 https://doi.org/10.1051/bioconf/202414102009

A conceptual approach to developing intelligent complexes for managing automated land reclamation systems

Evgeny Golovinov[1*]

[1]Federal Scientific Center for Hydraulic Engineering and Land Reclamation named after A.N. Kostyakova (VNIIGiM), 127434 Moscow, Russia

Abstract. This paper presents a conceptual approach to substantiating the structure and functional properties of intelligent complexes for operational management of processes in the operation of modern automated reclamation systems. The research is grounded in the need for formalizing land reclamation processes, emphasizing the classification of management methods into direct, reverse, and mixed approaches. The study discusses the division of processes into subgroups based on duration, spatial location, stability, and management capability, among other factors. The importance of strategic, tactical, and operational planning in managing reclamation systems is highlighted, with an emphasis on the role of process monitoring and feedback mechanisms. This framework aims to improve the efficiency and sustainability of land reclamation practices by integrating advanced management strategies.

1 Introduction

In the work of academician A.N. Kostyakov, the term "agricultural reclamation" (specifically, the reclamation of agricultural lands) is interpreted in two ways: as an activity aimed at the significant improvement of land to achieve high and consistent yields, and as a scientific discipline. A central concept in A.N. Kostyakov's definition of reclamation science is the management of soil regimes [1, 2].

According to the Federal Law "On Land Reclamation," this process involves the substantial enhancement of land through hydrotechnical, cultural, chemical, anti-erosion, agroforestry, agrotechnical, and other reclamation activities [3]. However, existing regulations do not adequately provide a comprehensive technological framework for land reclamation processes, instead offering fragmented descriptions of individual production steps.

In today's context, the formalization of processes is crucial for the accurate accounting, planning, and forecasting of agricultural production. To justify the necessity of process formalization in land reclamation, one should turn to control theory and address classification challenges. The primary methods of formalization include direct, reverse, and mixed approaches.

* Corresponding author: Golovinov@mail.ru

2 Material and methods

The direct method involves a coordinated examination of processes and procedural sequences in activities that require identifying an external influence to initiate the process. The reverse method focuses on analyzing the outcomes of an operation (such as yield, water volume, or humus content) and tracing back to the initial impact, identifying the originator and rationale behind the requirement. This sequence of actions outlines the processes in reverse.

Mixed application entails using both direct and reverse methods simultaneously, which is recommended and acceptable in complex scenarios that are challenging to analyze from a single perspective or in collaborative research.

In terms of terminology, processes are well described in the works of A.N. Kostyakov, A.D. Brudastov, S.F. Averyanov, V.V. Vedernikov, V.A. Kovda, B.S. Maslov, B.A. Shumakov, I.P. Aidarov, A.I. Golovanov, V.V. Shabanov, L.M. Rex, and others.

A common definition of the term "Process" (from the Latin *processus*, meaning "progress," and *procedere*, meaning "to move forward") in management refers to a series of actions that are repeated over time with a clear start and end, aimed at creating value for both external and internal stakeholders.

In the context of land reclamation, the production process consists of a series of activities performed by workers and tools, where resources, materials, and semi-finished products are transformed into final products with the desired quantity, quality, and variety within specified timeframes [5].

The technological process, a subset of the production process, involves specific actions aimed at altering or determining the state of the labor object [6].

This work suggests examining processes in relation to objects, specifically distinguishing between artificial and natural objects. Artificial reclamation objects can include systems like reclamation infrastructure, forest belts, reservoirs, and specially designed engineering-ecological systems. Natural reclamation objects encompass elements such as soils, grounds, forests, wetlands, closed water bodies, swamps, shrubs, and watercourses.

The primary influences on the development of reclaimed lands can also be categorized as natural or artificial. On improved lands, it would be inaccurate to classify all processes as artificial, even with intensive land use. Natural processes are those that occur over a period without human intervention, such as after the cessation of or prior to anthropogenic impact. For example, the development of a forest belt over several seasons typically occurs without human involvement. Soil formation or landscape changes on reclaimed lands also happen without human intervention, although these processes may take on a different character after reaching a certain point.

Artificial or anthropogenic processes are those influenced by human activity, whether periodic or continuous. Continuous impact might include the operation of a drainage system, while periodic impact could involve activities such as irrigation or fertilization.

The processes can be further classified into subgroups, as outlined in Table 1, based on the classification proposed by S.A. Maximov for biogeochemical barriers [1, 7, 8].

Table 1: Classification of processes by groups

1. By duration	
1.1. permanent	1.2. temporary
2. By spatial location	

2.1. linear	2.2. point		2.3. lateral
3. By stability			
3.1. stable		3.2. unstable	
4. By management capability			
4.1. manageable		4.2. unmanageable	
5. In relation to other processes			
5.1. external		5.2. internal (integrated)	
6. By the complexity of the internal structure			
6.1. simple		6.2. complex	
7. In relation to environmental conditions			
7.1. dependent		7.2. independent	
8. By the possibility of removal or replacement			
8.1. removable		8.2. non-removable	
9. By changing properties over time			
9.1. with changing properties over time		9.2. permanent	
10. By the level of external or internal regulation			
10.1. self-regulating		10.2. non-self-regulating	
11. By equipment with control and monitoring tools			
11.1. well-equipped	11.2. poorly equipped		11.3. not equipped
12. By scale			
12.1. global	12.2. regional	12.3. local	12.4. local
13. By the degree of moisture participation in the emergence and development of the process			
13.1. automorphic		13.2. hydromorphic	
14. By the participation of biota in the emergence and development of the process			
14.1. biotic		14.2. abiotic	

15. By efficiency in process management	
15.1. effective	15.2. ineffective

3 Results

Process management in the operation of reclamation systems should be based on planning, namely - Strategic, tactical, and operational planning.

Strategic planning is the process of creating and implementing plans, programs, and activities in the long term - 1 year; 3 years; 5 years. For a reclamation system, it is not advisable to consider long periods, as such tasks go to a higher level - the level of agricultural enterprise management. Strategic planning is a management mechanism aimed at setting and achieving priority goals in predicting and planning the development of the reclamation system.

Tactical planning is the link between strategic planning and operational planning. For a reclamation system, time intervals should be considered - from a month to a year. Tactical planning involves refining and adjusting the strategy for managing the reclamation system. Influencing factors include: soil survey results, analysis of available resources in the farm, medium-term meteorological forecasts.

Operational planning is the process of developing current plans and adjusting tactical plans for the operation of the reclamation system for periods of less than 2 decades. Influencing factors include: weather conditions, short-term meteorological forecasts, the state of the agrocenosis, technological measures, etc.

Operational management involves the development, optimization, and implementation of plans for technological operations to determine resource needs for the full cycle of production, storage, and sale of agricultural products, ensuring planned yields, high product quality, and soil fertility reproduction, considering resource limitations.

Management functions should be understood as a set of independent types of activities necessary for the management and organization of the production process.

The management task should be divided into four main functions:

- Compliance with technological operations, operational plans, and regulation of controlled processes;
- Implementation of feedback, which allows controlling the qualitative and quantitative characteristics of technological processes, as well as their impact on controlled processes;
- Adherence to deadlines for processes according to user requests during operational planning, considering weather conditions, resource limitations, specifics of technological processes, dynamics of moisture, and soil properties;
- Monitoring organization and analysis of the main parameters of resources involved in agricultural production: for example, water resources, land, soil, technical resources, etc.

4 Conclusion

In conclusion, this study highlights the importance of developing and implementing intelligent complexes for the operational management of processes in modern automated reclamation systems. The analysis of process formalization methods presented in the article underscores the need for integrating both direct and reverse approaches to achieve maximum management efficiency. Given the diversity of natural and anthropogenic factors affecting reclamation systems, the proposed classification of processes based on various criteria allows for more accurate planning and forecasting of agricultural development.

Strategic, tactical, and operational planning, grounded in the principles outlined in this article, has the potential to significantly enhance the productivity and sustainability of agricultural production while ensuring the rational use of resources and the maintenance of soil fertility.

References

1. Golovinov, E. E. *On the Need for Process Formalization in Land Reclamation* / E. E. Golovinov // Agrarian Scientific Journal. – 2023. – No. 1. – Pp. 124-127. – DOI 10.28983/asj.y2023i1pp124-127.
2. Golovanov, A. I. *Methodology of Reclamation* / A. I. Golovanov // Environmental Management. – 2009. – No. 4. – Pp. 5-16.
3. Federal Law of January 10, 1996, No. 4-FZ *"On Land Reclamation"* with amendments and additions from December 8, 2020.
4. *Economics of the Enterprise: Textbook* / I. S. Bolshukhina; under the general editorship of V. V. Kuznetsov. – Ulyanovsk: Ulyanovsk State Technical University, 2007. – 118 p.
5. Panov, M. M. *Evaluation of Company Performance and Management System Based on KPI.* – Moscow: Infra-M, 2012. – 255 p. – 500 copies
6. Interstate Standard GOST 3.1109–82* *"Unified System of Technological Documentation. Terms and Definitions of Basic Concepts"* (introduced by the resolution of the USSR State Standards Committee of July 30, 1982, No. 2988)
7. Maximov, S. A. *Justification of Reclamation and Land Reclamation Based on the Concepts of the Formation of Barrier Properties of Natural Objects*: specialty 06.01.02 "Reclamation, Reclamation and Protection of Lands": dissertation for the degree of Doctor of Technical Sciences / S. A. Maximov. – Moscow, 2020. – 346 p.
8. Maximov, S. A. *Scientific Foundations for the Formation of Biogeochemical Barriers in Land Reclamation and Reclamation* / S. A. Maximov. – Moscow: All-Russian Research Institute of Hydraulic Engineering and Reclamation named after A.N. Kostyakov, 2021. – 295 p. DOI 10.37738/VNIIGIM.2021.57.52.002.