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## HUMAN RESOURCE POTENTIAL OF KAZAKHSTAN'S SCIENCE: DYNAMICS, STRUCTURE AND REGIONAL DEVELOPMENT FEATURES

*The article examines the state and dynamics of the scientific staff of Kazakhstan based on national statistics and analytical materials reflecting changes in the R&D system. The development of research staff at the national and regional levels was analyzed, which made it possible to identify key trends in the formation of human capital in the scientific field. It is determined that the qualitative structure of the scientific staff is undergoing significant changes: the accelerated increase in the number of researchers with modern qualifications and the gradual strengthening of the professional core of research teams are shown. A pronounced spatial disparity in the distribution of personnel has also been revealed, with the largest urban agglomerations accumulating the bulk of researchers, while a number of regions demonstrate a steady decline in research potential. The methodological basis of the research includes comparative and structural analysis, which allows comparing the dynamics of different categories of scientific staff and determining the factors influencing regional differences. The changes in the qualification structure, the peculiarities of the growth of research personnel and the role of regional research centers in the formation of the national scientific system are analyzed. The results showed that the development of the scientific personnel base remains one of the central conditions for the effectiveness of R&D and the sustainable functioning of scientific institutions. The significance of the research lies in the possibility of using its findings in the development of scientific policy measures aimed at increasing the sustainability of human resources and strengthening regional scientific ecosystems.*

***Keywords:*** *human resources of science, R&D, research staff, regional differentiation, scientific policy, qualification structure, science development.*

***Кілт сөздер:*** *ғылымның кадрлық әлеуеті, ҒЗТКЖ, зерттеу персоналы, аймақтық саралау, ғылыми саясат, біліктілік құрылымы, ғылымды дамыту.*

***Ключевые слова:*** *кадровый потенциал науки, НИОКР, исследовательский персонал, региональная дифференциация, научная политика, квалификационная структура, развитие науки.*

**Introduction.** The issues of developing Kazakhstan's scientific potential over the past decades have occupied a central place in the scientific policy of the state, since it is the state of the personnel base that determines the ability of the national economy to form competitive knowledge and technology. The changes taking place in the R&D system affect not only the institutional mechanisms of resource allocation, but also the structure of human capital, on which the sustainability of research teams, the dynamics of scientific directions and the potential for integration into the international scientific space depend.

The foreign literature emphasizes that the human resource of science is formed unevenly, and its qualitative characteristics are changing under the influence of reforms, economic factors and changes in demand for research activities. These circumstances require a systematic analysis to identify key trends and identify the structural features of the national scientific sector.

The purpose of the study is to study the dynamics of the scientific staff of Kazakhstan and identify those structural changes that determine the current state and possible directions for the development of research potential. To achieve this goal, tasks were formulated to analyze national and regional parameters

of the personnel structure, identify trends in changes in the qualification structure and interpret factors affecting the spatial distribution of scientific staff.

The research materials are based on official national statistics and analytical sources describing the state of science and the innovation sector. The methods used are elements of comparative analysis, structural analysis, and an interpretive approach that allows us to compare the identified trends with the results of previous studies. Standard statistical procedures were used to process the data, ensuring the correctness of the comparison and reproducibility of the results. This approach allows us to present a holistic picture of the personnel dynamics of science and identify key areas for its further study.

**Literature Review.** The analysis of research devoted to the development of scientific potential and personnel systems demonstrates a steady interest in the formation of research competencies and the institutional conditions in which scientific personnel are reproduced. The works dealing with the evolution of innovation systems in Kazakhstan emphasize the importance of strategic orientation towards smart specialization, where the focus shifts to the concentration of resources and the development of scientific and technological niches [1]. Such studies form an important methodological framework for assessing human resources, since it is human capital that ensures the implementation of such strategies.

A separate section of literature examines the dynamics of human resources in the context of industrial and innovative development. Studies devoted to the personnel aspects of scientific and technological progress note that strengthening the role of research personnel is a key condition for increasing the competitiveness of the national economy [2]. In addition, considerable attention is paid to the transformation of the R&D environment, including mechanisms for the commercialization of research results and the impact of institutional reforms on the professional behavior of researchers [3]. The results of such work emphasize the need for a comprehensive analysis of the personnel structure as a basis for evaluating the effectiveness of the national R&D system.

A number of studies provide estimates of the productivity of scientific work, the impact of external factors and structural constraints typical of developing economies. Empirical data indicate the heterogeneity of scientific activity and the dependence of its results on the quality of human resources, the availability of infrastructure and the scale of research programs [4]. A significant contribution to understanding the role of research potential in innovative development is made by analyzing the factors of organizing the activities of medium- and high-tech enterprises, where the personnel component is considered as a structural element of the innovation cycle [5].

Special attention is paid to the characteristics of the research environment in Kazakhstan, including the problems of institutional pressure, personnel renewal and sustainability of research teams. In the works devoted to the reforms and structural challenges of science, it is emphasized that the personnel component remains one of the key nodes of tension that determine the speed and quality of scientific development [6]. A significant source of analytical information is the National Science Report, which records the transformation of the staff, regional differences and general trends in the dynamics of the scientific sector [7].

A critical synthesis of the presented studies shows that there are several unresolved issues. Among them are the lack of knowledge of the spatial structure of human resources, the influence of regional factors on the reproduction of researchers and the dynamics of the qualification structure in the long term. The identified contradictions and gaps confirm the need for further study of the regional and national level of personnel processes, which determines the relevance of this study.

**Main part.** The assessment of the scientific staff is a key element in understanding the real capabilities of the national research system, since it is the structure of those employed in R&D that determines the pace of formation of new knowledge and the degree of sustainability of scientific development. In practical work, it is often necessary to face the fact that quantitative indicators change earlier than the institutional contours, and therefore the analysis of personnel dynamics allows you to see those hidden processes that are not recorded by aggregated indicators. To clarify these trends, the use of statistical data for 2021-2024 provides an opportunity to consider how the general configuration of scientific work is changing, which groups are growing faster, and where new areas of concentration of research resources are being formed. These features can be traced in the information presented in Table 1, reflecting the main parameters of personnel dynamics in the R&D system of Kazakhstan.

Table – 1

**Key indicators of the human resource potential of Kazakhstan's science**

| Internal R&D costs by type of work | 2021 | 2022 | 2023 | 2024 | Change, 2024/2021 | |
|---|---|---|---|---|---|---|
| | | | | | +/- | % |
| Number of organizations (enterprises) engaged in R&D, units | 438 | 414 | 425 | 423 | -15 | 96.6 |
| Number of employees performing R&D, people | 21 617 | 22 456 | 25 473 | 27 146 | 5529 | 125.6 |
| of these: | | | | | | |
| research specialists | 17 092 | 18 014 | 21 534 | 23 152 | 6060 | 135.5 |
| of these: | | | | | | |
| Doctors of Sciences | 1 652 | 1 743 | 2 061 | 2 050 | 398 | 124.1 |
| doctors by profile | 55 | 96 | 85 | 318 | 263 | 578.2 |
| Doctor of Philosophy PhD | 1 962 | 2 462 | 3 458 | 4 156 | 2194 | 211.8 |
| Candidates of Sciences | 3 843 | 3 946 | 4 842 | 4 727 | 884 | 123.0 |

** compiled based on source [8]*

From the data in table 1, it can be seen that the dynamics of the scientific staff records the gradual complication of the structure of the national research system. During 2021-2024, the number of R&D organizations remained almost unchanged - the range of fluctuations turned out to be narrow, and the final decrease by 15 units only underlines the inertia of the institutional base. The stability of the indicator change usually creates the illusion of stability, although in practice it indicates the limitations of organizational growth. Such observations are often found in the analysis of peripheral innovation systems, where expansion is slower than the transformation of internal functions.

A completely different picture appears when considering personnel parameters. In four years, the number of R&D workers has increased by 5,529, which represents an increase of 25.6%. The scale of the shift becomes more pronounced when analyzing a core group of research specialists. An increase of 6,060 people suggests that the core of the scientific staff is expanding faster than the total number of people engaged in R&D. Such a disparity usually indicates an increase in research intensity, rather than a simple increase in auxiliary categories. In professional practice, a similar effect occurs during periods of intensification of national research project support programs, when the demand for skilled labor is increasing faster than the organizational base.

The structure of academic degrees demonstrates even more expressive trends. The number of doctors of sciences increased by 398 people. The rate of about 24% is low compared to other positions, but this group is traditionally updated slowly due to the high cost of training and long academic trajectories. The picture changes when analyzing doctors by profile: the growth from 55 to 318 researchers creates an abnormally high magnification factor. Such a leap usually accompanies the reforms of the certification system. In the author's professional experience, similar phenomena were observed after the revision of the requirements for qualification categories, which increases the influx of specialists in specific areas.

The most dynamic group is PhD. The number increased by 2,194 people and actually doubled. It is here that the main resource reserve of Kazakh science can be seen. Strengthening this category creates a more flexible and mobile research environment, where the focus is shifting towards project activities and international collaborations. Practice shows that the intensive influx of PhD students inevitably changes the nature of scientific production, strengthens the role of methodological training and expands the range of research approaches used.

The group of candidates of sciences maintains a predictable trajectory - an increase of 884 people. Despite the completion of the Soviet attestation model, this segment remains significant for many industries, where the accumulated school still forms the basis of research expertise.

Taken together, the structure shows a heterogeneous but steady redistribution of scientific potential. The organizational base is almost unchanged, but the staffing is growing and gradually shifting towards researchers with modern qualifications. Such processes form the prerequisites for updating the national scientific system, although they require further analysis, especially in terms of the quality of research

activity, and not just quantitative parameters. The transition to a regional analysis follows logically from the identified trends.

The nationwide growth of R&D personnel potential does not reveal the internal contours of the distribution of research resources, namely, the territorial structure often sets the real configuration of scientific development. The experience of observing regional systems shows that even with a stable institutional framework, differences in personnel dynamics can enhance or weaken the scientific effect for decades. That is why referring to regional data makes it possible to clarify the context and identify those areas where an increase in the number of researchers forms the core of future growth, and where staff shortages persist (Table 2).

Table – 2

**The dynamics of the number of scientists in the regions of Kazakhstan**

| Region | 2021 | 2022 | 2023 | 2024 | Change, 2024/2021 | |
|---|---|---|---|---|---|---|
| | | | | | +/- | % |
| Abai | 982 | 1 042 | 1 214 | 1 394 | 412 | 142.0 |
| Akmola | 782 | 748 | 775 | 788 | 6 | 100.8 |
| Aktobe | 381 | 420 | 472 | 515 | 134 | 135.2 |
| Almaty | 417 | 330 | 404 | 455 | 38 | 109.1 |
| Atyrau | 427 | 111 | 140 | 180 | - 247 | 42.2 |
| West Kazakhstan | 441 | 417 | 379 | 423 | -18 | 95.9 |
| Zhambyl | 393 | 407 | 405 | 318 | -75 | 80.9 |
| Zhetysu | 280 | 308 | 333 | 404 | 124 | 144.3 |
| Karaganda | 1 132 | 1 272 | 1 463 | 1 562 | 430 | 138.0 |
| Kostanay | 570 | 484 | 513 | 468 | -102 | 82.1 |
| Kyzylorda | 239 | 293 | 423 | 413 | 174 | 172.8 |
| Mangystau | 650 | 661 | 683 | 694 | 44 | 106.8 |
| Pavlodar | 447 | 477 | 551 | 624 | 177 | 139.6 |
| North Kazakhstan | 163 | 161 | 162 | 133 | -30 | 81.6 |
| Turkestan | 245 | 239 | 353 | 482 | 237 | 196.7 |
| Ulytau | 2 | 2 | 21 | 11 | 9 | 550.0 |
| East Kazakhstan | 920 | 1 004 | 1 051 | 1 060 | 140 | 115.2 |
| Astana city | 3 894 | 4 265 | 4 867 | 5 432 | 1 538 | 139.5 |
| Almaty city | 8 730 | 9 191 | 9 994 | 10 628 | 1 898 | 121.7 |
| Shymkent city | 522 | 624 | 1 270 | 1 162 | 640 | 222.6 |
| Republic of Kazakhstan | 21 617 | 22 456 | 25 473 | 27 146 | 5 529 | 125.6 |

** compiled based on source [8]*

The analysis of table 2 shows a noticeable contrast in the regional profile. The leading positions in absolute values are predictably occupied by the cities of Astana, Almaty and Shymkent. Their combined contribution forms more than half of the country's research corps. The increase in Astana, which reached 1,538 people, reflects the strengthening of the capital's scientific hub, where the concentration of universities and research institutes creates a stable core of project activity. Almaty continues to hold the status of the largest scientific center: the growth of 1,898 researchers confirms the sustainability of its academic ecosystem, where the traditional university environment is combined with the expanding sector of applied research. Shymkent is showing a particularly sharp jump, with more than a twofold increase in population. Such movements are usually recorded in regions where new scientific and educational clusters are being created or industrial-oriented research sites are expanding.

There is a multidirectional dynamic among the regions. The Karaganda region has strengthened its position by adding 430 researchers. Steady growth is also recorded in Pavlodar, Kyzylorda, East Kazakhstan and Zhetisu regions. Each of them forms its own development profile: somewhere the technical orientation prevails, somewhere the role of agricultural research increases. The author's field practice confirms that such regions are most often focused on highly specialized research competencies, which makes the increase especially significant - it improves the local personnel balance and increases the likelihood of the formation of sustainable research groups.

The contrast is formed by territories where the number of R&D workers is decreasing. In Atyrau region, a decrease of almost half looks abnormal against the background of growth in the country. Upon closer examination, such changes are most often associated with the transformation of the structure of enterprises and the redistribution of research tasks in the large corporate sector. Zhambyl, Kostanay and North Kazakhstan regions also show negative dynamics. Such regions are characterized by a long-term personnel gap, which is difficult to overcome without targeted measures to strengthen research centers and increase the attractiveness of a research career.

The Ulytau region deserves special attention. Formally, small values conceal an intense relative change - an increase of more than five times. In the context of the formation of a new region, such dynamics reflect the process of institutional formation and the emergence of the first stable scientific groups.

The regional map of scientific personnel is being built as a multi-layered structure: large cities accumulate a significant part of the research potential, while a number of regions are gradually strengthening their positions, and some territories are facing a steady personnel squeeze. This distribution confirms the conclusion about the high spatial heterogeneity of scientific development in Kazakhstan. Practical experience in analyzing regional innovation systems suggests that this pattern persists for a long time and requires targeted measures aimed at maintaining a balance between national research centers and peripheral territories.

**Conclusion.** The analysis of the scientific staff of Kazakhstan has revealed the steady growth of the country's research potential with continued institutional stability. The dynamics of the number of R&D workers and the increasing proportion of researchers with modern qualifications show a gradual renewal of the professional structure, which creates a more flexible and project-oriented scientific environment. Regional differentiation confirms the uneven distribution of human resources: the largest research centers accumulate the main potential, while some regions face long-term personnel compression. This contrast reinforces the need for targeted measures to support regional scientific ecosystems, which increases the importance of research results for management decisions in the field of science. The novelty of the conducted research lies in the comprehensive interpretation of quantitative trends, combining the national and regional levels of analysis into a single assessment system. The findings can be used in the development of R&D development programs, the formation of incentive systems for research personnel and the strengthening of regional research centers. The prospects for further research are related to assessing the qualitative characteristics of scientific activity, studying the factors of attracting and retaining researchers, as well as modeling the spatial distribution of scientific potential over a long period of time.

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## ҚАЗАҚСТАН ҒЫЛЫМЫНЫҢ КАДРЛЫҚ ӘЛЕУЕТІ: ДАМУ ДИНАМИКАСЫ, ҚҰРЫЛЫМЫ ЖӘНЕ ӨҢІРЛІК ЕРЕКШЕЛІКТЕРІ

### Аңдатпа

Мақалада ұлттық статистика деректері мен ҒЗТКЖ жүйесіндегі өзгерістерді көрсететін талдамалық материалдар негізінде Қазақстан ғылымының кадрлық құрамының жай-күйі мен динамикасы қарастырылған. Ұлттық және өңірлік деңгейлердегі зерттеу персоналының дамуы талданды, бұл ғылыми саланың адами капиталын қалыптастырудағы негізгі үрдістерді анықтауға мүмкіндік берді. Ғылыми персоналдың сапалық құрылымы айтарлықтай өзгерістерге ұшырайтыны анықталды: қазіргі заманғы біліктілігі бар зерттеушілер санының жедел өсуі және ғылыми ұжымдардың кәсіби өзегін біртіндеп нығайту көрсетілген. Сондай-ақ, кадрларды бөлудің кеңістіктік теңсіздігі анықталды, онда ірі қалалық агломерациялар ғылыми қызметкерлердің негізгі бөлігін жинақтайды, ал бірқатар салалар зерттеу әлеуетінің тұрақты төмендеуін көрсетеді. Зерттеудің әдіснамалық базасы ғылыми қызметкерлердің әртүрлі санаттарының динамикасын салыстыруға және аймақтық айырмашылықтарға әсер ететін факторларды анықтауға мүмкіндік беретін салыстырмалы және құрылымдық талдауды қамтиды. Біліктілік құрамының өзгерістері, зерттеу кадрларының өсу ерекшеліктері және Ұлттық ғылыми жүйені қалыптастырудағы өңірлік ғылыми орталықтардың рөлі талданды. Нәтижелер ғылымның Кадрлық базасын дамыту ҒЗТКЖ тиімділігінің және ғылыми институттардың тұрақты жұмыс істеуінің орталық шарттарының бірі болып қалатынын көрсетті. Зерттеудің маңыздылығы кадр әлеуетінің тұрақтылығын арттыруға және өңірлік ғылыми экожүйелерді нығайтуға бағытталған ғылыми саясат шараларын әзірлеу кезінде оның тұжырымдарын пайдалану мүмкіндігінде жатыр.

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# КАДРОВЫЙ ПОТЕНЦИАЛ НАУКИ КАЗАХСТАНА: ДИНАМИКА, СТРУКТУРА И РЕГИОНАЛЬНЫЕ ОСОБЕННОСТИ РАЗВИТИЯ

**Аннотация**

В статье рассмотрено состояние и динамика кадрового состава науки Казахстана на основе данных национальной статистики и аналитических материалов, отражающих изменения в системе НИОКР. Проанализировано развитие исследовательского персонала на национальном и региональном уровнях, что позволило выявить ключевые тенденции в формировании человеческого капитала научной сферы. Определено, что качественная структура научного персонала претерпевает существенные изменения: показано ускоренное увеличение численности исследователей с современными квалификациями и постепенное укрепление профессионального ядра научных коллективов. Выявлено также выраженное пространственное неравенство распределения кадров, при котором крупнейшие городские агломерации аккумулируют основную часть научных работников, тогда как ряд областей демонстрирует устойчивое сокращение исследовательского потенциала.

Методологическая база исследования включает сравнительный и структурный анализ, позволяющий сопоставить динамику различных категорий научного персонала и определить факторы, влияющие на региональные различия. Проанализированы изменения квалификационного состава, особенности роста исследовательских кадров и роль региональных научных центров в формировании национальной научной системы.

Полученные результаты показали, что развитие кадровой базы науки остаётся одним из центральных условий эффективности НИОКР и устойчивого функционирования научных институтов. Значимость исследования заключается в возможности использования его выводов при разработке мер научной политики, направленных на повышение устойчивости кадрового потенциала и укрепление региональных научных экосистем.