DETERMINING THE PRIORITY RESEARCH AREAS IN FOOD SECURITY AND BIOECONOMY OF UKRAINE BY EXPERT SURVEY

***Anton Koretskyi[1], Kaspars Naglis-Liepa[2], Dmytro Tkach[1], Olena Vasilyeva[1]**
[1]State Institution ‘Dobrov Institute for Scientific and Technological Potential and Science History Studies of the NAS of Ukraine’, Ukraine
[2]Latvia University of Life Sciences and Technologies, Latvia
*Corresponding author’s e-mail: koretskyianton@gmail.com

Abstract
The research uses the Delphi method to identify the priority research areas for Ukraine’s scientific and technological (S&T) development. Conducted in three stages from July to December 2024, the research engages 543 experts across nine thematic blocks, including ‘Food security, sustainable agricultural development and related technologies, bioeconomy’. The study aims to update the priority research areas established in 2021, identify potential priority research areas of Ukrainian agriculture in 2024 considering the influence of the Russian military invasion, and explore innovative approaches to Ukrainian S&T policy. Experts evaluate the potential research areas based on relevance, personnel, equipment, achievements, and international cooperation of the research area. The study shows the significant gaps in Ukraine’s current science policy framework. Key outcomes include refining priority research areas, confirmed by over 50% of experts, and developing recommendations for strengthening Ukrainian S&T policy. The research identifies new high-priority research areas in Ukraine (percentage of highest relevance ratings among responses) under the thematic block ‘Food security, sustainable agricultural development and related technologies, bioeconomy’: ‘Nanotechnology, biotechnology for efficient processing of agricultural raw materials into food and technical products, green energy’ (82%), ‘Energy and resource-saving technologies and technical means of agro-industrial production’ (68%), ‘Institutional support for national security and sustainable development through the development of comprehensive programs for the development of the national economy, defence capability and the well-being of the population’ (66%).

Keywords: food security, bioeconomy, sustainable agriculture, S&T policy, technological foresight.

Introduction

Food security and bioeconomy play a crucial role in resilient supply chain stability, providing the UN SDGs 2030 Agenda in an ongoing full-scale war. Ensuring food security in Ukraine faces unstable household incomes, food prices, logistics disruption, and rising inflation (Berndt et al., 2022; Kuzoma, 2024). During the past two years, the state of the food supply, its availability for the population, and the self-sufficiency of domestic production have been declining (Hafurova et al., 2024; Meijl et al., 2022). Ukraine’s main internal problems, such as irrational use of land, labour migration, destructive chemicalization of products and losses of land reproduction, increased their influence (Podsokha, 2023). An essential contribution to this field of study was made by Shvets et al. (2023) who identified directions in the innovative development of bioeconomy, food security based on smart specialisation strategies by Central and Eastern European countries (Shvets et al., 2023). There are works dedicated to specific aspects of food security, such as food shortfall influenced by environmental pollution and the population rising and its overcoming by the development of the agro-industrial complex (Olshanska et al., 2022). Other authors provided a three-round survey and proved the urgency for modelling a national strategy for bio-economic transformation and its harmonisation of EU policies (Vostriakova, 2024). There are papers devoted to solving strategic planning problems, promoting methods for pre-foresight research (Deineko & Sheludko, 2021), determining the priorities of innovative development of the economy based on official statistical information and the Scopus database (Koretskyi, 2017), and identifying priorities for S&T like the green economy, digital transformation, zero hunger, and healthcare (Pysarenko et al., 2020). At the same time, there has been no in-depth research on defining the scientific priorities in the conditions of full-scale war concerning the negative tendencies in agricultural infrastructure, the formation of multifaceted S&T policy recommendations, determining the biggest problems at the stages of implementing a new scientific discovery, measures to restore human resources, etc. Hence, this paper aims to fill this gap. The study aims to determine whether the areas of scientific development that experts recognised as priorities in 2021 remain relevant, as well as to identify new challenges that have gained significance in modern conditions and require the concentration of efforts of domestic scientists, in particular for the post-war restoration of the agrarian sector of Ukraine, to identify new ideas regarding the mechanisms for implementing the state’s S&T policy, emphasising non-standard ideas and alternative approaches to its development.

Materials and Methods

To ensure the organisation of the survey, nine methodological groups worked for each of the nine thematic areas (Popovych et al., 2024). The general methodological group coordinated the activities of these groups, a total of twenty five researchers. For each of the nine thematic areas, the methodological group prepared a single type of Google questionnaire. It was proposed to evaluate specific studies recognised as a priority in 2021 by experts of the relevant thematic area in the form of closed questions when assessing the relevance, personnel and material support, scientific achievements and the level of international cooperation, as well as in the form of open questions when formulating new ideas and proposals. Afterwards, the methodological groups of the relevant thematic areas sent links to Google questionnaires and collected responses, monitored the completion time, and communicated directly with experts if necessary. Members of the thematic groups also directly participated in the initial interpretation and comprehension of the received materials. In addition, in the form of open questions, they were asked to name those problems and areas of research that, in their opinion, were relevant today but were not named in 2021 (Popovych, 2022).

The survey was conducted in three stages using the Delphi method and the latest methodological recommendations of the RAND Corporation (Khodyakov et al., 2023), considering the experience of previous forecasting and analytical studies carried out by the Dobrov Institute. The basis for assessing the relevance of research areas and their potential was the results of a study conducted in 2021 using the Delphi method. This expert assessment and forecasting approach is based on a phased survey of experts to reach an agreement on specific issues. The study includes three stages with clearly defined tasks. The first round carries out an initial assessment of the relevance of research areas and generates new ideas for priorities and policies. The second round aims to refine the assessments of the significance of research areas based on previous results and a preliminary evaluation of the ideas put forward. The third round finalises new ideas, identifies priority areas for research and policies, and achieves a coordinated vision of key recommendations. In the survey, 543 experts assessed nine thematic research blocks. Fifty-eight experts worked in the thematic area of ‘Food security, sustainable development of agriculture and related technologies, bioeconomy’.

Results and Discussion

In the context of active hostilities and counteraction, the issue of reviewing scientific and technical priorities and identifying new areas of scientific research is becoming more relevant. It is essential to focus on those scientific innovations that will have practical significance and strengthen their S&T potential. In the second round of the survey, experts were asked to review the pre-research areas identified as priorities in the 2021 survey (Table 1).

Table 1

Research directions within the research block: ‘Food security, sustainable agricultural development and related technologies, bioeconomy’ according to the 2021 list, and the current assessment of their relevance and potential

	Research direction	TOP RELEVANCE (percentage of experts who gave the highest relevance score - 5 points, %)	Average score				
			Relevance	Talent	Equipment	Contributions	International cooperation
1	Nanotechnology, biotechnology for efficient processing of agricultural raw materials into food and technical products, ‘green energy’	82%	4.55	3.62	3.16	3.30	3.43
2	Energy- and resource-saving technologies and technical means of agro-industrial production	68%	4.32	3.70	3.22	3.24	3.30
3	Institutional support for national security and sustainable development through comprehensive national economic, defense and welfare programs	66%	4.37	3.63	3.43	3.26	3.54
4	Genetic foundations for increasing the productivity of cereal grains with enhanced adaptive potential to adverse environmental factors	64%	4.28	3.79	3.28	3.49	3.28
5	Development of methods for targeted manipulation of plant heredity. Genetic improvement of plants using molecular genetics and marker-assisted selection with enhanced adaptive potential to adverse environmental conditions	59%	4.11	3.39	2.97	3.17	3.28
6	Information-resource screening of soil conditions in Ukraine for their natural and artificial restoration	57%	4.14	3.59	3.19	3.27	3.43
7	Biofortification of grains (increasing the content of essential phytonutrients in grains)	53%	4.08	3.42	3.06	3.28	3.08

Source: authors’ calculations based on the results of the experts’ survey.

The shown results demonstrate that the highest level of relevance (82%) took the direction ‘Nanotechnology, biotechnology for efficient processing of agricultural raw materials into food and technical products, ‘green energy’. Also, high priority was given to the directions ‘Energy-and resource-saving technologies and technical means of agro-industrial production’ (68%), ‘Institutional support for national security and sustainable development through comprehensive national economic, defence and welfare programs’ (66%) and ‘Genetic foundations for increasing the productivity of cereal grains with enhanced adaptive potential to adverse environmental factors’ (64%).

The lowest relevance was given to the research directions ‘Formation of a valuable genotypic base of new high-protein crops as an alternative source of animal-origin products for sustainable food security’ (39%) and ‘Building a qualitatively new paradigm of eco-socio-economic growth based on inclusivity’ (46%). These positions may be due to the lack of high-tech laboratories and modern equipment and the long duration of obtaining practical results. The worst situation of all indicators is ‘Genomic selection in animal husbandry’ (37%). Most experts do not believe that it deserves priority support. Almost a third note is that the equipment is currently insufficient for conducting research or is simply absent. Another third considers the current equipment to be outdated and ineffective. Only 6.8% believe that the equipment is sufficient. Assessments of human resources, achievements and international cooperation indicate that the development of this direction is possible only through participation in the work of foreign scientific centres. We consider those three directions mentioned before as those that lost their high priority for Ukrainian science in the mid and long term.

In the third round, experts had the opportunity to evaluate new proposals for research areas supported by most experts in the second round. Table 2 provides a generalized assessment of experts’ most supported new ideas to supplement the list of promising areas for the thematic block.

Table 2

New ideas for research directions within the research block: ‘Food security, sustainable agricultural development and related technologies, bioeconomy’

	Research direction	**TOP RELEVANCE (percentage of experts who gave the highest relevance score - 5 points, %)**	**Average score**				
			Relevance	**Talent**	**Equipment**	**Contributions**	**International cooperation**
1	Development of post-war restoration methods for agrophytocenoses, including agricultural lands, cleaning of soils and water resources contaminated as a result of the large-scale invasion of the Russian Federation into the territory of Ukraine	74%	4.62	3.72	3.10	3.36	3.36
2	Enhancing drought resistance of crops. Searching for new approaches to increase crop yields	65%	4.40	3.73	3.23	3.55	3.15
3	Development of national breeding, national seed production, intellectual property in seed production. Creation and implementation of high-quality grain crops as the basis for food and economic security of the state	63%	4.35	3.93	3.30	3.83	3.20
4	Creation and transfer of the first grain crop varieties in Ukraine with unique grain characteristics intended for the production of healthy food products	55%	4.28	3.55	3.20	3.40	3.18
5	Development of technologies and technical means for ensuring the country’s sustainable agricultural production and food security. Circular economy	51%	4.22	3.38	3.03	3.05	3.22
6	Environmental protection, restoration of the country’s ecological security. Integration of fundamental agroecology principles into agricultural development. Sustainable natural resource management	51%	4.31	3.51	3.10	3.34	3.08

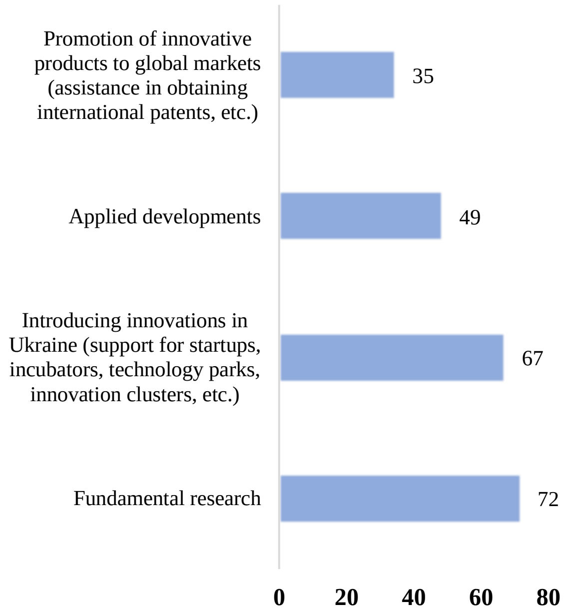
Source: authors’ calculations based on the results of the experts’ survey.

The shown results demonstrate that the highest level of relevance (74%) took the direction ‘Development of post-war restoration methods for agrophytocenoses, including agricultural lands, cleaning of soils and water resources contaminated as a result of the large-scale invasion of the Russian Federation into the territory of Ukraine'. Besides that, a high priority was given to the directions 'Enhancing drought resistance of crops'. Searching for new approaches to increase crop yields (65%), 'Development of national breeding, national seed production, and intellectual property in seed production'. 'Creation and implementation of high-quality grain crops as the basis for food and economic security of the state' (63%) and 'Creation and transfer of the first-grain crop varieties in Ukraine with unique grain characteristics intended for the production of healthy food products' (55%). Experts decided that the above-mentioned research directions are the most relevant scientific priorities for Ukrainian bioeconomics and food security. Cleaning soils and water contamination from explosive materials will be appropriate for the next decades.

The research directions, judging from the experts' opinions, can't be assessed as priorities for Ukrainian S&T: 'Development of technologies for producing ethanol biodiesel fuel based on renewable raw materials' (49%), 'Biotechnologies for accelerated reproduction of agricultural animals, ensuring veterinary and sanitary well-being'. 'Development of serums and vaccines for agricultural animals' (44%), 'Genetic engineering of plants and animals; transgenic organisms'. Research on the impact of genetically modified products on the human body (44%), 'Development of unmanned (remote) monitoring systems for agricultural lands based on artificial intelligence' (43%). Judging from the experts' opinions, the less relevant research directions are 'Phytosanitary condition of agrocenoses'. Formation of a genetic bank of domestic varieties of fruit and ornamental crops. 'Development of plant protection systems and tools based on NBIC technologies' (39%), 'Development of new environmentally safe plant growth regulators based on azagheterocycle derivatives to increase productivity and stress resistance of crops' (26%) and 'Creation and implementation of systems for efficient resource use (nitrogen/nutrients, crop protection agents, etc.) to reduce greenhouse gas emissions and increase the profitability of crop production' (24%). The experts' opinion in Ukraine can explain such a tendency because there are not enough qualified staff, the availability of high-tech equipment, research background and the necessary level of scientific international cooperation for solving scientific problems mentioned before.

In the second round of the survey, experts voted for the directions of S&T policy in Ukraine that should be focused on as a priority. Figure 1 shows the highest priority of S&T policy for providing 'Fundamental research' (72%). Such a direction of science allows for the creation of new scientific knowledge and the preparation of technological breakthroughs in the future. The direction 'Introducing innovations in Ukraine' (67%) received a high assessment from the experts, indicating the desire to transform scientific developments into actual commercial products within the country, which can be used for post-war economic recovery and strengthening the technological sector. The less actual directions for Ukrainian S&T are 'Applied development' and 'Promotion of innovative products to global markets (assistance in obtaining international patents)' with 49% and 35% of all responses, respectively. These results explain that promoting innovative products is necessary but not the first task for implementing and focusing on the S&T policy.

Figure 1
The state's S&T policy should be focused on directions (the percentage of experts' responses)

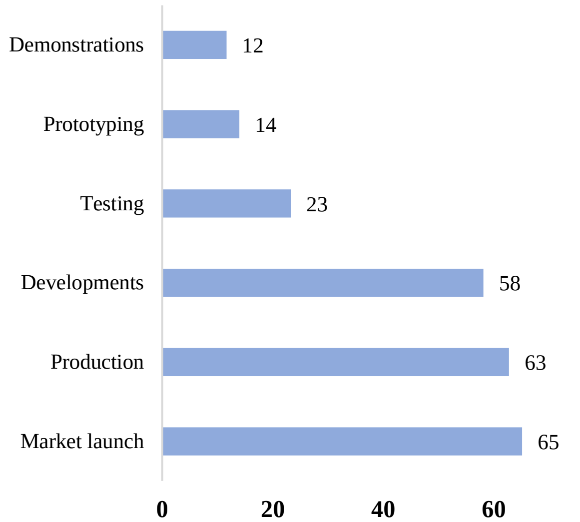


Source: authors' calculations based on the results of the experts' survey.

'Market launch' (65%), 'Production' (63%) and 'Developments' (58%) are the stages of implementing a new scientific discovery where the most significant problems arise from the experts' opinions, Figure 2. Fewer problems occur in the early stages of implementing a new scientific discovery, such as 'Demonstrations' (12%), 'Prototyping' (14%) and 'Testing' (23%). A clear tendency lies in that the later and final stages of creating a new scientific discovery require much higher human, material, and financial resources. Only leading scientific institutions can afford to bring their discovery to the market. That's why cooperation with businesses and international partners plays a significant role in gaining success. This emphasises the importance of international collaboration to advance scientific discoveries. It is defined that a much bigger problem is not implementing scientific discovery into the industry but scaling it up.

Figure 2

The most significant problems arise at the stage of implementing scientific discovery (the percentage of experts' responses)

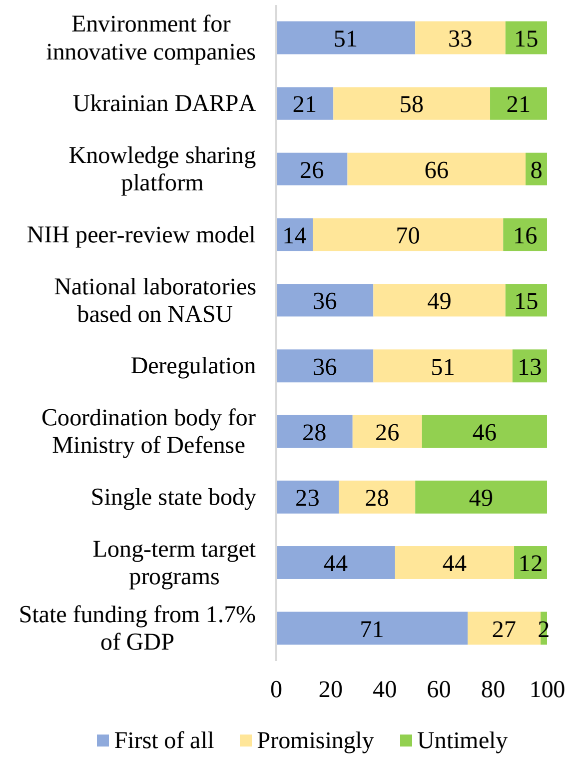


Source: authors' calculations based on the results of the experts' survey.

In the third round of the survey, experts were asked to assess the priority of the state's S&T policy measures, Figure 3. The experts identified the following S&T policy measures as a top priority for fulfilment:
1. 'State funding from 1.7% of GDP' (71%) by increasing government spending for science, approximately to $3.04 billion per year;
2. 'Environment for innovative companies' (51%) by creating a favourable environment for startups and innovative companies (reducing bureaucracy, access to venture capital, supporting incubators and accelerators, developing technology parks and innovation clusters; 3. 'Long-term target programs' (44%) are formed by providing long-term target programs with appropriate guaranteed funding in clearly defined priority areas. Also, experts think that deregulation and reduction of bureaucratic procedures in organizing and financing research (36%) and development of a model similar to the US National Laboratories based on the institutes of the National Academy of Sciences of Ukraine are also necessary S&T policy measures and must be implemented as a priority. On the other hand, there are quite a lot of experts who think that creating a 'Single state body' (49%) by making a single state authority responsible for innovation policy, eliminating the dispersion of responsibility between different ministries) and 'Coordination body for Ministry of Defence of Ukraine' (46%) by creating a coordination body between research institutions, defence industry enterprises and the Ministry of Defense to ensure effective interaction, ensuring full state financing of the entire cycle of defence-oriented developments are the untimely policy measures for fulfilment.

Figure 3

Assessment of the state's scientific priorities and S&T policy measures (the percentage of experts' responses)

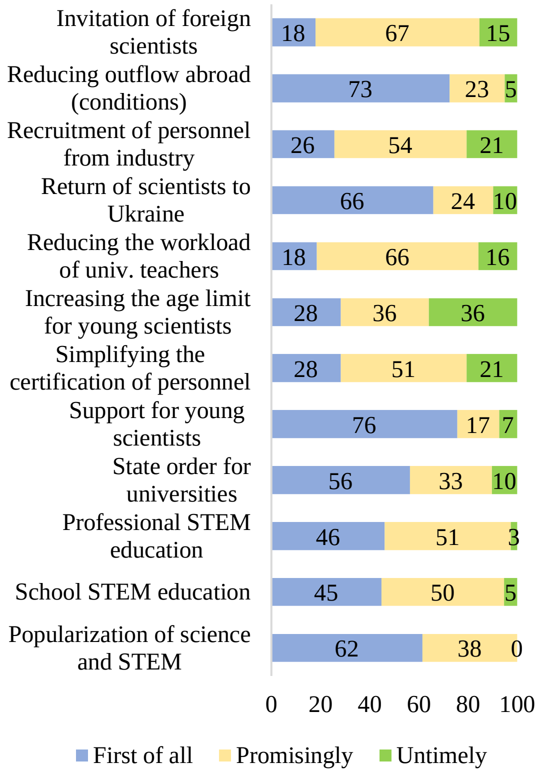


Source: authors' calculations based on the results of the experts' survey.

As we see, first, S&T policy needs to enlarge the base funding of science, provide long-term target programs with guaranteed financing, and reduce the influence of controlling state bodies at all stages of the innovation cycle. In the third round of the survey, experts assessed the priority measures to restore human resources as an essential target of the state's S&T policy, Figure 4. The experts identified the following S&T as a priority guidelines for the implementation: 1. 'Support of young scientists' (76%), 2. 'Reducing outflow abroad (ensuring proper working conditions and wages)' (73%); 3. 'Return of scientists to Ukraine' (66%), and 'State order for universities' (56%). Experts assessed 'Invitation of foreign scientists' (67%) and 'Reducing the workload of university teachers' (66%), 'Recruitment of personnel from industry' (54%) and 'Simplifying the certification of personnel' (51%) as those that are promising measures to restore the human resources. Still, they are not as efficient as mentioned before, as first of all, for fulfilment. Judging the gained results, we define that supporting young scientists and making proper conditions for their career development are vital S&T policy measures for stimulating the restoration of scientific staff. Experts noted the importance of supporting the middle generation of experienced scientists who can transfer their knowledge to the younger, rising generation.

Figure 4

Assessment of priority measures to restore human resources (the percentage of experts' responses)



Source: authors' calculations based on the results of the experts' survey.

Conclusions

1. The study defines the highest relevance priority research directions that have not lost their high actuality in Ukraine despite the influence of full-scale war (percentage of relevance responses): 'Nanotechnology, biotechnology for efficient processing of agricultural raw materials into food and technical products, 'green energy' (82%), 'Energy-and resource-saving technologies and technical means of agro-industrial production' (68%) and 'Institutional support for national security and sustainable development through comprehensive national economic, defence and welfare programs' (66%).
2. The study defines the highest relevance priority research directions for the development of Ukrainian S&T for a mid- and -long term: 'Development of post-war restoration methods for agrophytocenoses, including agricultural lands, cleaning of soils and water resources contaminated as a result of the large-scale invasion of the Russian Federation into the territory of Ukraine' (74%), 'Enhancing drought resistance of crops'. Searching for new approaches to increase crop yields (65%) and 'Development of national breeding, national seed production, intellectual property in seed production'. 'Creation and implementation of high-quality grain crops as the basis for food and economic security of the state' (63%).
3. The state's S&T policy must be focused chiefly on 'Fundamental research' (72%) and 'Introducing innovations in Ukraine (support for startups, incubators, technology parks, innovation clusters, etc.)' (67%) as essential cornerstones of progressive science.
4. 'Market launch' (65%), 'Production' (63%) and 'Developments' (58%) are the most challenging stages of implementing a new scientific discovery. Only leading scientific institutions can afford to bring their discovery to the market and scale it up.
5. S&T state policy needs to enlarge the base funding of science, provide long-term target programs with guaranteed financing, and reduce the influence of controlling state bodies at all stages of the innovation cycle.
6. Experts noted that supporting young professionals is the most efficient S&T policy measure to restore scientific staff.

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