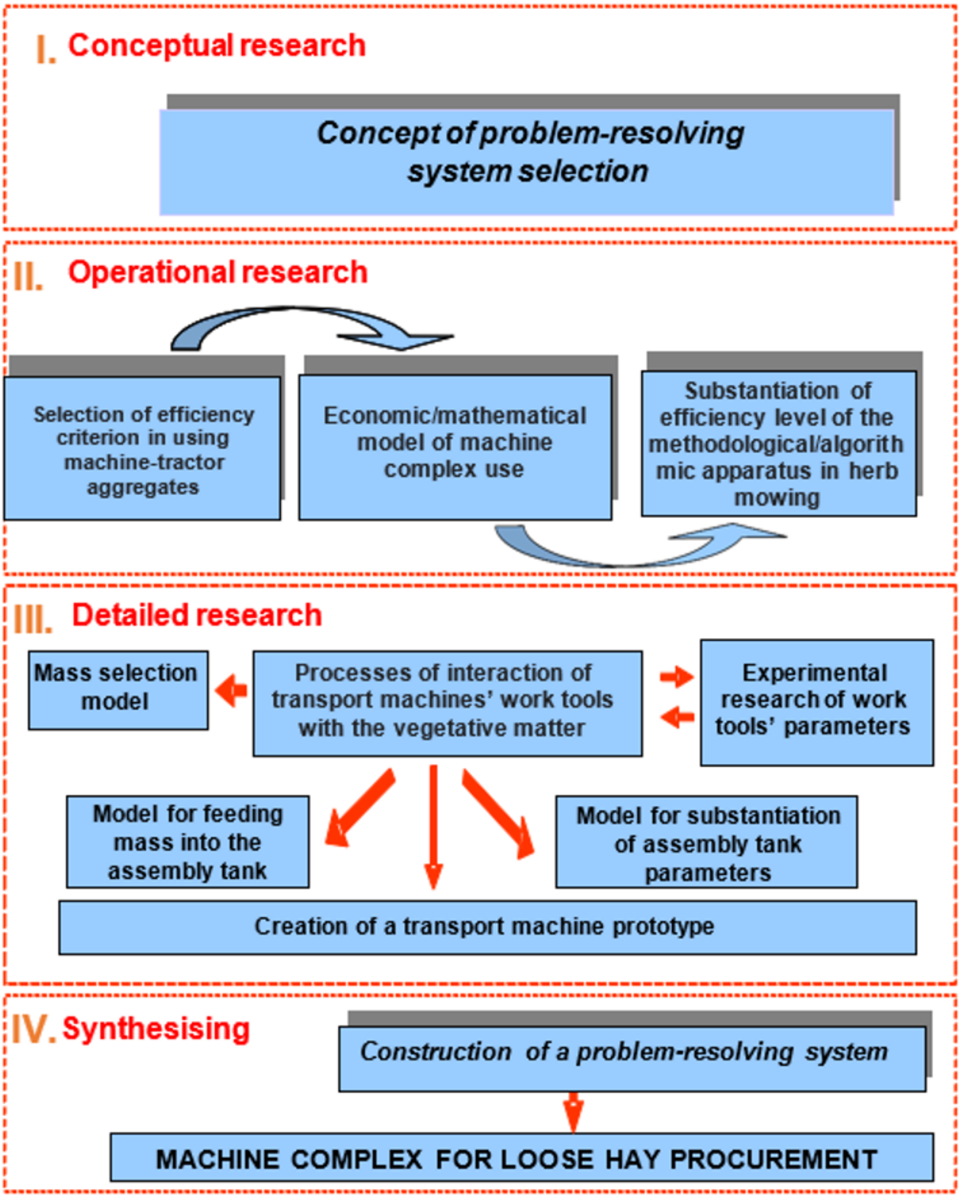

Fig. 1. Systemic principles of problem investigation and resolution.

The work is based on the principles of the systemic approach to the investigation of complex systems. In this case, the description of such system's operation – technological machinery complex – was made at three qualitatively different methodological levels: conceptual, operational and detailed. The difference in levels is characterised by the complexity of the considered system (subsystems, elements). At the conceptual level, the functioning of the existing technological machinery complex for hay procurement is considered, and the concept for the construction of a new complex is substantiated on the basis of its analysis. At the operational level, the technological complex functioning is considered, with special attention to separate technological operations and aggregates. In particular, at this level, the boundaries of efficient use of machine-tractor aggregates for herb mowing are substantiated on the basis of studying the obtained economic/mathematical model. At the detailed level, the functioning of the harvesting unit is considered, as well as the interaction of its individual elements: picking, feeding and transporting work tools handling the vegetative matter. The consideration and description of the system follows the principle: from the general to the particular. The process of such contemplation makes it possible to achieve some discrete positive results for subsystems and elements.

The synthesis of positive solutions will make it possible to construct and implement a problem-resolving system that ensures the achievement of the set goal. The description in this part of the research follows the principle: from simple to complex.

As an example, let us take a closer look at the realisation of the operational level of the scheme (Figure 1).

The economic and mathematical model for the use of the technological machinery complex for the procurement of loose hay is as follows.

The complex costs of the work are calculated using the formula [1,2]:

$$C_k = \sum_s \sum_i \sum_\varphi C_{si\varphi} \cdot N_{si\varphi} + \sum_j \alpha_j \cdot Б_j \cdot N_j + C_L \varepsilon + (1+\delta) \sum_j \frac{Б_j N_j}{T_j} + П_{si\varphi} \quad (1)$$

where $C^{si\varphi}$ – costs of using *φ*-aggregate for *i*-work in *s* – billing period;

$N^{si\varphi}$ – number of *φ*-aggregates used for *i*-work in *s* – billing period;

α_j – renovation charge coefficient for *j*-machine;

$Б^j$ – book value of *j*- machine;

T^j – service life of *j*-machine (years);

δ – corporate income tax rate, $\delta = 0.1$;

N^j – number of *j*-machines required to implement the annual work scope;

ε – share of time consumption in this operation in the mechanic's total work time;

$П^{si\varphi}$ – cost of production losses connected with technological operations.

$$\underset{\max S}{N_j} = \sum_i \sum_\varphi K_{i\varphi j} \cdot N_{is\varphi} \quad (2)$$

where $K^{i\varphi j}$ – number of units within a *φ*-aggregate at *i*-work.

The costs of using the *φ*-aggregate during the *s*-billing period are determined using the formula:

$$C_{si\varphi} = (\sum_{j} P_j \cdot K_{i\varphi j} + З_{i\varphi} + Г_{i\varphi} + Ф_{i\varphi})W_{экi\varphi s} \cdot D_s \text{, Tenge} \quad (3)$$

where P^{j} – costs of technical maintenance, current and capital repairs of *j*-machine of φ -aggregate during *i*-work, *tenge/ha (hectare)*;

$З^{i\varphi}$ – labour pay costs for *i*-work with *φ*-aggregate, *tenge/ha*;

$Г^{i\varphi}$ – fuel and lubricant costs of *φ*-aggregate during *i*-work, *tenge/ha*;

$Ф^{i\varphi}$ – other direct costs of basic and auxiliary materials (fertilisers, seeds, herbicides, etc.), *tenge/ha;*

$W^{экsi\varphi}$ – productivity of *φ*-aggregate during *i*-work, *ha/hour*.

The labour remuneration costs required to perform the annual work volume are derived using the formula:

$$C_L = N_L Ц_L \quad (4)$$

where N^{L} – number of mechanics required to perform the annual work volume, *persons*;

$Ц^{L}$ – cost of paying to a single person, *tenge/person.*

The calculations are performed under the following conditions:

1) each *i*-work is performed technologically in coordination with other works during *s*-billing periods in full volume:

$$F_j = \sum_{\varphi s} W_{si\varphi} X_{si\varphi} k_{cmsi\varphi} \quad (5)$$

where $X_{si\varphi}$ is the number of *φ*-aggregates needed to perform *i*-work during *s*-period.

2) the number of machines needed to comply with the hay procurement annual volume is determined on the basis of the strenuous *s*-period:

$$X_j \geq \sum_{i} \sum_{\varphi} k_{ij\varphi} X_{si\varphi} \quad (6)$$

where *k = 1,2 ... k*

3) the need for mechanics is determined by the strenuous billing period of simultaneously working mechanics:

$$N_L = \sum_{i} \sum_{\varphi} Л_{si\varphi} \cdot k_{cmsi\varphi} \cdot X_{si\varphi} \quad (7)$$

where $Л^{si\varphi}$ – numbers of personnel operating on *φ*-aggregate during *s*-period at *i*-job.

4) nonnegativity and integrality of variables:

$$X_{i\varphi s}, X_{j}, X_{L} \geq 0 \text{, integers} \tag{8}$$

where *i=1...n; φ=1...n; s=1...n.*

The analysis of costs and applied technologies for procurement of loose and baled hay shows that they match each other. At the same time, the calculations show that if the hay transportation distance exceeds 35 km the costs of transporting loose hay will be higher than in case of transporting baled hay. However, the productivity of machines picking up baled hay is significantly lower than that in the case of loose hay. Therefore, the baled hay procurement technology can be recommended for transportation distances exceeding 35 km.

The calculations made according to formulas 1-8 made it possible to specify the limits of efficient use of machines for herb mowing. The use of towed mowers in aggregate with MTZ-80 tractors is economically justified in case of herb yield below 16 *centners/ha*. In case of yield above 16 *centners/ha,* the machines with towed rotary windrowers ZhVP-9,1 are more efficient. Harvesting machines with mounted reapers on 3rd-class reaping threshers are not efficient for herb mowing in the conditions of Northern Kazakhstan irrespective of the crop yield. This is explained by the higher costs of acquisition, maintenance and repair of a reaping aggregate.

The more expressed increase of complex costs involving the machines with trailed reaper in case of lower yield crop is explained by the increased losses due to the higher mowing cut (about 15 cm), compared to towed mowers (about 5 cm).

4 Conclusion

1. The use of systemic analysis in designing the system for ensuring the efficiency of loose hay mechanised procurement served as a basis for the development of a conceptual solution to the problem and representation of the structure and the system in the form of an integral whole.

2. The concept for solving the given problem is rooted in the fact that increasing the efficiency of mechanised procurement of loose hay can be achieved by developing a technological machinery complex based on highly reliable wheeled tractors MTZ-80 working with towed mowers and rotary towed reapers for mowing, depending on the herb yield, and with highly productive towed pickup loaders with substantiated parameters of work tools and assembly tanks for pick-up of swaths. To load and transport the formed stooks, the application of multiple haystackers based on MTZ-80 tractors, as well as paired carts “Giant”, in the aggregate with wheeled tractors of 40-50 *kN* drawbar category*,* proved to be efficient. The use of such technological machinery complexes is supposed to provide the reduction of work performance timeframe and improvement of the procured hay quality compared with the technological complexes based on re-equipped worn-out reaping threshers.

3. The research specifies and substantiates the framework for the efficient application of harvesting machinery for herb mowing according to the composite expenditure criterion. The aggregates based on wheeled tractors MTZ-80 and towed mowers are efficient in case of crop yield below 16 *centners/ha*. In the case of crop yield above 16 *c/ha,* harvesting units based on MTZ-80 tractors with towed reapers ZhVP-9,1 are more efficient. The aggregates based on 3rd-class reaping threshers with mounted rotary windrowers are not efficient for herb mowing in the conditions of Northern Kazakhstan.

References

1. U.K. Kerimova, G.S. Kasenbaev, Bul. Turan Univ. **4**, 85-92 (2021). https://doi.org/10.46914/1562-2959-2021-1-4-85-92
2. V.E. Andriyanov, Designing and implementing machine systems for crop production in the region (Almaty, 2002)
3. N.V. Krasnoshchekov, Tractors Agric. Mach. **1** (2002)
4. F.I. Peregudov, F.P. Tarasenko, Introduction to Systemic Analysis (Higher School, Moscow, 1989)
5. V.L. Astafiev, *Conceptual approach to substantiation and choice of high-performance machinery complexes for crop production in Northern Kazakhstan*, in Status of the problem and prospects for development of agroengineering science in modern conditions: Proceedings of International Applied Research Conference, pp. 18-20 (Almaty, 2006)