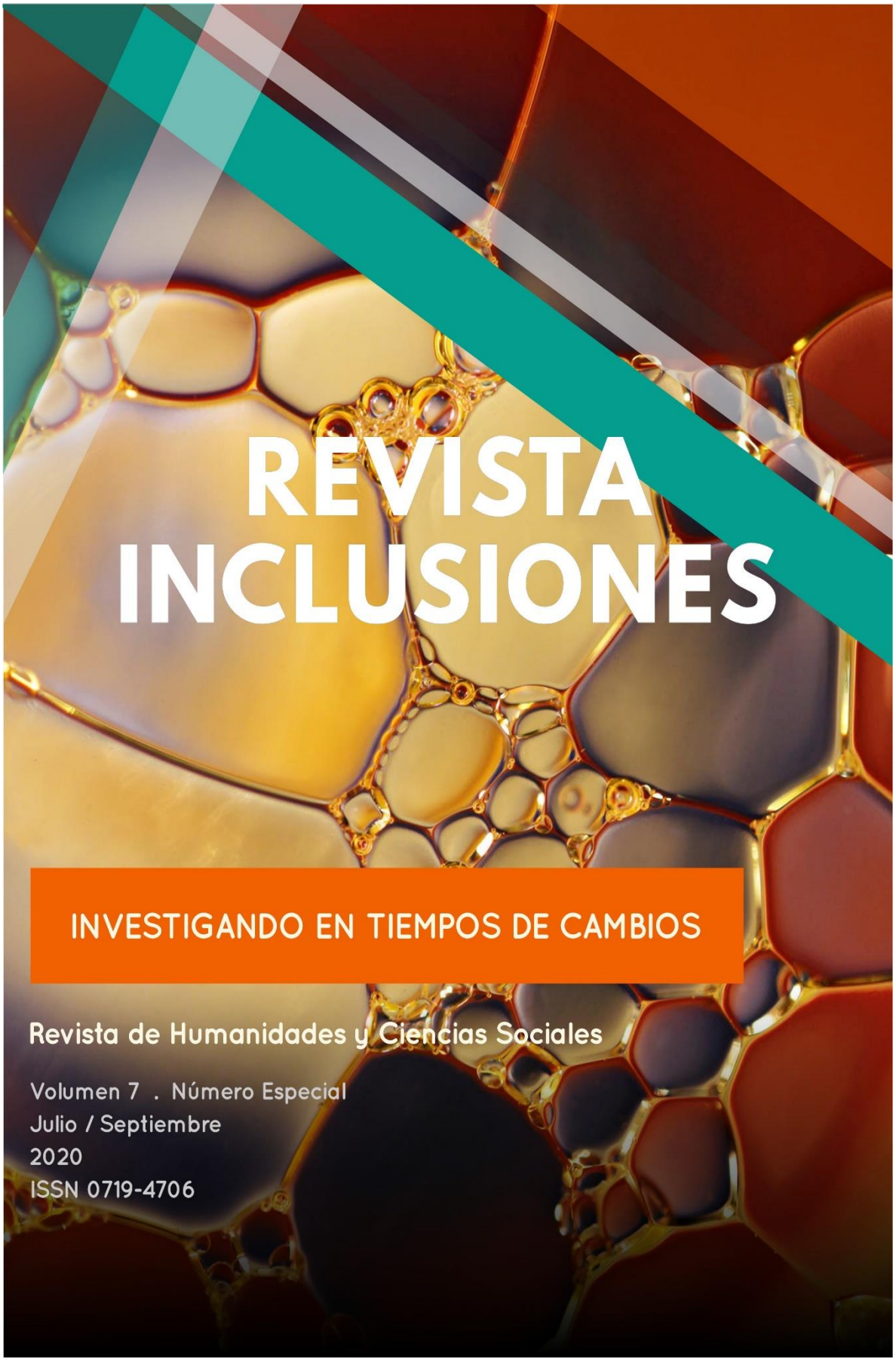

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CLUSTER CONFIGURATION FOR WASTE TREATMENT OF FOREST COMPLEX OF THE YENISEI SIBERIA[1]

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Abstract

Subject of research: the processes of cluster generation for the waste treatment of forest complex in the macro-region of the Yenisei Siberia based on the concept of smart specialization. *Object*: development of a cluster configuration model for the processing of forest complex waste on the methodological basis of a system and evolutionary approach, the concept of controlled diversification of the cluster structure using related industries technologies. *Methods*: process audit, expert assessment, surveys, ananlysis and synthesis, time series analysis, evolutionary analysis, rank method. *Results*: the prospects of a combination of evolutionary and controlled processes in the cluster are assessed, possible risks of cluster development and promising technological chains for the production of high value-added end products from forest waste are identified, a target model for the configuration of a forest waste processing cluster is developed. *Conclusions*: the clustering of modern industries around the idea of deep processing of forest raw materials will make it possible to give the development of the region's timber complex an appropriate degree of sustainability and innovation, avoid blocking the development of technologies, and coordinate the interests of quad-helix actors.

Keywords

Cluster – Forestry residues wastes – Smart specilisation – Technological chains

[1] The study was supported by the Krasnoyarsk Regional Fund for the Support of Science and Scientific and Technical Activities in the framework of the scientific project "Cluster Formation Concept for the Forestry Wastes Processing in the Yenisei Siberia for the Period Until 2030" (application No. 2019051795120, contract No, 09/19 of 07/12/2019).

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Introduction

Among the global problems that humanity needs to urgently and comprehensively address, the problem of waste should be noted. This problem is quite acute for the forest complex. In particular, when deforestation, over 40% remains not exported, since it belongs to the category of snon-standard timber, 50-60% goes to waste at the stages of timber sawing and subsequent processing. At the same time, the integrated processing of forest waste is a profitable business that allows you to get the final product with high added value.

The hypothesis of the study is that due to the support of interaction between institutions participating in the cluster and diversification in related industries, a synergistic effect will appear due to the introduction of innovations and expressed in increasing profitability, financial stability, and expanding the sales market, despite the geographical remoteness of the Yenisei Siberia regions.

Due to the technological features of the forestry complex, waste recycling cannot be a problem for individual enterprises; it is an interdisciplinary and interregional task. This problem must be solved within the framework of such a macro-region as the Yenisei Siberia (includes the Krasnoyarsk Territory, the Republic of Khakassia and the Republic of Tyva). The share of the Krasnoyarsk Territory in the total regional gross product of the macroregion exceeds 90%, and the trends in the development of its forest complex and waste processing are generally the same as in other subjects of the federation.

Studies have shown that for the period from 1991 to 2018 there was a decrease in the share of forest products in the gross regional product (GRP) of the Krasnoyarsk Territory to 2.5% (2018)[2]. One of the main reasons for this is the closure of a number of interconnected enterprises of the timber and chemical industry that actually used the waste of the timber industry (sawdust, wood chips, *etc.*), including the city of Krasnoyarsk - hydrolysis and pulp and paper production, as well as the production of man-made fiber . All this led not only to a deterioration of the environmental situation in the region, but also affected demographic imbalances. The population leaves the forest areas and moves to settlements provided with jobs. For example, the population of the city of Igarka in connection with the liquidation of the Igarsky sawmill and transshipment plant for the period under review decreased from 27 thousand to 3.7 thousand people.

The problems in the timber industry of the region are systemic in nature and require a systemic solution that harmonizes the interests of enterprises, authorities and the local community in the economic, social, and environmental spheres. One of such solutions is the creation of a high-tech forest industry cluster in Yenisei Siberia. The founders of the cluster theory proved that clusters are not formed “from above” by the state, the government can only create conditions for establishing a cluster, that is of free interaction. Integration of efforts of business entities, authorities and the scientific and educational community of the Yenisei Siberia should be aimed at supporting the cluster type of interaction in the regional forestry complex, which has innovative potential and motivation to solve environmental problems.

[2] The Government of the Krasnoyarsk Territory, “The Preliminary Strategy for the development of the forest complex of the Krasnoyarsk Territory until 2030. The official portal of the Krasnoyarsk Territory: Ministry of Forestry of the Krasnoyarsk Region” (Ministry of Forestry of the Krasnoyarsk Territory, June 22, 2019), http://mlx.krskstate.ru/dat/File/57/dokumenty/Proekt%20Strategii.pdf.

According to the most famous definition of M. Porter, a cluster is a group of geographically concentrated interconnected companies that compete, but at the same time are working together[3]. Along with the development of the conceptual apparatus of cluster theory, methodological approaches to identifying clusters have been developed[4], the creation of prerequisites for their development[5], the role of clusters in the development of national innovation systems[6]. Methods have been developed for identifying cluster success factors, including individual stages of its evolution[7].

The development of the cluster begins "with the clash of local and external knowledge", the growth in the number of new participants is due to the exchange of local knowledge and the inflow of external knowledge[8], i.e. geographical diffusion[9]. If the cluster is developed by enterprises of related industries, then higher innovation activity is observed than in the case of narrow industry specialization[10]. It has been suggested that the presence of specialized clusters may impede the long-term innovative development of regions[11].

In many respects, these ideas confirm the conclusion of P. Cooke that the formation and development of the cluster occurs due to the interbranch flow of knowledge[12]. A number of studies emphasize how important is the exchange of specialized knowledge and skills at

[3] M. Porter, Competition, ed. O.L. Pelyavsky, transl. from English (Moscow: Williams, 2005).

[4] A. A. Mantsaeva and T. G. Delikova, "Sistema indikatorov dlya otsenki potentsiala formirovaniya klastera v regione", Bulletin of the Voronezh State University of Engineering Technologies, Vol: 4 num 20 (2016): 476–483, accessed March 20, 2020, http://www.vestnik-vsuet.ru/vguit/article/view/1206; T. V. Mirolyubova; T. V. Karlina and T.Yu Kovaleva, Modeli i faktory sozdaniya i razvitiya regional'nykh klasterov: monografiya (Perm, Russia: Perm State National Research University, 2013); INNO Germany AG, Clusters and clustering policy: a guide for regional and local policy makers, 2010, https://cor.europa.eu/en/engage/studies/Documents/Clusters-and-Clustering-policy.pdf.

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[8] Pengfei Li, "A tale of two clusters: knowledge and emergence", Entrepreneurship & Regional Development, Vol: 30 num 7–8 (2018): 822–847.

[9] Thomas Kemeny and Michael Storper, "Is Specialization Good for Regional Economic Development?", Regional Studies, Vol: 49 num 6 (2015): 1003–1018.

[10] Jarle Aarstad; Olav A. Kvitastein and Stig-Erik Jakobsen, "Related and unrelated variety as regional drivers of enterprise productivity and innovation: A multilevel study", Research Policy, Vol: 45 num 4 (2016): 844–856; Rune Njøs and Stig-Erik Jakobsen, "Cluster policy and regional development: scale, scope and renewal," Regional Studies, Regional Science, Vol: 3 num 1 (2016): 146–169; Philip Cooke, "Transversality and Transition: Green Innovation and New Regional Path Creation", European Planning Studies, Vol: 20 num 5 (2012): 817–834; Philip Cooke, Complex Adaptive Innovation Systems: Relatedness and Transversality in the Evolving Region (London: Routledge, 2013).

[11] Rune Njøs and Stig-Erik Jakobsen, "Cluster policy and regional development...

[12] Philip Cooke, Complex Adaptive Innovation Systems...; Rune Njøs and Stig-Erik Jakobsen, "Cluster policy and regional development ...

the intersection of industries[13]. At the same time, it is noted that knowledge should not be unrelated, warning against excessive diversification of the cluster structure[14].

An active research has been conducted as a part of the cluster theory in Russia as well. The results of the research analysis showed that, firstly, the clusters supported by the state as a whole are focused on the transfer of knowledge from abroad, through cooperation with research institutions inside and outside the country[15]. Secondly, the state itself evaluates the activity of any cluster through the prism of its influence on the socio-economic development of the region. Thirdly, there are certain methodological problems associated with the activity of clusters and, first of all, with the so-called innovative clusters[16] (identification of sources of innovation, regulatory issues, *etc.*).

Thus, outside the active scientific debate are the environmental effects of clustering, taking into account the interests of the population and the whole, the microlevel of cluster research, the features of cluster development in the so-called “old” industries, various aspects of reconstructing broken relationships and preventing technological blocking[17] of cluster development as their evolution.

In this regard, the aim of the study is to justify the target model of the cluster configuration for the processing of forestry residues wastes of the Yenisei Siberia macroregion taking into account the interests of its participants, the state and society. Based on the analysis of modern literature on clustering problems, the spatial and technological principle of building a cluster without reference to the existing boundaries of the industry is chosen, based on the innovative effects of diversification in related industries, which will increase the stability of the future cluster to technological changes.

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[17] R. Perkins, “Technological «Lock-In»” in International Society for Ecological Economics Internet Encyclopaedia of Ecological Economics (Boston, MA: International Society for Ecological Economics, 2003).

Methods

The methodological basis for the study of clusters is the systemic and evolutionary[18] approaches, using general scientific methods of comparison, analysis and synthesis, based on world experience. The diversity of the implementation environment of cluster initiatives and directions of state support is taken into account on the basis of the concept of a quad helix[19], which is a further development of the theory of the "triple helix" [20], with the addition of a new actor – society[21]. Understanding the importance of such interaction increases the likelihood of success of entrepreneurial projects in a certain territory, promotes the localization of industries and the growth of their innovative and technological level, inevitably affecting the cluster configuration.

The developed methodology of the system approach[22] makes it possible to justify and coordinate aspects of the interaction of cluster members, makes it possible to obtain an ecosystem effect and ensure cluster viability. The theory of sustainability of economic systems, consistent with the system-integration theory[23], acts as the basis for the development of a cluster configuration that is resistant to changes in the composition of participants, operating conditions, technological changes that support the steady growth of the macroregion's economy, including from environmental and social positions[24], on the scale of a regional forest cluster[25].

The use of the concept of "smart specialization" [26] in this work provides a theoretical basis for the formation of cluster development strategies, competencies of participants, the choice of areas of specialization, the activation of structural changes in the timber industry sectors and the associated solution of social and environmental problems, the formation of

[18] Michaela Trippl et al., "Perspectives on Cluster Evolution: Critical Review and Future Research Issues," European Planning Studies, Vol: 23 num 10 (2015): 2028–2044.

[19] Elias Carayannis and Evangelos Grigoroudis, "Chetyrekhzvennaya spiral' innovatsiy i «Umnaya spetsializatsiya»: proizvodstvo znaniy i natsional'naya konkurentosposobnost'", Foresight and STI Governance, Vol: 10 num 1 (2016): 31–42.

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[21] N. V. Smorodinskaya, "Troynaya spiral' kak novaya matritsa...; Nataliya V. Smorodinskaya and Daniel D. Katukov, "When and why regional clusters become basic building blocks of modern economy," Baltic Region, Vol: 11 num 3 (2019): 61–91; Elias Carayannis and Evangelos Grigoroudis, "Chetyrekhzvennaya spiral' innovatsiy...

[22] G. B. Kleiner; R. M. Kachalov and N.B. Nagrydnaya, "Strategiya razvitiya klasterov: Formirovaniye terminologii", Nauka. Sintez strategii klastera na osnove sistemno-integratsionnoy teorii, Vol: 7 (2008): 9–39; E. V. Melnikova and Yu A. Bezrukikh, "Ustoychivost' biznes-modeli v upravlenii promyshlennym predpriyatiyem", Ekonomika i Menedzhment Sistem Upravleniya, Vol: 24 num 2–2 (2017): 216–221; E. V. Melnikova and Y.A. Bezrukikh, "Business model of industrial enterprise: sustainability assessment", in Proceedings of the 30th international business information management association conference (IBIMA (Madrid, Spain, 2017), 2988–3001.

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[24] Sébastien Sauvé, Sophie Bernard, and Pamela Sloan, "Environmental sciences, sustainable development and circular economy: Alternative concepts for trans-disciplinary research", Environmental Development, Vol: 17 (2016): 48–56.

[25] K.V. Rezanov, "Metodologicheskiy podkhod k obespecheniyu ustoychivogo razvitiya klasternoy modeli lesnogo kompleksa regiona", Upravleniye Ekonomicheskimi Sistemami: Elektronnyy Nauchnyy Zhurnal [, Vol: 4 num 86 (2016): 2.

[26] Nataliya Smorodinskaya and Daniel Katukov, "Dispersed Model of Production and Smart Agenda of National Economic Strategies", Economic Policy, Vol: 12 num 6 (2017): 72–101.

an impulse for diversification into new industries. In turn, the theory of macro-regional zoning and strategy[27] forms the basis for embedding cluster policy in the development context of Yenisei Siberia.

To solve the research problems, methods of technological audit, expert assessments, interviewing, questioning, analysis and synthesis, time series analysis, evolutionary analysis, and rank methods are used. To conduct a technological audit, a technique is proposed that is applicable to a complex of enterprises. In accordance with it, an analysis of the activities of 87 enterprises located in the Yenisei Siberia was carried out. The selection in terms of production volume and number of employees is structured into three groups, it includes 2 large enterprises (20% of the total number in the group), 10 medium (7%) and 75 small (5%). Microenterprises were excluded from the study (according to various estimates, their total number exceeds 3,5 thousand), on which, as a rule, no more than 1-2 people are engaged exclusively in timber sawing, largely from unaccounted raw materials. During the audit, the compliance of existing production capacities, technologies, equipment, personnel with the possibilities of processing forest waste, which allows creating products with high added value, was analyzed. The possibilities of applying advanced technologies at existing enterprises were also considered.

Verification of technological chains in the target model of cluster configuration was carried out by comparing the results of the technological audit with the results of a survey of potential cluster participants and the data of peer inspections. The ranking method was used when processing the results of the questionnaire of participants in the cluster interaction (87 people). Processing the results of an expert survey was carried out by the method of pairwise comparisons. Representatives of the scientific community were involved as experts. The capabilities of expert assessments were used to identify the root enterprises of the future cluster, types of waste, and technologies for its possible processing. The technological audit was carried out by specialists of the Krasnoyarsk Regional Center for Biotechnological Engineering. In order to support the motivation for waste processing, an additional sociological survey of the region residents was carried out based on the quad helix methodology.

Results

The authors of this study conducted a survey of the enterprise management team of the timber processing complex, where a technological audit was conducted, as part of the development of the Concept for the development of a cluster for processing waste from the forest complex on the territory of the Yenisei Siberia for the period until 2030. A 10-point scale was used, divided into levels (high, medium, low) with subsequent ranking of average points. The questionnaire made it possible to assess the level of readiness for joining the cluster and the main motives for clustering, to identify the products and types of waste proposed for further processing.

The interest of forestry enterprises in waste processing was rated as average (6.2 points), as well as the level of readiness for cluster interaction (6.7 points). The perception of the sufficiency of power and institutional support is somewhat lower - 5.4 points, the level of resource support is rated as insufficient to achieve such ambitious goals - 2.9 points. An analysis of the responses showed that the most significant arguments for interaction in the

[27] V. I. Sarchenko, ed., Upravleniye razvitiyem Metodologiya regional'noy strategii: monografiya (Krasnoyarsk: Krasnoyarsk Siberian Federal University, 2018).

cluster for potential participants are the availability of financing for investment projects, and access to markets for export, primarily foreign ones. And here, in their opinion, the Russian state should play a special role.

In addition, a sociological survey of 360 residents of the forest regions of the Yenisei Siberia macroregion was conducted, where also a ten-point system was used to measure satisfaction with medical supplies, education, salary, employment, transport infrastructure, the environment, *etc.* According to a survey of the region's population, the most important for society are respectable salary, employment and the environment. State support of private business is not a priority for the population. The identified expectations of employees regarding flexible employment opportunities confirm the conclusion of foreign researchers on the distribution of risks in a cluster environment[28].

As a result, a number of conclusions can be drawn. Firstly, for society the most significant are the projects related to improving the environmental situation, the processing of waste, including the timber industry, we can expect the unconditional support of such projects from the population. High expectations are associated with the emergence of additional working positions with relatively respectable salary for these territories. This will stop the outflow of the population from the forest regions of the macroregion, which will allow preserving, and perhaps even improving, the quality of medical and educational services in these areas (the provision standards depend on the population). At the same time, environmental potential motives are less significant for potential cluster members. The opinion of the forest community may be a decisive external factor for participation in the cluster project.

Secondly, there are a number of prerequisites for the development of a cluster for waste treatment of the timber industry complex. Among those: the availability of local raw materials, supply and counter demand for processed products (pellets, fuel briquettes, *etc.*), the presence of enterprises of related and supporting industries in the region (forestry, engineering, educational institutions, *etc.*), the desire of the authorities to solve environmental problems, development of the scientific and educational complex of the region. Types of waste that are "reasonable, environmentally safe and technologically possible to use as secondary raw materials"[29] were determined by comparing the results of an expert survey, technological audit and questionnaire.

Finally, taking into account the interests of society, the state and business and the views of the scientific and educational community of the region, it was possible to clarify the configuration model of the cluster for waste treatment of the forest complex in the macro-region of Yenisei Siberia. A retrospective analysis of the territorial-production complex of the region showed that one of the factors of its collapse was the technological blocking of the development of "anchor" enterprises. The first stage of the technological audit of existing enterprises in the region revealed the possible value chain in the timber industry and related industries.

According to experts, the waste processing cluster in the Yenisei Siberia can develop "around" one or several key companies, which through their activities will stimulate the creation and development of other technologically interconnected enterprises. Ideally, such

[28] K. Wennberg and G. Lindqvist, "How do entrepreneurs in clusters contribute to economic growth?" SSE/EFI Working papers in business administration num 3 (2008).
[29] INNO Germany AG, Clusters and clustering policy...

key companies should be the enterprises of the timber chemical industry - pulp and paper and biochemical enterprises. They will enable the emergence of a number of technological chains for the production of end products with high added value, including the production of cardboard and paper products, liquid biofuels, animal feed, synthetic rubber, tires and rubber products, viscose yarns, general and special purpose fabrics, clothing , pharmacological and perfumery products, *etc.* The cluster configuration diagram is shown in Figure 1.

The cluster configuration was developed by the authors of the study on the basis of the analytical work carried out by building technological chains for the production of final products with high added value.

Discussions

The proposed cluster configuration option takes into account the evolution of timber processing industries in the region[30] and is consistent with the results of studies of clustering processes in other regions. In particular, to create the core of a cluster of another multi-forestal region - the Khabarovsk Territory, it is proposed the development of general processing industries, including the use of waste; or diversification of production, the combination of forest and non-forest production[31]. The proposed cluster configuration option, on the one hand, is individual for such a macroregion as the Yenisei Siberia, and on the other hand, the approaches used in its construction can be replicated in whole or in part in other forest regions of the Russian Federation and in other states. The proposed configuration corresponds to the idea of organizing cluster types of “sectors with complex specialization, which is formed at the interface of several technologically related industries” [32]. There are no publications devoted to understanding the configuration and development of forest waste processing clusters based on a combination of evolutionary and controlled processes in Russia.

[30] V. I. Sarchenko, ed., Upravleniye razvitiyem Metodologiya regional’noy strategii...
[31] K. V. Rezanov, “Metodologicheskiy podkhod k obespecheniyu...
[32] Nataliya Smorodinskaya and Daniel Katukov, “Dispersed Model of Production...

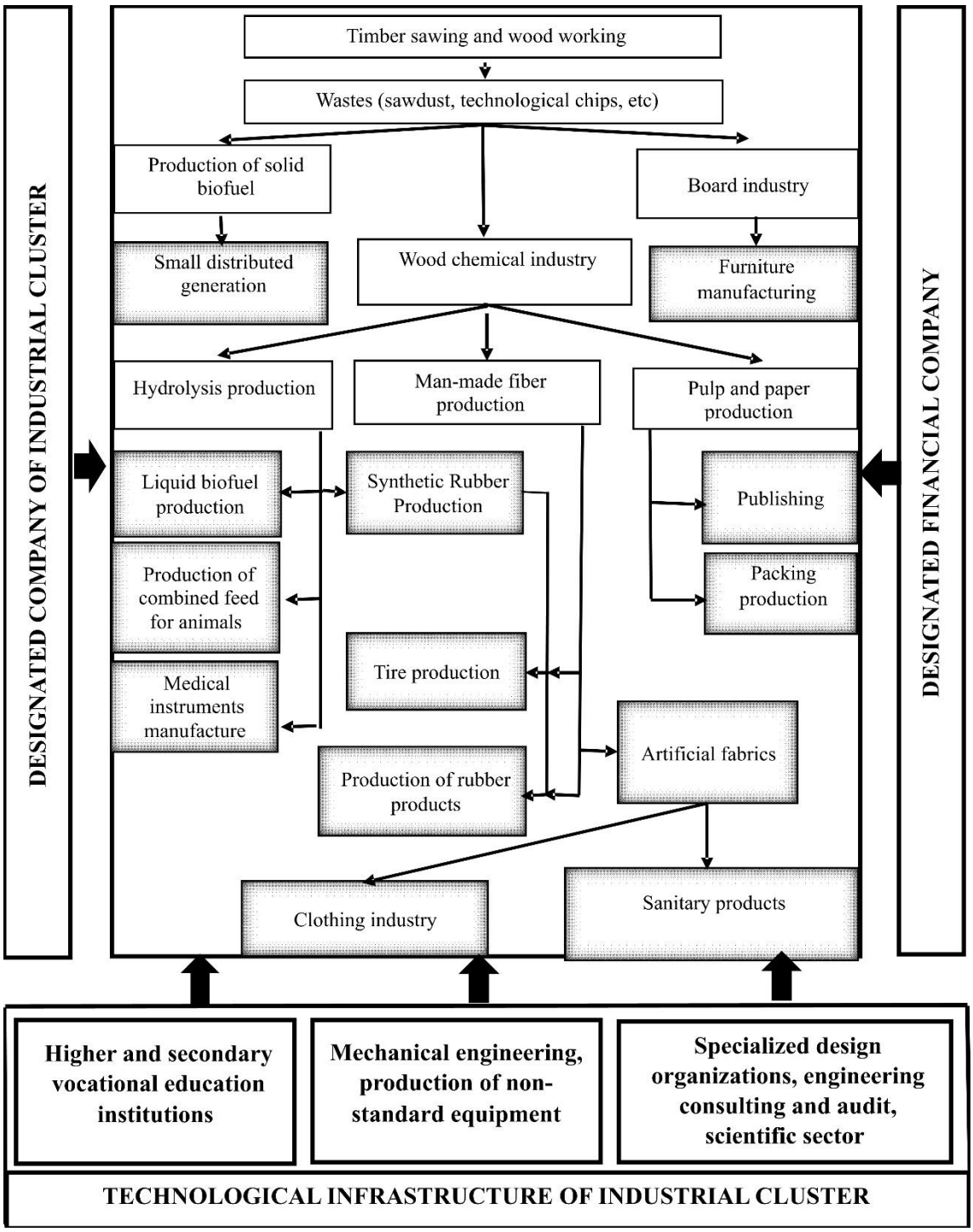

Figure 1
The main elements of the industrial cluster for the waste treatment
of the forest complex of the Krasnoyarsk Territory

Foreign sources emphasize the need for cluster diversification[33], a combination of conscious cluster initiative and an evolutionary approach in cluster formation[34], with justification of the situational nature of the effects[35]. The specificity of the projected cluster requires a combination of efforts of social, political and business leaders, the scientific community, which, according to the concept of a quad helix, contributes to the creation of innovative clustering effects.

The creation and involvement of certain infrastructure institutions, including a specialized organization of an industrial cluster (organization and coordination), a specialized financial organization (financing of cluster enterprises), and a permanent technology transfer platform can serve as a tool to stimulate the creation of a waste recycling cluster in the Yenisei Siberia educational and consulting institutions, *etc.*

The practical interest in clustering on the part of business in the forest sector is due to government support, which considers clusters as one of the drivers of regional competitiveness, innovation and economic growth[36]. The creation of clusters will allow updating the territorial and sectoral structure of not only the timber industry complex due to the introduction of new resource-saving technologies and recycling technologies[37], but also related industries, which in general will increase the GRP. According to experts, the growth potential of the revenues of timber enterprises only in the Krasnoyarsk Territory is estimated at 3.0-3.5 times[38]. These estimated indicators generally confirm the hypothesis of this study regarding the expected synergistic effect, which, on the one hand, will increase the financial stability and efficiency of forestry enterprises, and on the other, expand the consumer market for their products. Estimates of the clustering potential in the forest complex of the region, obtained in the work[39] by Vasilieva, Likhachev, and Filimonenko, confirm the significant possibilities of clustering, extracting a synergistic effect and innovative development in wood processing.

The effectiveness of clustering in the forest sector is confirmed by the experience of Finland, the USA, Canada and several other countries. In particular, in the works devoted to the study of the development of the forest complex in Finland, it was shown that due to

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[33] Ron Boschma and Gianluca Capone, “Institutions and diversification...; Jukka Luhas et al., “Product Diversification in Sustainability Transition: The Forest-Based Bioeconomy in Finland”, Sustainability, Vol: 11 num 12 (2019): 3293, accessed March 20, 2020, https://www.mdpi.com/2071-1050/11/12/3293.

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[35] Pengfei Li, “A tale of two clusters...

[36] T. Yu. Kovaleva, “Theoretical-Methodological Bases and Results of Estimation of the Effectiveness of Cluster Spatial Development of the Russian Federation Regions”, Vestnik of Astrakhan State Technical University. Series: Economics num 2 (2018): 101–111; V. Mirolyubova; T. V. Karlina and T. Yu Kovaleva, Modeli i faktory sozdaniya...; L. Gokhberg, ed., Technological Future of the Russian Economy: Report for the XIX April International Scientific Conference on economic and social development, Moscow, April, 10-13 (Moscow: Higher School of Economics, 2018).

[37] A. V. Rubinskaya; Yu A. Bezrukikh and E.V. Melnikova, “Retsikling kak sposob effektivnogo ispol’zovaniya resursov promyshlennogo predpriyatiya”, Rossiyskiy Ekonomicheskiy Internet-Zhurnal, Vol: 4 (2016): 55.

[38] V. I. Sarchenko, ed., Upravleniye razvitiyem Metodologiya regional’noy strategii...

[39] Z. A. Vasilieva; T. P. Likhachev and I. V. Filimonenko, “Otsenka bazovykh predposylok...

the use of cluster mechanisms, the country, with only 0.5% of the world's forest resources, provides 10% of the world export of wood products and 25% of paper[40].

According to Finnish scientists, these achievements were obtained, on the one hand, due to the synergistic effect of the cluster, and on the other, due to the action of four main mechanisms: economy of scale, learning effects, adaptive expectations, network effects[41]. The economy of scale is easily reproduced in a multi-forestal region and can reduce fixed costs and costs of technological preparation of production[42]. The learning effect involves the dissemination of knowledge between network participants in order to improve production[43], according to the survey, most potential cluster participants are ready to share knowledge only if they participate in joint projects. The value of adaptive expectations for the forest industry is relatively small, due to long supply chains, primarily related to bioeconomics[44]. The role of network effects is more significant: at the time of creation, they play a positive role, and in the period of maturity and aging, they play a negative role. So at the stage of creation and development of the cluster, new participants are attracted, which subsequently leads to the accumulation of their critical number[45], as a result, the inertia in development and demand increases[46], which impedes the introduction of new technologies and blocks the diversification of products[47]. To extract the network effect in the created cluster today, the efforts are needed to develop informal contacts between participants, involving educational and scientific organizations, as sources of modern competencies and innovative solutions.

The results obtained by the authors do not contradict the experience of other regions and countries. The concretization of the hallmarks of clusters as a self-developing system carried out in the work[48] by Kovaleva may be useful in further work. Using the concept of a quad helix as a theoretical basis for structuring a cluster in the forestry complex of the Yenisei Siberia macroregion allows solving not only the problems of efficiency, but also the problems of ecology and wate treatment of the forest complex, which are quite acute in a number of regions of the Yenisei Siberia.

Conclusions

The proposed cluster configuration for the waste treatment of the timber industry of the Yenisei Siberia is consistent with the dynamics of the opportunity windows presented in the work [49] by Gokhberg. If there is no interindustry component in short period, then in the medium term development it is expected in related industries (wooden housing construction,

[40] E. N. Skvortsov, “Protsess klasterizatsii v mirovoy ekonomike” in Economics, management, finance: Proceedings of the VI Internet scientific conference (2016, Krasnodar, Russia) (Novation, 2016), 23–26, https://moluch.ru/conf/econ/archive/172/9406/.

[41] V. I. Sarchenko, ed., Upravleniye razvitiyem Metodologiya regional’noy strategii...

[42] Zhanna Chernova, “Analiz nauchnykh podkhodov k ekonomicheskoy prirode klastera”, On-line Journal “Naukovedenie,” Vol: 6 num 6 (2014): 167EVN614.

[43] D. A. Sheikin, “Ot teorii klasterov - k teorii klasternogo razvitiya regionov: evolyutsiya i problematika”, Kreativnaya ekonomika [Creative Economy], Vol: 10 num 11 (2016): 1263–1272.

[44] Jukka Luhas et al., “Product Diversification in Sustainability Transition...

[45] V.I. Sarchenko, ed., Upravleniye razvitiyem Metodologiya regional’noy strategii ...

[46] Jarle Aarstad, Olav A. Kvitastein, and Stig-Erik Jakobsen, “Related and unrelated variety...; Ekaterina Islankina and Thomas Wolfgang Thurner, “Internationalization of cluster initiatives...

[47] Ekaterina Islankina and Thomas Wolfgang Thurner, “Internationalization of cluster initiatives...

[48] T. Yu. Kovaleva, “Theoretical-Methodological Bases...

[49] L. Gokhberg, ed., Technological Future of the Russian Economy ...

geoinformation monitoring of forests, biotechnologies, biodegradable polymers, biofuels). In the long run period, the development of forest nanotechnologies, genetic technologies, plantation forest growing, and mechanical engineering of a new generation is forecasted.

At the same time, possible risks associated with the creation and further development of a cluster for waste treatment of the forest complex of the Yenisei Siberia should be noted. Due to the fact that the vector of overtaking development is reproduced, underestimation of the latest convergent technologies[50] (genetic and nanotechnologies), both available and potential, is possible, which will affect the final efficiency of the cluster under consideration. It is necessary to take into account the potential of non-timber forest resources, including the production of organic food.

Clustering of the timber industry enterprises around the idea of waste processing will create organizational and managerial conditions for achieving greater competitiveness, macro-regional localization of modern production facilities for the deep processing of forest raw materials, solving development problems, promoting entrepreneurial activity, introducing innovations in a group of interrelated industries, which determines the relevance and importance of development conceptual foundations of the formation and development of forestry cluster of the Yenisei Siberia.

Research conducted in the framework of cluster theory is of great importance for the economy of the region. It is not a secret that the natural resources available on its territory and, primarily, forest resources are used irrationally. It is necessary to develop tools to stimulate the creation and development of clusters in the primary sectors of the economy and to adapt the cluster structure to the specifics of the Yenisei Siberia macroregion.

The proposed cluster configuration approaches can be useful for the global scientific community in terms of the innovative development of clusters based on traditional resources and waste processing using the latest technologies. The vector of further research should be directed towards the search for a combination of diversification and specialization of the cluster and mechanisms to prevent technological blockage of cluster development by improving its design within the regional specifics.

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