Formation of an Agricultural Cluster Based on the Ranking of Enterprises

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Abstract. The article deals with the formation of the cluster core and its environment with the clarification of the organizational structure. Much attention is paid to the necessity and sufficiency of including organizations in the cluster at the time of its formation and initial stage of operation. The authors suggest to use a ranking method based on the significance of the cluster's areas of work as well as the organizations that belong to each of them. At the same time, the cluster's work areas are related to its missions in the destination: industrial; innovative; satisfying the requirements inside the cluster; satisfying the requirements outside the cluster; social; territory development; cluster development. Within each of the directions the minimum number of organizations sufficient for the effective operation of the cluster was determined. Then the cluster organizations were ranked according to the allocated missions. Based on the ranking organizations of primary importance at the initial stage of the cluster are identified: organizations that provide financial services, supply machinery, equipment, production lines and knowledge as well as bulk buyers. The cluster has a "zone of necessary organizations" for starting the cluster as well as a "zone of efficiency increasing" that can be expanded and replenished as necessary.

1. Introduction
Cluster initiatives have been developing in the world for decades [1] and the Russian Federation is already using the accumulated experience in this area [2] sometimes significantly changing it to adapt to local conditions. Nevertheless, clusters are increasingly included in the Russian economy as an autonomous economic unit. At the same time, considerable attention is paid to the organizational structure of the formed clusters [3,4] because of it significantly affects to the manageability of the cluster and – ultimately – the effectiveness of its work [5].

The agro-industrial complex is probably more ready to implement clusters since it has historical analogues in the form of machine-tractor stations [6]. To date, a significant amount of scientific materials has already been accumulated on the problems of agricultural cluster development [7] including organizational management schemes and interaction of organizations outside and within it [8]. As a rule, an agricultural cluster includes organizations of a fairly diverse profile and areas of activity: some of them are singled out as the core and other parts playing a supporting and a servicing role – as
"satellites" (figure 1) [9]. At the same time, the "development" (functional, financial, organizational, etc.) of both the cluster center organizations and the services remains outside the scope of consideration.

![Organizational structure of the agro-industrial cluster](image)

**Figure 1.** Organizational structure of the agro-industrial cluster.

We know nothing of options that consider the need to include organizations – even those seeking to enter it and not forced from the outside – in terms of whether their functionality is sufficient to fulfill the cluster's mission. Therefore, it is necessary to create a mechanism for evaluating the necessity and sufficiency of including organizations in the cluster when it is formed or at the initial stage of operation. It should be emphasized that an already functioning and sufficiently developed cluster does not need this method since it considers the inclusion of "external" organizations, as a rule, from the point of view of increasing the actual efficiency of activities rather than potentially possible. In addition, the heads of organizations in the current cluster are already aware of weaknesses and are aware of the need to strengthen them evaluating tangible and intangible assets that would like to attract additional external resources.

It is proposed to clarify the organizational structure of the agro-industrial cluster and the scheme of interaction of organizations in its composition (figure 2) while the functioning of the proposed structure should be understood as follows. Management and coordination of the cluster structure is inextricably linked, first of all, with the production and processing of basic products that ensure the use of private resources of a separate organization or several at once in the direction of the goal. Therefore, it is not correct to represent them as separate blocks. At the same time, this block also coordinates the work of all organizations in the cluster so it should be the center of the cluster. However, the authors do not adhere to the concept that exceptionally effective management is the basis of any production since managing an object without the object itself does not make sense. In a cluster environment the control unit assumes a coordinating role rather than a controlling one. Therefore, the rank of this cluster core block will be significantly lower than that of the block responsible for production and processing of products.
Figure 2. Updated scheme of organizations’ interaction in the agro-industrial cluster.

Units responsible for science and training needs to be combined into one and they will always have bi-directional streams: developed knowledge and latest information to units of production and management information for analysis and generation of new knowledge, on the contrary, from the units of production and management. The rank of organizations in this area of cluster activity will be determined by the following considerations when two separate options are possible. The first is if an agricultural cluster has high-tech equipment (especially foreign-made equipment) then it strictly complies with the regulatory documents of its manufacturer. This includes getting software updates in a timely manner and its specialists will regularly undergo professional development. In this case, the dependence on new knowledge coming from the science and training block will be insignificant and the need for clustering will be low for such organization. The second option assuming a relatively low level of production and processing of products will significantly "link" the enterprise to organizations for science and advanced training. If, of course, the company’s management is going to reach a new level of production and increase its efficiency. In the second case the rank of this block will be significantly higher than in the first.

Other blocks usually have unidirectional flows of products and services and can be partially or even completely replaced by resources of organizations in the cluster core. In fact, their inclusion in the cluster is dictated by reducing the costs of organizations in the cluster core. Therefore, their total rank will not exceed the rank of the organization/organizations in the cluster core even if their number is large enough. In this case we are talking about assigning a general rank for the category of organizations that serve the main production process followed by "dividing" the total value in accordance with the rank of each organization included in it. In a single case the role (and rank) of these organizations may increase – if the cluster core performs non-diversified production. In this case the core's rank is significantly reduced and it is redistributed to organizations that serve the main production.

Next, we will consider a typical agricultural cluster with no pronounced specialization in a particular area of production at the stage of its formation.
2. Methodology
The authors suggest using the method of ranking by significance of the directions indicated in the diagram of figure 2 as follows [10]:

- **R₁** – industrial mission – 0.05;
- **R₂** – innovation mission – 0.05;
- **R₃** – mission to meet needs within the cluster – 0.2;
- **R₄** – mission to meet needs outside the cluster (market saturation mission) – 0.4;
- **R₅** – social mission – 0.05;
- **R₆** – the territory development mission – 0.05;
- **R₇** – the cluster development mission – 0.2,

here the sum of all ranks equals 1.

Let's explain the assigned rank for each mission. The developing cluster (as well as the cluster at the stage of formation) realizes the potential of the core and that is why the mission of market saturation significantly prevails over all of them. In addition, organizations at this stage are interested in strengthening ties to achieve a common goal – hence the high rank of the mission to meet needs within the cluster. The cluster development mission also contributes to achieving this goal that is why it also has a high rank. All other missions are assigned a secondary role but it should be emphasized that the strength the cluster's position the more the rank of the social mission as well as the territory development mission. If the cluster reaches the level of "high" innovation and begins to play a leading role in its field (for example, by selling intellectual property rights) then both industrial and innovation missions will increase. Unfortunately, this development option is quite unique for an agricultural cluster.

Within each of the directions the minimum number "L" of organizations "kᵢ" was determined that sufficient for the function:

- **L(k₁)** – financial organizations/investors (with the option to choose the best commercial offer) – 2;
- **L(k₂)** – science, innovation, training (with the possibility to choose the latest knowledge in various fields of science – 2 as well as the highest quality of training services – 1) – 3;
- **L(k₃)** – maintenance of machinery and production lines – 2;
- **L(k₄)** – supply of tools; spare parts, equipment and emerging technology; new varieties/breeds – 4;
- **L(k₅)** – sales and promotion (trade intermediaries including wholesale customers – 2, advertising agencies – 1) – 3;
- **L(k₆)** – direct consumers of products (stores – 3, enterprises that consume cluster products – 1) – 4.

Next, each organization will be evaluated in terms of the set of provided services "Rᵢ" with calculating the arithmetic mean for an individual set of parameters "kᵢ(Rᵢ)". The values for the actual cluster center "Z" will be defined in the same way. To find the coordinates of the geometric center "M" of the cluster the arithmetic mean values "kᵢ" and Z will be calculated for the corresponding coordinates (directions).

By setting the coordinate axes where x – the number of organizations (or the number of services provided) and y – the arithmetic means for an individual set of parameters (ranking) a graph of the density of points in the cluster will be built. In this case, taking into account the number of missions and the maximum set mission rank we get \( x_{\text{max}} = 7 \), \( y_{\text{max}} = 0.4 \).

3. Implementation
Let's rank the directions of functioning of the "kᵢ" cluster organizations by the selected missions. To do it we will evaluate each of them from the point of view of performing the above-mentioned missions.

1. Financial and credit direction – \( k₁(y) = \{R₃; R₆; R₇\} \).
   Explanation: the implementation of the \( R₆ \) and \( R₇ \) missions will help attract new customers.
   Substituting the values \( Rᵢ \) we get \( k₁(y) = \{0.2; 0.05; 0.2\} \) when \( x = 3 \). Calculating the arithmetic mean of the values on the "y" axis we get the following coordinates \( k₁(x;y) = (3; 0.15) \).
   Similarly, we get the coordinates for the other directions.
2. Science, innovation and training – \( k₂(y) = \{R₁; R₂; R₃; R₅; R₇\} \).
Explanation: the implementation of the R5 mission will contribute to increasing the level of education of the population in the cluster destination and leads to increasing the demand for education and advanced training.

1. Explanation: the implementation of the R5 mission will contribute to increasing the level of education of the population in the cluster destination and leads to increasing the demand for education and advanced training.

2. \( k_2(y) = \{0.05; 0.05; 0.2; 0.05; 0.2\} \) when \( x = 5 \) and finally \( k_2(x; y) = (5; 0.11) \).

3. Maintenance – \( k_3(y) = \{R_1; R_3\} \).

4. Supply – \( k_4(y) = \{R_1; R_2; R_3\} \).

5. Sales and promotion – \( k_5(y) = \{R_1; R_2; R_3; R_7\} \).

6. Direct consumers of products – \( k_6(y) = \{R_1; R_3; R_4\} \).

7. Estimate the cluster center \( Z \) using a similar approach - \( Z(y) = \{R_3; R_4; R_7\} \).

8. Find the geometric center \( M \) of the cluster as the arithmetic mean of all coordinates \( k_j \) and \( Z \) on the "x" and "y" axes.

\( M(x; y) = (3.29; 0.156) \).

Let’s plot \( k_j \), \( Z \) and \( M \) defined above in the Cartesian system (figure 3). Authors propose to distinguish two areas in the cluster – organizations which necessary for its functioning and organizations whose activities can be partially or completely replaced with the loss of some of the cluster’s efficiency.

![Figure 3](image-url)
that perform the functions of science, innovation and training as well as service. It is likely that without these directions the cluster at the stage of formation and development can perform its functions for some time. This can be explained by the fact that the center cluster has a certain margin of safety (inertia of development) therefore used resources allow us to continue production and/or processing of cultivated products with independent service technicians involved. Therefore, the inner circumference can be called a zone of organizations to launch the cluster and the external area of improving the efficiency of the cluster that can be expanded and updated as necessary.

Due to the fact that several organizations are expected to be involved in each direction (the total number may reach 21 in our case) it is necessary to rank organizations by significance to highlight organizations of primary importance among them as well as lower gradations. This will allow to focus on organizations that are really necessary for the implementation of all planned missions and avoid organizations which joined the cluster in order to use shared resources exclusively for their own development. However, we must remember to create conditions for healthy competition among organizations in the cluster.

Organizations will be ranked by dividing the already ranked direction by the number of organizations in it and assigning a weight coefficient for each of them (table 1).

| Direction                                      | Number of organizations | Weight number | Parameter identifier | Rank |
|-----------------------------------------------|-------------------------|---------------|---------------------|------|
| Financial organizations $k_1(x)=0,15$         | 2                       | 0,80          | k_{11}              | 0,120|
| Organization 1 (works with agricultural       |                         |               |                     |      |
| organizations)                                |                         |               |                     |      |
| Organization 2                               |                         | 0,20          | k_{12}              | 0,030|
| Science, innovations, training of personnel $k_2(x)=0,11$ | 3                       |               |                     |      |
| Research institute                           | 0,35                    |               | k_{21}              | 0,040|
| University                                   | 0,55                    |               | k_{22}              | 0,060|
| Centre of excellence                         | 0,10                    |               | k_{23}              | 0,010|
| Maintenance $k_3(x)=0,125$                    | 2                       | 0,50          | k_{31}              | 0,065|
| Technic and equipment                        |                         |               |                     |      |
| Processing line                              |                         | 0,50          | k_{32}              | 0,065|
| Supply $k_4(x)=0,1$                           | 4                       | 0,25          | k_{41}              | 0,025|
| Tools                                        |                         |               |                     |      |
| Spare parts, equipment                       | 0,25                    |               | k_{42}              | 0,025|
| Emerging technology                          | 0,25                    |               | k_{43}              | 0,025|
| New varieties/breeds                         | 0,25                    |               | k_{44}              | 0,025|
| Sales and promotion $k_5(x)=0,125$            | 3                       | 0,45          | k_{51}              | 0,056|
| Wholesale customer 1                         |                         |               |                     |      |
| Wholesale customer 2                         |                         | 0,45          | k_{52}              | 0,056|
| Advertising agency                           |                         | 0,10          | k_{53}              | 0,013|
| Direct consumers of products $k_6(x)=0,1$     | 4                       | 0,10          | k_{61}              | 0,010|
| Shop 1 (located on the cluster territory)     |                         | 0,25          | k_{62}              | 0,025|
| Shop 2 (located outside the cluster territory)|                         | 0,25          | k_{63}              | 0,025|
| Shop 3 (located outside the cluster territory)|                         | 0,25          | k_{64}              | 0,040|
| Enterprise consumes the cluster products       |                         | 0,40          |                     |      |
Let's explain the entered weight number. Financial organizations that specialize in working with agricultural producers are well aware of the specifics of production and processing of products. Therefore, they are more accurately aware of the risks of creating a cluster and its subsequent operation. In addition, for example, banks have preferential rates for credit for organizations from the agricultural sector. It should be emphasized that a bank cannot enter a cluster directly unless it is created by its members. However, its place can be taken by an investor who is also know the policy of agricultural production.

The choice of a higher weighting factor in favor of the University is due to the fact that its specialists can perform some of the work at all free of charge because of the fact that they receive a testing ground for new knowledge in return. In addition, former graduates who – as organizers or participants of the cluster are familiar with the areas of work and their quality – can apply to the university. At the same time, research institutes cultivate only contractual relations and centre of excellence has, as a rule, less scientific "weight" in comparison with the university.

Stores located outside the cluster territory also perform advertising and representative functions in relation to stores located in the cluster location. Therefore, their rank is significantly higher. Since enterprise consumes of the cluster products being a much larger and also, they are wholesale consumer of products so they have a higher rank than the stores.

Let's present the $k_{ij}$ values of organizations arranged in the table as a graph (figure 4).

![Graph](image)

**Figure 4.** Sorting cluster organizations in descending order of rank.

The graph shows that organizations of primary importance for the functioning of the cluster are those that provide financial services, supply machinery, equipment, production lines and knowledge as well as buyers of large quantities of cluster products. Other organizations can be included as the cluster develops. Therefore, at the stage of cluster formation and at the first stages of its operation there is no need to include organizations from all areas of activity at once.

4. **Conclusion**

On the basis of the conducted researches it is possible to formulate the following conclusions.

1. Management functions are not a separate "category" of the cluster – they are presented as part of the core and include coordinating actions.
2. In a cluster there is a "zone of required organization" for starting the cluster as well as a "zone of efficiency improvement" for the future cluster development which can be expanded and
replenished as needed. In other words, not all organizations are "equally useful" at the stage of forming and starting a cluster. In addition, you can’t "force" organizations into a cluster as well as accept everyone who wants to become a member of it.

3. The “pool” of organizations that determine the success of a cluster at the start of its operation includes financial organizations, organizations that supply machinery, equipment, production lines, and knowledge as well as buyers of large quantities of cluster products. It should be emphasized that public and private entities can act as financial organizations in addition to banks. Therefore, this article considers financial organizations as part of a cluster although this is not necessary.

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