Management of natural-anthropogenic complexes of rural areas as active systems

D S Nardin and S A Nardina
P.A. Stolypin Omsk State Agrarian University, 2, Institutskaya Ploshchad, Omsk, 644008, Russian Federation
E-mail: ds.nardin@omgau.org

Abstract. The article presents the results of a study of natural-anthropogenic complexes of rural areas, which are formed in the process of production of grain crops, as active systems. The features of the management of active systems in the subject-subject paradigm of relationships are shown, the necessity of using network management based on communication links and reflexive processes as a basic type of management of natural-anthropogenic complexes of rural areas is substantiated. The natural-anthropogenic complex as a subject of management is presented in the form of four active subsystems interacting with each other and with the environment external to the complex. This interaction is based on the formation and development of networks in the field of technological support for the functioning of the natural-anthropogenic complex, formal and informal social networks formed by the population of rural areas, networks that include elements of the economic subsystem and ecological networks of rural areas, formed as under the influence of economic activity a person, and regardless of its presence in a particular territory. In the conclusion, data are presented that indicate the need for further development of ideas about the management of natural-anthropogenic complexes of rural areas at the methodological level within the framework of the post-non-classical type of scientific rationality and environmental management of complex self-developing systems, into which natural-anthropogenic complexes of rural areas are gradually transformed.

1. Introduction
The relevance of the stated research topic is due to the huge influence of natural-anthropogenic complexes (NAC), formed in the process of human economic activity, on the socio-economic and environmental conditions of life of not only the rural, but also the urban population. The sustainable development of the NAC in rural areas is the basis for the socio-economic security of the rural population, since it not only provides the required standard of living in the countryside, but also forms an adequate response to local and global climatic changes taking place in various parts of our planet. The issues of ensuring the required standard of living of the rural population and their dependence on the sustainable development of rural areas and natural-anthropogenic complexes located on them are presented in the works of many authors [1-6]. At the same time, some authors consider the dependence of the standard of living of the urban population on the sustainable development of natural-anthropogenic complexes, which can also form in the urban environment [7]. These trends in the development of agricultural production are already visible not only to researchers, but also to the business community and begin to have a significant impact on the technological subsystem of the NAC in rural areas. Much attention is also paid to the study of the sustainable development of...
agriculture and the NAC of rural areas in conditions of climate change, as evidenced by the works of many authors [8-10].

The increased attention to the sustainable development of agriculture and the NAC of rural areas, which are formed in the process of human economic activity, necessitated the improvement of the basic models, mechanisms and technologies for managing the NAC of rural areas. The classical approach to the management of rural areas NAC as complex systems, which is based on a feedback mechanism, cannot provide the required level of management due to its limitations. The management of sustainable development of rural areas NAC requires considering them as active systems that act not as an object, but as a subject of management. This approach to management is characteristic of the non-classical type of scientific rationality with the basic paradigm of the "subject-subject" relationship.

2. Materials and methods

The methodology of this research is based on the generalized results of the philosophical and methodological analysis of the evolution of ideas about management presented in the works [11-13].

The theoretical basis of the research is the main provisions of second order cybernetics. In this case, an active system acts as the basic object of control, that is, a system that affects the subject of control and is in the subject position in relation to the subject. In practice, this manifests itself in the self-organization of complex systems, the elements of which manifest communication activity, are able to independently create communication links and integrate into existing ones. A distinctive feature of the management of such systems is an interdisciplinary approach, the need for which arises in the formation of communication links between the active elements of the system belonging to various branches of science.

At the methodological level, the basic types of control in such systems are reflexive, informational and network control.

Further, within the framework of this study, the methodological level of management will be considered in detail in relation to the natural-anthropogenic complexes of rural areas that arise in the process of grain production in the Omsk region.

3. Results

NAC of rural areas, arising in the process of grain production in the Omsk region, as active systems, are characterized by the following features.

The first feature is that in the structure of the NAC enlarged, four active subsystems can be distinguished, which have a certain influence on the subjects of management, transferring the NAC to the subject position.

The technological subsystem, which includes varieties of grain crops and agricultural technologies for their cultivation, machinery and equipment for performing technological operations, as well as modern digital solutions in the field of data collection and processing, is a complex complex, the driving force of self-development of which is the process of variety change and variety renewal. Over the past three years, scientists of the Omsk State Agrarian University have created unique varieties of spring soft and perennial wheat, the mass introduction of which into production can radically change the existing model of management in the grain sub-complex of the region [14]. The technological aspect of these changes is associated with wheat varieties resistant to disease and pest damage. Under the conditions of the basic seed farms of the university, the costs of plant protection products from diseases and pests (brown and stem rust) have decreased by 80% -100%. The introduction of the large-grain gray wheatgrass variety (an analogue of perennial wheat) allowed the university's basic farms to significantly reduce the number of technological operations associated with the cultivation of the land: the useful life of crops without replanting is 7 years, during which grain is harvested (6-7 centners per hectare) and hay (up to 80 centners per hectare). In addition, the introduction of varieties with purple and black grain color, suitable for organic farming, leads to a change in the technological model of management. The cultivation of such varieties requires a significant increase in the culture of agriculture and the abandonment of mineral fertilizers in favor of organic ones. The development of
the technological subsystem of the grain complex requires from the heads of business entities significant changes in the approach to business management that is; it has a direct impact on the entities that manage the development of NAC in rural areas.

The economic subsystem of the NAC of rural areas, formed in the process of grain production, is also actively developing, influencing the subjects of management. The cultivation of new varieties of grain crops selected by the Omsk State Agrarian University with unique antioxidant and functional properties (bare spelled, wheat with purple and black grain color), as well as grown using the technology of organic farming, requires significant changes in the sales system of the products produced. Currently, of the 3 million tons of grain produced annually in the Omsk region, more than 70% are feed grain. The produced organic grain and grain for functional nutrition cannot be effectively sold through the existing channels, since it is focused on a completely different segment of the grain market. Accordingly, it is necessary to build new relationships with counterparties for its effective implementation. According to our calculations [14], an additional increase in the income of agricultural producers in this case can be up to 50% of the current level. However, in order to obtain additional income, it is necessary to significantly change the existing economic subsystem in the grain sub-complex both at the level of individual economic entities and at the level of the region as a whole.

The social subsystem of the NAC of rural areas, formed in the process of grain production, is one of the most dynamic. Due to the introduction of new digital technologies and modern technology integrated into digital control networks [15-17], a significant transformation of the competence profile of workers employed in production is predicted. So far, these processes in the grain sub-complex of the Omsk region are not manifested, but our research shows that from 10% to 15% of agricultural producers in the region already have approved investment programs aimed at transforming technological subsystems. In addition, in the Omsk region, under the overall coordination of the Ministry of Agriculture and Food of the region, the Digital Agriculture platform is being developed. Together, all these processes in the next 2-3 years will have a significant impact on the social subsystem of the NAC in rural areas of the Omsk region.

The ecological subsystem of the NAC of the rural areas of the Omsk region, formed in the process of grain production, is also actively developing, exerting a serious impact on the subjects of management. One of the serious manifestations of this development is the rise in the level of groundwater in the northern and northern forest-steppe zones of the Omsk region. This leads to flooding and flooding of agricultural land, a significant change in the diet of plants. These processes occur regardless of human economic activity and, most likely, are caused by the natural cycles of the territories. But they have a serious impact on the rest of the subsystems of the NAC in rural areas and require serious efforts from agricultural producers to maintain the stable functioning of the NAC formed in the process of grain production.

The second feature is that for each of the selected subsystems, to one degree or another, self-organization in a network form is characteristic without the allocation of a dominant center.

The technological subsystem of the NAC of rural areas, formed in the process of grain production, is decentralized in the Omsk region. This is manifested in the absence of clearly expressed centers of attraction both in terms of material and technical support (supplies of basic resources, machinery and equipment are carried out by many suppliers, none of which controls the market), and in the supply of seed material - varieties are cultivated in the Omsk region foreign selection, varieties of Russian selection from other regions of Russia and varieties of local selection, created at the Omsk State Agrarian University and the Omsk Agrarian Scientific Center. At the same time, in the field of material and technical supply in the region, an extensive network of manufacturers, suppliers, official dealers and intermediaries has been created, which effectively solves the problems of technical, technological and resource support of the grain sub-complex of the region. A network form of interaction has also been established between the entities that provide the region's producers with seeds of new varieties. This network includes Russian (including the Omsk region) and foreign research institutions, basic seed farms and organizations providing storage and transportation of seeds. There is also no single control center in this network.
The economic subsystem of the NAC of rural areas, formed in the process of grain production, is also represented as a network of organizations, which includes the production, processing and storage of grain, as well as its marketing. The ecological subsystem of the NAC is a combination of natural-climatic factors, including soils, temperature regime, precipitation, populations of diseases and pests, weeds, varieties of grain crops, which are also in network interaction with each other. As applied to the Omsk region, this is largely a natural network, which includes factors related to human activities (varieties, fertilizers and protective equipment). If, for example, we analyze the NAC of rural areas that are formed in the countries of Western Europe, then the situation looks the opposite: the natural diversity there is minimal, which makes the ecosystems extremely unstable. Therefore, one of the key principles of sustainable development of the NAC in these countries is the conservation and restoration of natural diversity.

An example of the creation of network communities for the social subsystem of the NAC in rural areas is the unification of rural residents for the development of agrarian tourism [18-20]. It will not be possible to launch and successfully develop this activity outside of network relationships.

Third, the transformation of a vertically integrated economic system into a network form requires the use of appropriate management tools both at the level of individual commodity producers and at the level of territories, including the region as a whole. A feature of the Omsk region is that the network form of the economic model is most pronounced at the macro level (municipal district, region) and, to a lesser extent, at the level of individual economic entities.

4. Discussion

Within the framework of the non-classical type of scientific rationality, the NAC of rural areas are active self-developing systems that have a direct impact on the subjects of management, while becoming in the subject position. At the same time, the NAC of rural areas ceases to be just objects of management, on which it is required to periodically exert administrative influence. The subjectivity of the NAC in rural areas is manifested in the fact that all elements of these complex systems self-organize and self-develop, often regardless of the directing influences and goals of human activity.

At the same time, the processes of self-organization of subsystems of the NAC of rural areas have a direct impact on the subjects of management (heads of agricultural organizations and the corresponding regional and municipal authorities), forcing them to also improve themselves. In this case, the main instrument of influence is the communication links that arise between both the subject and the object of management, and between individual subsystems of the NAC in rural areas.

In contrast to feedbacks, on which classical management is based, communication links allow building simulation models for managing the NAC in rural areas, and for individual subsystems (technological, social and economic) using organizational-activity games as a basic management model.

Effective management of network structures that are formed in the corresponding subsystems of the NAC in rural areas cannot be effectively carried out within the framework of a hierarchical management system, since in such structures there is no single decision-making center and vertical subordination of elements. Accordingly, in this case, network control must be applied, the essence of which is, in fact, to the control of self-organization processes within the HSC subsystems.

5. Conclusion

A feature of network management as a management of the processes of self-organization and self-development of networks is the creation of conditions necessary for the successful interaction of network participants. With regard to the NAC of rural areas that are formed in the process of grain production, this means creating favorable conditions for increasing the efficiency of interaction between suppliers of material and technical resources, machinery, equipment and seeds, as well as commodity producers within the framework of the technological subsystem; creation of optimal conditions for interaction between grain producers, organizations that carry out part-time work and storage of grain, as well as its delivery within the marketing system (economic subsystem). The self-
organization of employees and other groups of the rural population living on the territory of the NAC also needs to be monitored and directed in the right direction. Very often, ignoring the work with public opinion can complicate or make it impossible to implement a project.

Network management today is one of the most effective types of NAC management in rural areas that are formed as a result of the production of grain crops. At the same time, the concept of self-developing polysubject environments and environmental management, which is the most promising from the point of view of the development of the methodology for managing the NAC of rural areas, will gradually enter into modern management practice.

Acknowledgments
«The reported study was funded by RFBR according to the research project № 19-010-00482»

References
[1] Nardin D S and Nardina S A 2020, Sustainable development management of natural-anthropogenic complexes of rural territories. *Journal of Advanced Research in Dynamical and Control Systems* 12(3 Special Issue) 1447–1452
[2] Ovchinnikova N, 2020, Analysis of sustainable development of rural areas in Russia: Results, challenges and solutions. *EES Web of Conferences* 210 14002
[3] Diuldin M, Bykova N, Zhuchenko A, Cheremisin A and Switala F 2020 Sustainable development of rural areas, Russian issues. *IOP Conference Series: Earth and Environmental Science* 578(1) 012005
[4] Laurett R, Paco A and Mainardes E W 2021, Sustainable Development in Agriculture and its Antecedents, Barriers and Consequences – An Exploratory Study. *Sustainable Production and Consumption* 27 298-311
[5] Iqbal M A, Abbas A, Naqvi S A A, Samie A and Ahmed U I 2020 Drivers of farm households’ perceived risk sources and factors affecting uptake of mitigation strategies in pakistan: Implications for sustainable agriculture. *Sustainability* (Switzerland) 12(23) 98951-917
[6] Rudel T K 2020, The variable paths to sustainable intensification in agriculture. *Regional Environmental Change* 20(4) 126
[7] Gomez-Villarino M T and Ruiz-García L 2021 Adaptive design model for the integration of urban agriculture in the sustainable development of cities. A case study in northern Spain. *Sustainable Cities and Society* 65 102595
[8] Zhang Y, Chao Y, Fan R, Ji K and Xu B 2021 Spatial-temporal trends of rainfall erosivity and its implication for sustainable agriculture in the Wei River Basin of China. *Agricultural Water Management* 245 106557
[9] Mukhopadhyay R, Sarkar B, Jat H S, Sharma P C and Bolan, N S 2021 Soil salinity under climate change: Challenges for sustainable agriculture and food security. *Journal of Environmental Management* 280 111736
[10] Scheer C, Pelster D E and Butterbach-Bahl K 2020 Editorial Overview: Climate change, reactive nitrogen, food security and sustainable agriculture - the case of N2O. *Current Opinion in Environmental Sustainability* 47 A1-A4
[11] Stepin V 2009 Self-developing systems and philosophy of synergetics. *Economic strategies* 7 24-35
[12] Lepskiy V E 2010 *Reflexive-active environments of innovative development* (Moscow: Establishment of the Russian Acad. Sci., Institute of Philosophy, RAS) 256
[13] Lepskiy V E 2012 Reflexive aspects in the evolution of ideas about management. *International scientific and practical interdisciplinary journal "Reflexive Processes and Control"* 1-2(12) 26-55.
[14] Nardin D S, Krasnaya Y S, Nardina S A, Mozzherina T G and Aleshchenko V V 2016 Prospects of import substitution of seminal wheat in the russian federation by breeds of local
selection. *International Journal of Economic Research* 13(6) 2453–2463

[15] Zhang X and Zhang Z 2020 How do smart villages become a way to achieve sustainable development in rural areas? Smart village planning and practices in China. *Sustainability (Switzerland)* 12(24)10510 1-20

[16] Adamowicz M and Zwolinska-Ligaj M 2020 The "smart village" as away to achieve sustainable development in Rural Areas of Poland. *Sustainability (Switzerland)* 12(16) 6503

[17] Allanina L M, Smirnova E A, Kalafatov E A, Shadskaja I G and Shirokovskikh S A 2020 Sustainable development of rural areas: Increasing employment in the context of digital technologies development. *Journal of Advanced Research in Dynamical and Control Systems* 12(4) 1069-1076

[18] Arru B, Furesi R, Madau F A and Pulina P 2021 Agritourism, farm income differentiation, and rural development: The case of the region of montiferru (Italy). *Smart Innovation, Systems and Technologies* 178 SIST 80-90

[19] Kazmina L, Makarenko V, Provotorina V and Shevchenko E 2020 Rural tourism (agritourism) of the Rostov region: Condition, problems and development trends. *E3S Web of Conferences* 175 10001

[20] Ciolac R, Adamov T, Iancu T, Rujescu C and Marin D 2019 Agritourism-A sustainable development factor for improving the 'health' of rural settlements. Case study Apuseni Mountains area. *Sustainability (Switzerland)* 11(5) 1467