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Needs and gaps sssessment of the higher education programmes in the field of cryosphere in Central Asia

GEF-UNDP-UNESCO Cryosphere Project

Serikzhan Atanov
University of Fribourg

Dilrabo Shukurova
Individual Consultant

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Draft report

by

Serikzhan Atanov

Dilrabo Shukurova

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Chapter 1. Introduction

This analysis is based on the results of two regional meetings held in April 2024 in Almaty, Kazakhstan, under the GEF-UNDP-UNESCO Cryosphere Project, which identified the need for strengthened capacity in cryosphere research, monitoring and management in Central Asia.

Within the framework of the Regional Workshop on Strengthening the Resilience of Central Asian Countries through Cryosphere Data and Action Plans held on April 3-4, 2024 - the workshop participants, including leading experts from academic, educational and governmental institutions in the region identified three key issues related to the cryosphere in the region. One of the three key challenges was identified as the Shortage of qualified professionals in cryosphere research, monitoring and management, which was recognized as one of the barriers to the effective use of cryospheric data, as well as strengthening knowledge of climate change impacts on the cryosphere and water resources and ensuring sustainable development of the region.

During the regional panel discussion “Science-Policy Dialogue on Cryosphere Change in Central Asia” held on April 3, 2024 - experts noted the obvious aging of professional staff combined with a notable lack of young specialists entering glaciology, which is a major concern given the multitude of issues requiring deep understanding and innovative approaches in this field. The panelists stressed that the lack of, or insufficient support for, dedicated glaciology programs at universities in the region exacerbates the situation.

The outcome of the panel session “Dialogue of Science and Policy” was the recommendation to create and support specialized educational programs on glaciology in Central Asia. This initiative was perceived as a priority measure to address the human resource deficit and increase the region's resilience to changes in the cryosphere, including glacier melting, snow cover changes and permafrost thawing, which directly affect water security and disaster risk management. In response to these findings, a cross-sectoral Working Group was formed, whose first meeting outlined the importance of assessing the current state of higher education in the cryosphere and developing recommendations for its development. To accomplish this task, a regional study was organized, including a survey of three key groups: practitioners in cryosphere research and monitoring, university faculty, and recent graduates of relevant educational programs.

The survey covered 62 respondents from 9 universities in four Central Asian countries: Kazakhstan (26.7% of participants), Kyrgyzstan (23.3%), Uzbekistan (30%) and Tajikistan (20%). Women made up 40.3% of the sample, ensuring some gender diversity. Separate questionnaires were developed for each target group, adapted to their specifics and approved by the Working Group. This approach ensured a comprehensive analysis combining academic perspectives of teachers, practical experience of specialists and expectations of young personnel just starting their professional activity.

The survey was designed to assess various aspects of cryosphere training. University faculty members provided data on educational programs, research capabilities, and technical capacity, which allowed for the identification of institutional strengths and weaknesses. Practitioners shared their perspectives on graduate readiness and labor market needs, pointing out the gap between academic preparation and actual professional requirements. Recent graduates, in turn,

described the quality of the education received and its applicability to the workplace, which provided insight into their professional adaptation. The data collected allowed for a detailed analysis of the current state of cryosphere education programs in Central Asia, identifying key gaps such as lack of practical skills, weak links to the labor market, and limited specialization in glaciology. The results of this study form the basis for recommendations aimed at modernizing curricula, strengthening international cooperation and introducing specialized programs at universities in the region to provide Central Asia with qualified human resources to build capacity for research, monitoring and management of the cryosphere in a changing climate.

1.1 Respondent information

1.1.1 General information

Analysis of the questionnaire results may contain fewer responses than the total number of respondents (62), as not all participants provided answers to all questions in electronic format.

To classify age groups in this analysis, age categorization by Central Asian countries was reviewed and summarized into the following groups:

Table 1. Classification of age groups

Age	Age group
18 – 32 years	Youth
33 – 54 years	Middle age
55+ years	Elderly age

Questionnaire 1 - Practitioners

This questionnaire covered 34 respondents from four Central Asian countries: Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan. The majority of responses (14 people) came from Uzbekistan, with 7 responses from Kyrgyzstan and Tajikistan each, and 6 responses from Kazakhstan (Figure 1).

he dominant age group among the respondents of this questionnaire consists of specialists aged 33–54 years (59.5%), followed by young specialists (up to 32 years old) at 28%, and elderly specialists (55+ years old) at 12.5% (Figure 2). The median age of respondents is 36 years, indicating that the sample contains a sufficient number of both young and experienced specialists.

The share of women, in turn, is only 18.7%, reflecting the existing gender imbalance in the professional field (Figure 3).

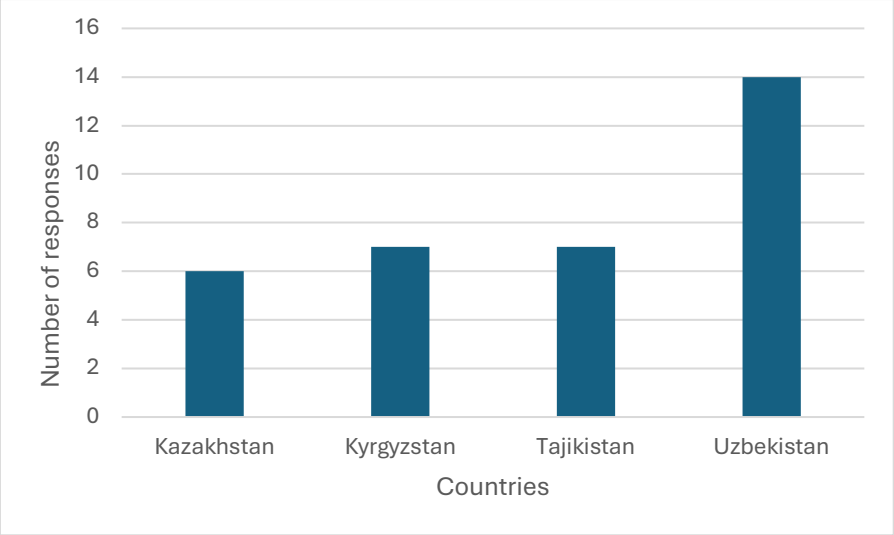


Figure 1. Number of responses to Questionnaire 1 by country

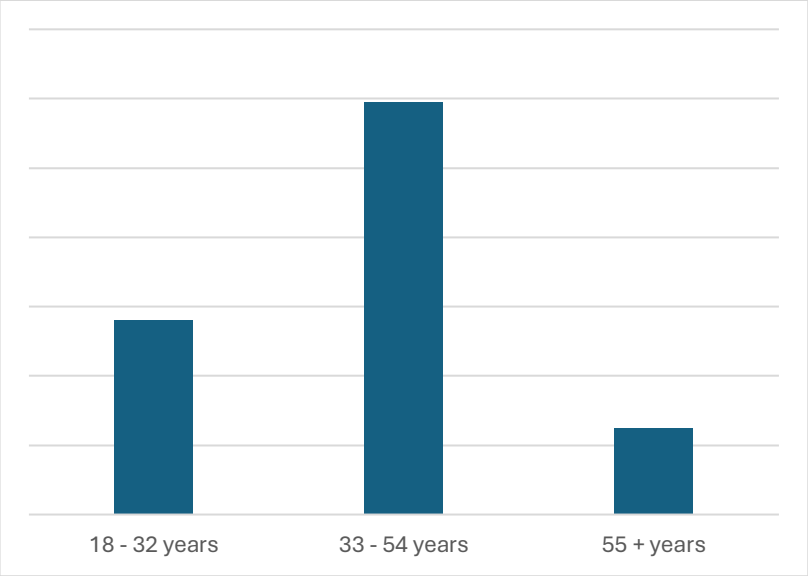


Figure 2. Age representation in Questionnaire 1

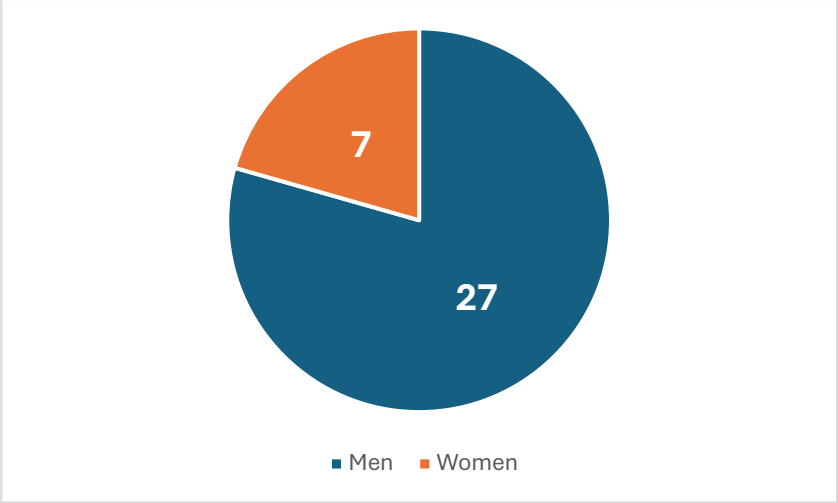


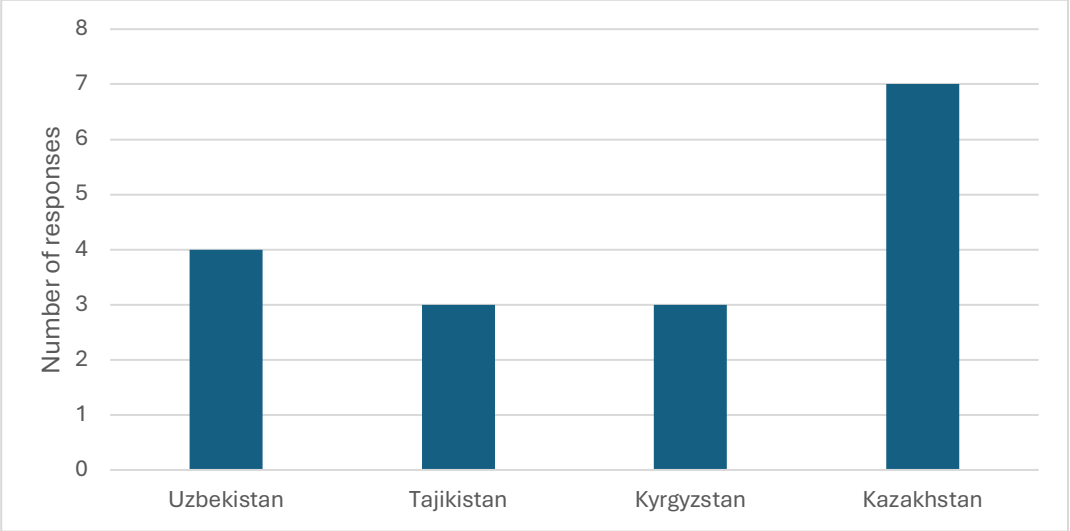
Figure 3. Gender representation in Questionnaires 1

Questionnaire 2 – University faculty members

This questionnaire covered 17 respondents from Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan. The majority of responses (7 people) came from Kazakhstan, followed by 3 responses from Kyrgyzstan and Tajikistan each, and 4 responses from Uzbekistan (Figure 4).

The dominant age group among the representatives of the academic community participating in the survey consists of employees aged 33 to 54 years (47% of respondents). Young employees (under 32 years old) make up 35% of participants, while elderly employees (55 years and older) constitute 18% (Figure 5). The median age of respondents is 42 years.

The gender distribution among the respondents of this questionnaire is nearly equal: men account for 53% of the total participants, while women represent 47% (Figure 6).



Figures 4. Number of responses to Questionnaire 2 by country

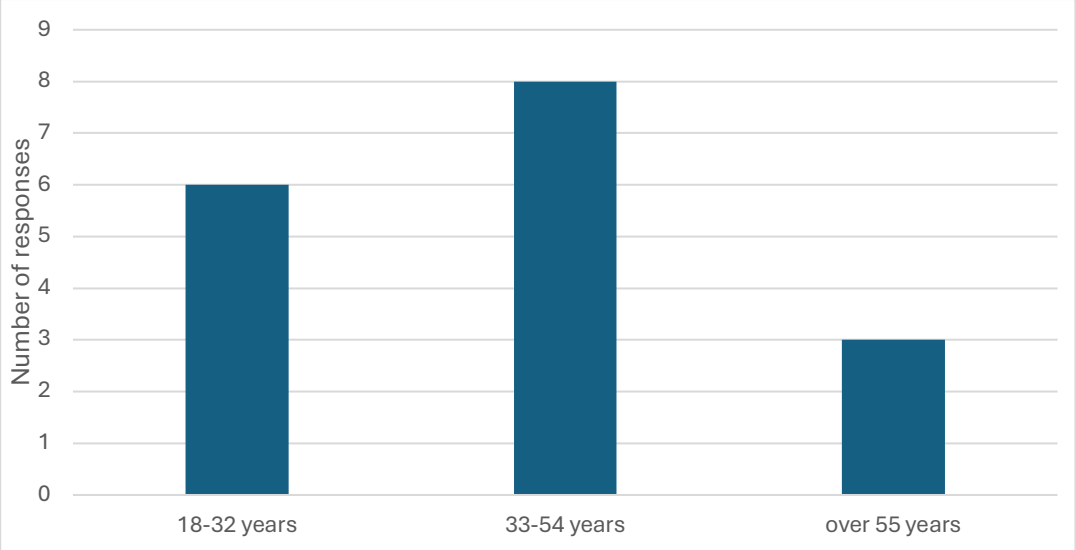


Figure 5. Age representation in Questionnaire 2

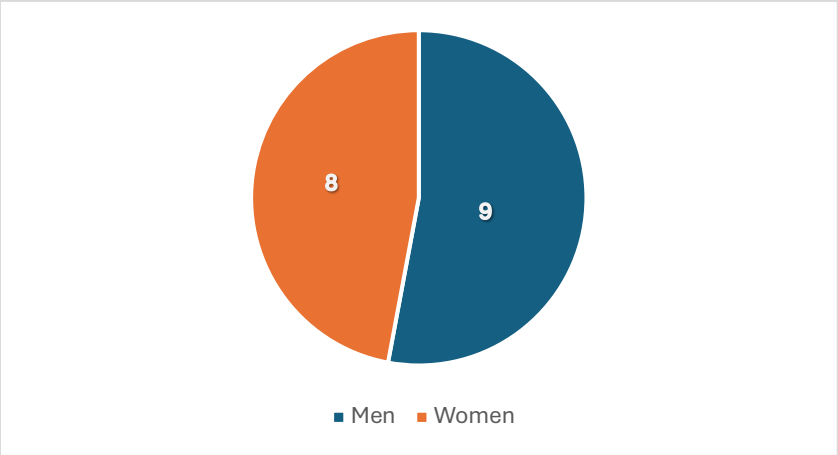


Figure 6. Gender representation in Questionnaires 2

Questionnaire 3 - Recent graduates

Questionnaire 3 collected 11 responses from Kazakhstan, Kyrgyzstan, Tajikistan, and Afghanistan. Unfortunately, no responses were received from Uzbekistan. Figure 7 presents the distribution of responses to Questionnaire 3 by country. The highest number of responses came from Kyrgyzstan (4 responses), followed by Kazakhstan (3 responses), and 2 responses each from Tajikistan and Afghanistan. It is important to note that respondents from Afghanistan completed their last level of education in Kazakhstan. This factor will be considered during the detailed analysis of their responses to the questions in Questionnaire 3.

The age distribution of respondents in Questionnaire 3 is represented by only two groups: 18–32 years and 33–54 years, with youth predominating at 73% (Figure 8). The median age of

respondents is 23 years. The gender distribution among respondents in Questionnaire 3 is nearly equal (Figure 9).

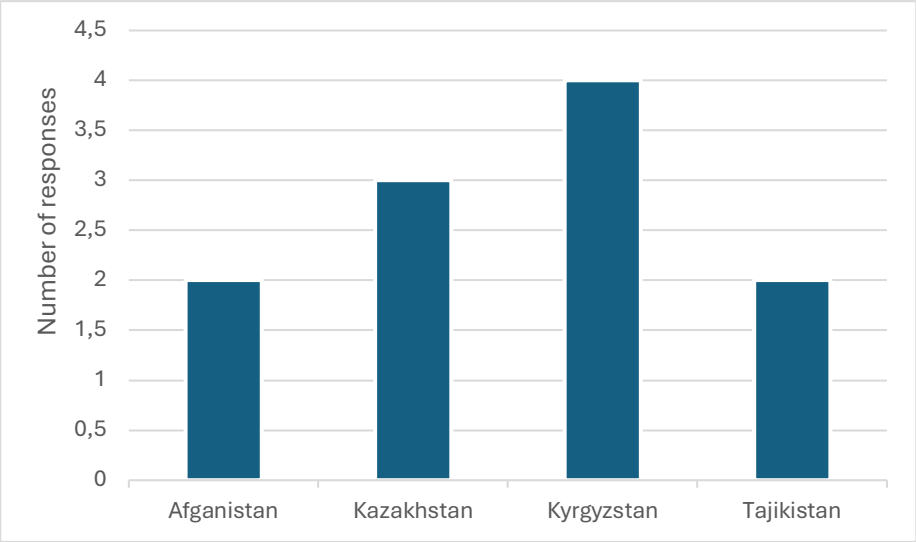


Figure 7. Number of responses to Questionnaire 3 by country

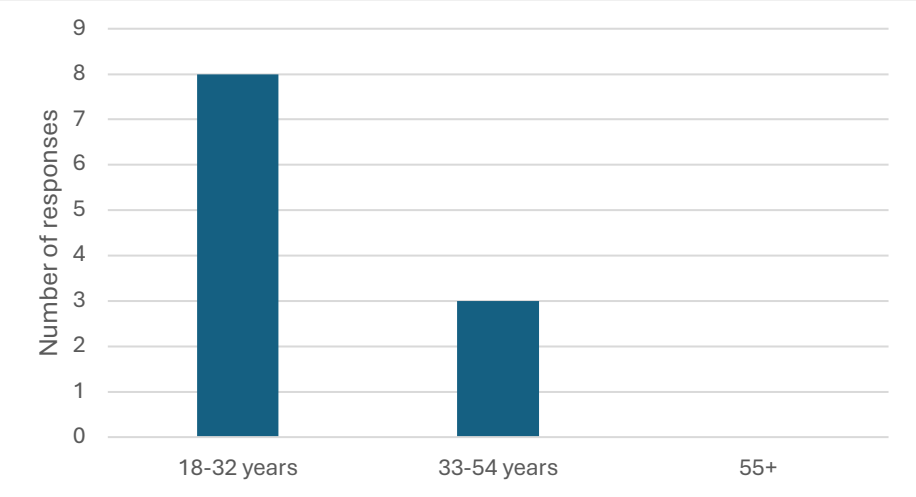


Figure 8. Age representation in Questionnaire 3

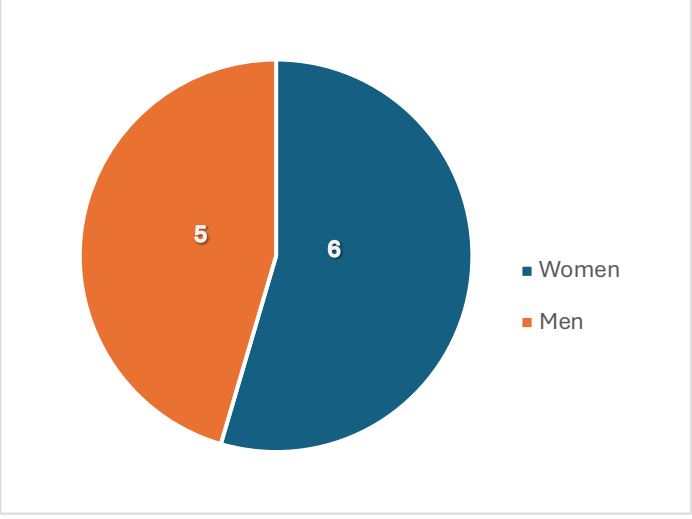


Figure 9. Gender representation in Questionnaire 3

1.1.2 Education and work experience of respondents

This section provides an overview of the collected information on education, universities where respondents obtained their degrees, organizations, and job responsibilities.

Questionnaire 1 – Practitioners

The majority of respondents hold a master's degree, accounting for 50% of the total number of participants (Figure 10). Holders of doctoral degrees make up 41%, followed by bachelor's degree holders at only 6%, and just 3% (1 respondent) with vocational education.

The universities where respondents received their most recent education are distributed as follows: 29 respondents (85%) obtained their latest degree in Central Asia, while 5 respondents (15%) completed their last level of education in Russian Federation.

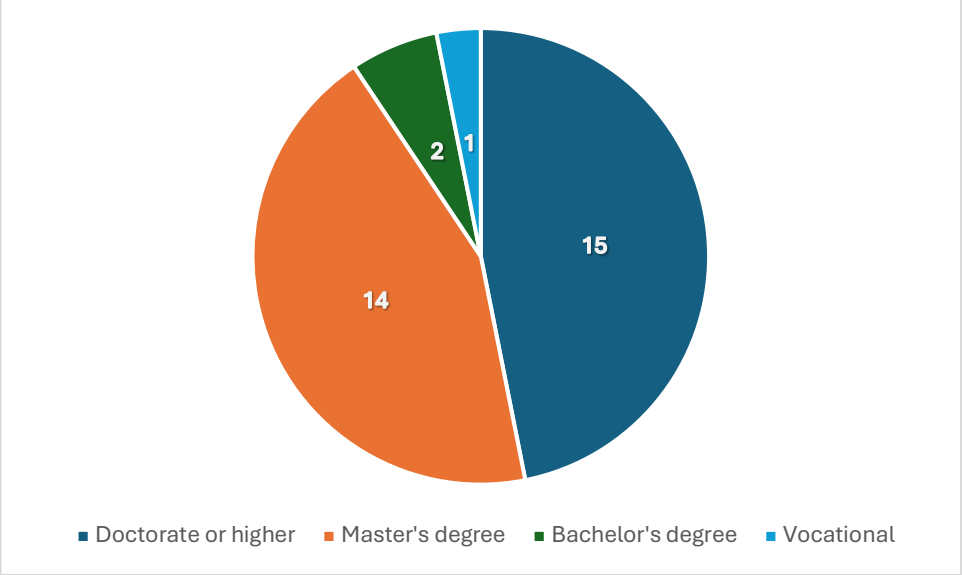


Figure 10. Educational level of respondents in Questionnaire 1

Responses to Questionnaire 1 were provided by representatives from the following organizations: 27 respondents work in research institutes, 4 responses came from employees of government institutions, 2 respondents work in international organizations, and 1 response was from a municipality/local government body. The positions of respondents range from junior research associates to heads of departments and directors of organizations. A significant portion (16 respondents) consists of research staff, including junior, mid-level, and senior researchers.

The majority of respondents have substantial work experience in their current organizations, ranging from 5 to 10 years (Figure 11). The average length of work experience among respondents is 9 years, with a median of 6.5 years. The median, which falls within the group of respondents with 5 to 10 years of experience, indicates a balanced representation of both highly experienced and relatively new employees in their respective organizations. Additionally, a median exceeding 5 years may suggest a certain level of job stability among respondents in their current workplaces.

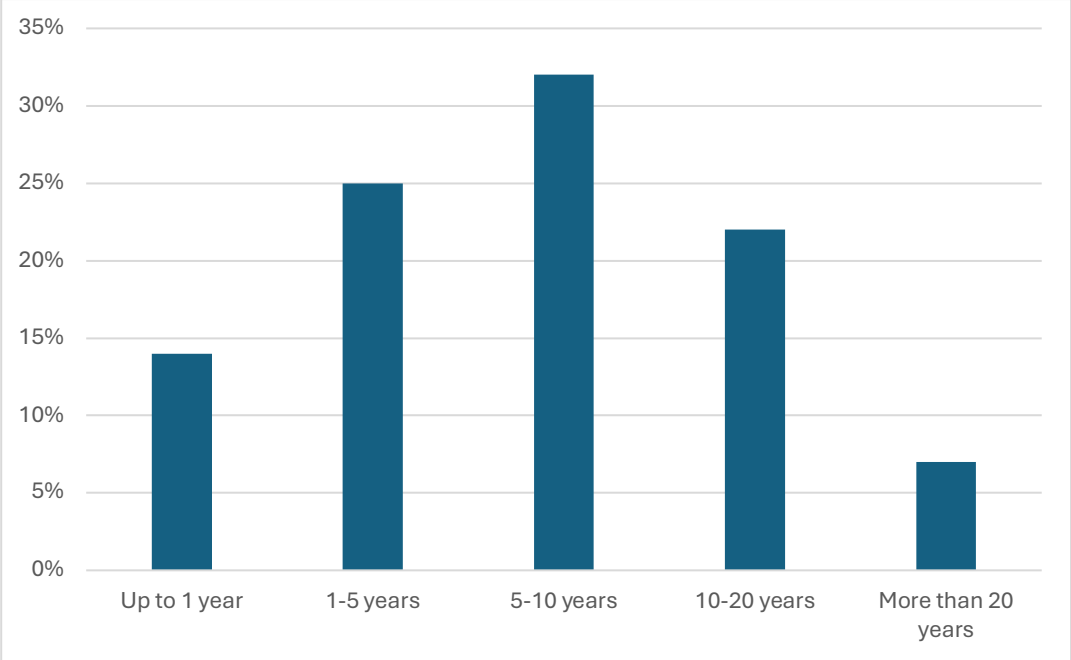


Figure 11. Work experience of respondents in Questionnaire 1

Questionnaire 2 - University faculty members

In contrast to the respondents of Questionnaire 1, the majority of respondents in Questionnaire 2 hold a doctoral degree (65%), followed by master's degree holders (35%). There are no respondents with a bachelor's degree or vocational education in this survey (Figure 12).

Among the respondents, 14 individuals obtained their most recent education in Central Asian countries, reflecting the dominance of the regional educational system among the participants. Three respondents completed their most recent education in Europe, including Germany and Russia. All respondents who studied beyond the region pursued education at the doctoral level or higher.

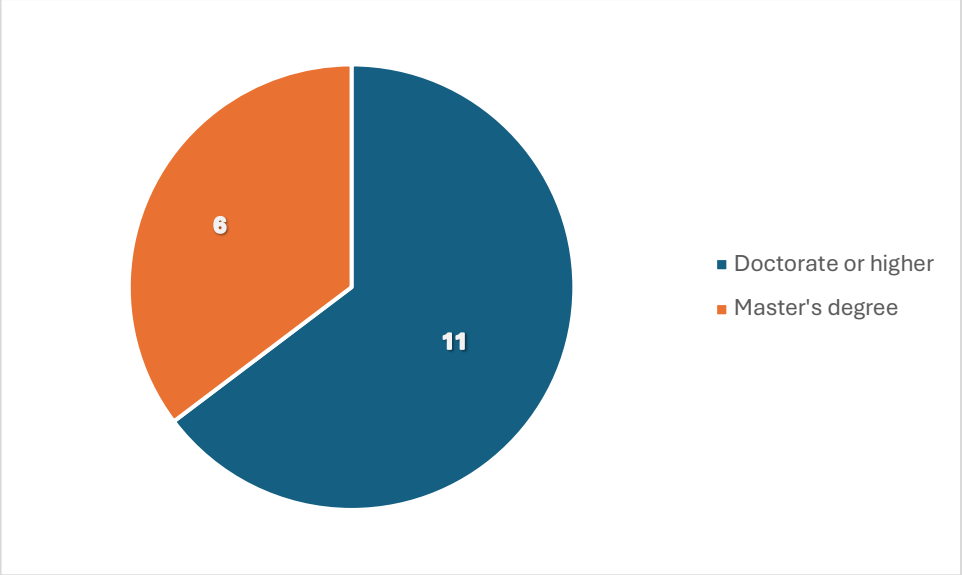


Figure 12. Educational level of respondents in Questionnaire 2

Not all respondents have teaching experience, however, they represent the academic community through their affiliation with universities and their work within them. Their positions vary from professors and lecturers to research associates. 9 respondents hold positions such as lecturers, associate professors, or full professors. 8 respondents are doctoral students, research associates, or specialists.

3 out of 17 respondents indicated that they either do not work in this field or do not engage in teaching. Their responses will be used with limitations in the analysis. The work experience of the remaining group employed at universities in the field of cryosphere studies is distributed as follows: a significant proportion (43%) has between 5 and 10 years of experience, followed by 21.5% with 10–20 years of experience and another 21.5% with over 20 years. Additionally, 14% have between 1 and 5 years of experience. No respondents reported having less than one year of work experience (Figure 13). The average work experience of respondents in Questionnaire 2 is 10 years, with a median of 7 years.

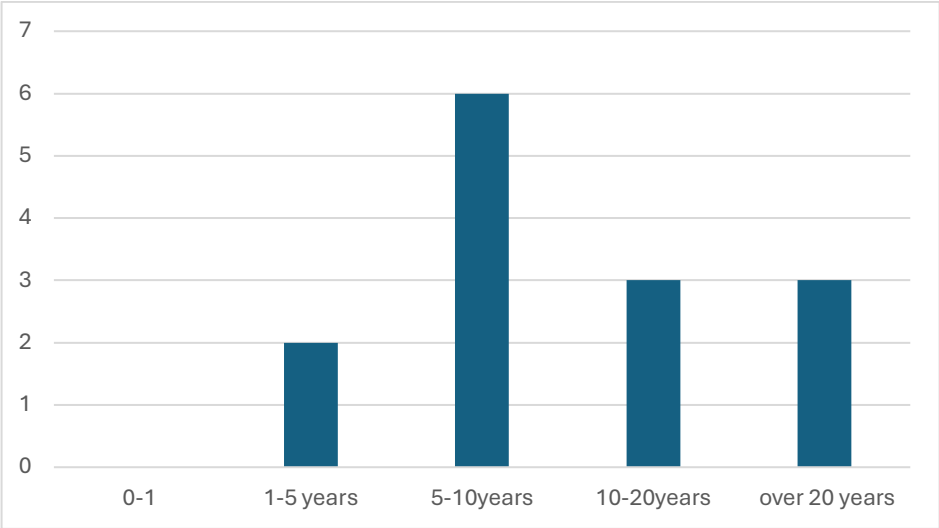


Figure 13. Work experience of respondents in Questionnaire 2

Questionnaire 3 - Recent graduates

The majority of respondents in this Questionnaire (10 out of 11) hold a master's degree, while only 1 respondent has a bachelor's degree. All respondents obtained their most recent education in Central Asian countries. They are graduates from natural sciences, engineering, technical, and humanities disciplines.

3 respondents indicated that they are temporarily unemployed. The remaining 8 work in research institutes and international organizations. At the same time, only 3 respondents reported working in a field related to the cryosphere, while another 3 were uncertain, and 5 stated that they do not work in this field. Among those who confirmed working in the cryosphere sector, their work experience ranges from 4 to 12 months. Respondents' positions include consultants, junior research associates, advisors, and engineers.

1.2 Information on respondents' workplaces

This section presents data on organizations, government institutions, and universities to analyze the current situation in fields related to the cryosphere.

1.2.1 Questionnaire 1 – Practitioners

To assess the existing human resource capacity of organizations, respondents were asked questions regarding the number of colleagues in their organizations or departments working on cryosphere-related issues. The number of personnel engaged in cryosphere-related topics varies across organizations, ranging from fewer than 2 to more than 20 individuals (Figure 14). A significant proportion of respondents (41%) indicated that their department or organization has between 15 and 20 employees working on cryosphere-related issues. This suggests that a significant number of organizations surveyed are actively involved in addressing cryosphere-related matters.

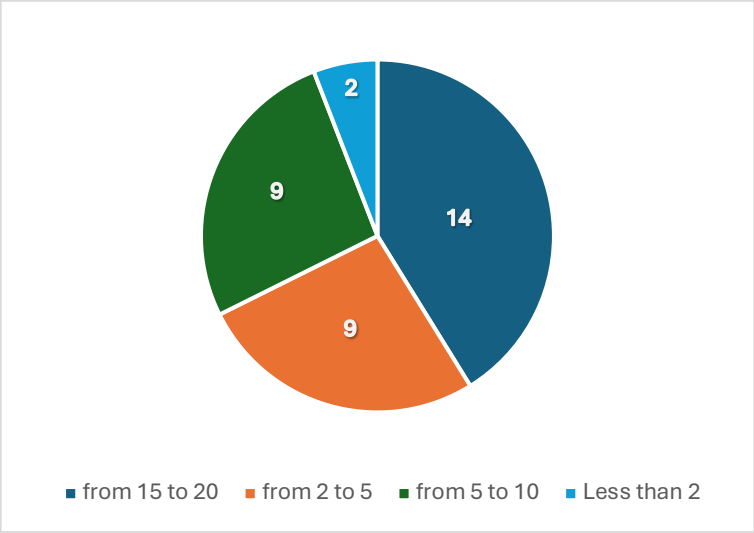


Figure 14. Number of employees working in departments and organizations in cryosphere-related fields

Organizations with a higher number of employees working in the cryosphere field are primarily research institutes, research centers, and government agencies. The average number of employees per organization is 9 people.

Salary is an important factor in choosing a future profession or workplace. In the cryosphere sector in Central Asia, salary ranges from $100 to over $1,000. The majority of specialists in the sample reported that the average salary in their organizations is between $100 and $400 (Figure 15), while the overall average across all responses is $480.

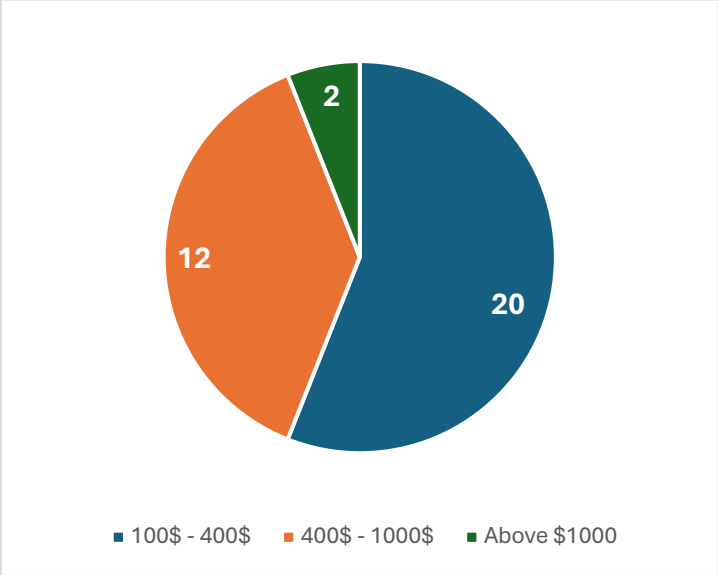


Figure 15. Average salary in organizations working in the cryosphere sector

At the same time, 50% of respondents consider the amount of payment received as satisfactory to the amount of work performed. 29.4% of respondents consider the amount of payment received to be good in relation to the amount of work performed, and 15% consider it not satisfactory. At the same time, 50% of respondents consider the amount of payment received as satisfactory in relation to the amount of work performed. 29.4% believe that the payment corresponds well to the amount of work performed, and 15% believe that the level of payment is unsatisfactory.

1.2.2 Questionnaire 2 – University faculty members

To analyze the professional profile and working conditions of university faculty members in Central Asia in the context of their role in training for cryosphere research and management, we asked a series of questions focused on their current jobs and academic activities. Respondents were asked to indicate the university where they work, their position and length of time working in the cryosphere field, and, if they are faculty members, to list the subjects they teach. In addition, data were collected on the number of employees in their faculty or department, the average salary at the university, and their opinion on the relevance and satisfaction of their salary level to their workload and qualifications. These questions allowed us to assess the institutional environment, professional experience and level of job satisfaction of faculty members, which is critical to understanding their contribution to the development of cryosphere education programs in the region.

Questionnaire 2 collected 17 responses from representatives of 9 universities in the region (Table 2).

Table 2. List of universities participating in the survey

№	Country	institution of higher education
1	Kazakhstan	L.N. Gumilyov Eurasian National University (ENU)
2	Kazakhstan	Al-Farabi Kazakh National University (KazNU)
3	Kazakhstan	Kazakh-German University (KNU)
4	Kyrgyzstan	Kyrgyz National University (KNU-KG)
5	Kyrgyzstan	University of Central Asia (UCA)
6	Kyrgyzstan	Central Asian Institute for Applied Earth Research (CAIAG)
7	Tajikistan	Tajik National University (TNU)
8	Uzbekistan	Mirzo Ulugbek National University of Uzbekistan (NUUz)
9	Uzbekistan	Tashkent Institute of Irrigation and Agricultural Mechanization Engineers (TIIAME)

Figure 16 presents the number of staff members working in one faculty or department. In most university faculties/departments where respondents are employed, more than 20 people work; however, it is not specified whether they all teach or are exclusively involved in cryosphere-related studies.

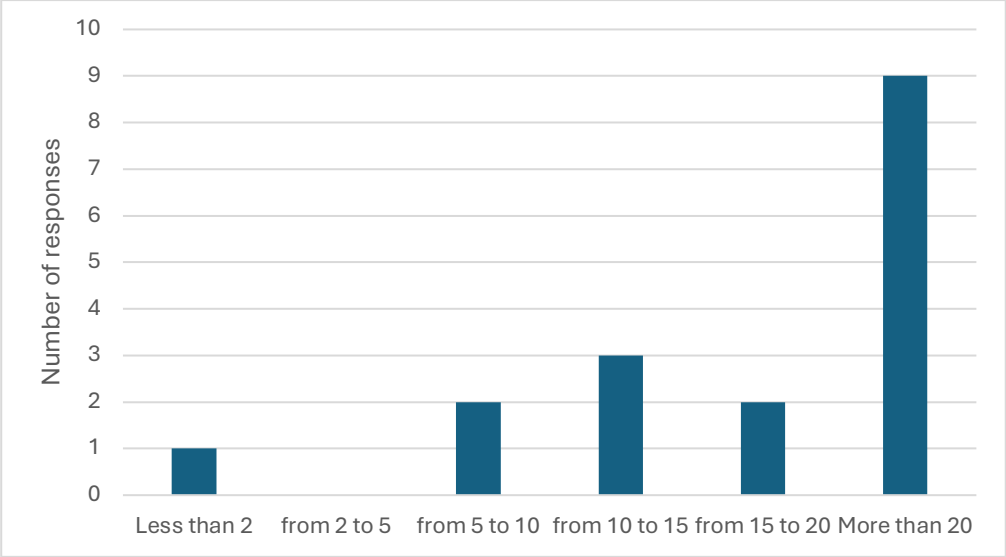


Figure 16. Number of staff working in university faculties/departments of respondents

When it comes to the number of lecturers teaching disciplines related to the cryosphere, respondents' answers indicate that most faculties have fewer than 2 or between 2 and 5 lecturers specializing in such disciplines (Figure 17).

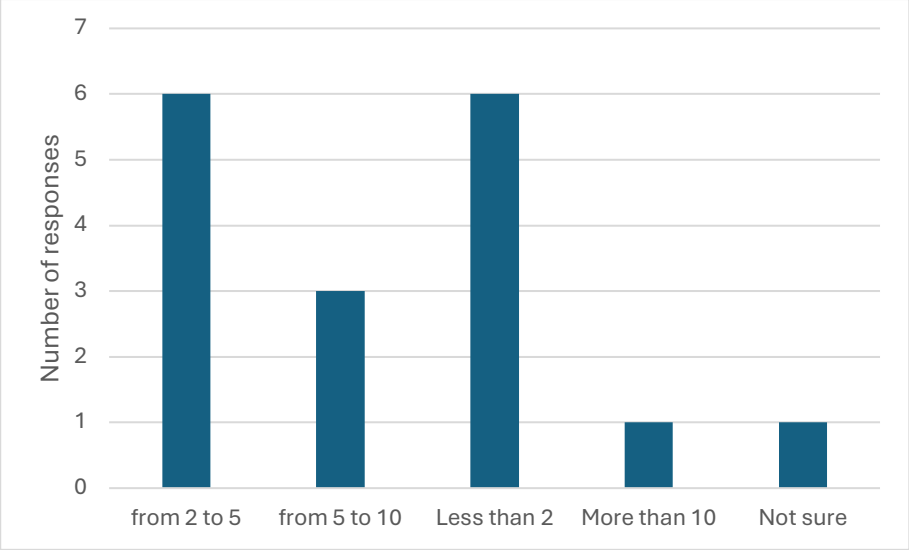


Figure 17. Number of lecturers teaching cryosphere-related disciplines in respondents' universities

The main salary range in universities (62.5%), as reported by respondents, is between $400 and $1,000. The second most common salary range is between $100 and $400 (31.3%), while more than $1,000 is earned by 6.3% of respondents (Figure 18). Based on these responses, 47% of respondents are partially satisfied with their salary, 35.3% are satisfied, and 17.7% are dissatisfied. Additionally, 47% of respondents believe that their salary adequately corresponds to their qualifications and workload, while 29.5% feel that it poorly corresponds, and 23.5% consider it well aligned.

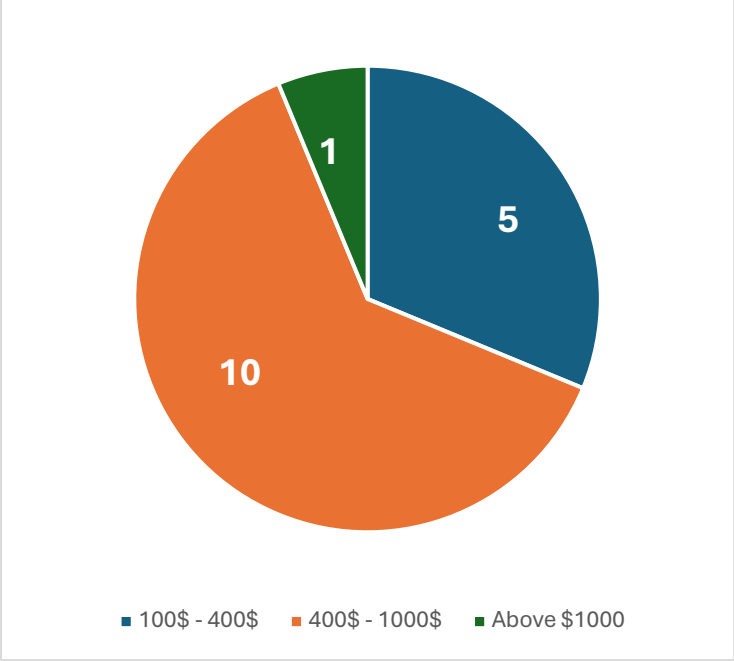


Figure 18. Average salary in universities offering cryosphere-related education

Respondents were asked whether they teach and which subjects they cover. Out of 17 respondents, only 3 indicated that they do not engage in teaching. The remaining 14 respondents mentioned a total of approximately 35 subjects they teach (including variations and synonyms).

Among them, the most commonly mentioned subject (or discipline) is hydrology and water resources management, cited in 8 out of 14 responses. This is followed by climatology and glaciology-related disciplines. Technological disciplines (GIS, digital technologies, modeling) rank third in frequency of mention (Figure 19).

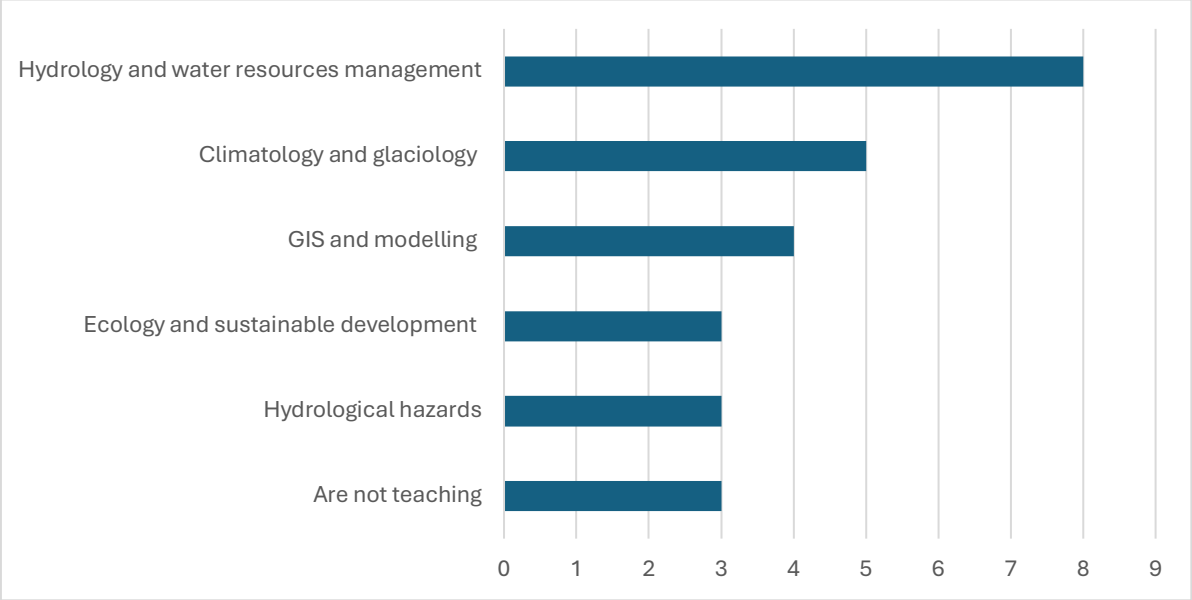


Figure 19. Mention of subjects taught by respondents in Questionnaire 2

1.2.3 Questionnaire 3 – Recent graduates

To assess the professional status and experience of recent graduates in the context of their employment and relationship to the cryosphere, respondents were asked questions aimed at gathering information about their current jobs and their relevance to the study area. We asked: what organization they are currently employed in, whether they hold professional positions in cryosphere-related fields, and if so, how many months of experience they have in the field. Their current positions, places of residence, and international experience in cryosphere-related fields were also clarified. These questions made it possible to assess the extent to which graduates are involved in professional activities, their geographical location, and their level of global interaction, which is particularly important for understanding their role in addressing cryosphere issues in Central Asia.

This group demonstrates significant heterogeneity in terms of educational background, professional experience, and geographical context, which requires caution when interpreting their data for a systemic analysis of cryosphere-related issues in the region. The analysis boundaries include the following countries: Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan.

The majority of respondents—specifically 6 out of 11—studied Integrated Water Resources Management (IWRM), which is a social science focused on governance and management aspects rather than the technical domains of cryosphere research, such as hydrology or glaciology. Only one respondent graduated in hydrology, one in geodesy and remote sensing, one in environmental engineering, and one in hydrogeology. Thus, the group is dominated by graduates with socio-management education rather than technical specializations, which may result in limited attention to the technical aspects of cryosphere research.

In terms of professional experience, only three respondents clearly stated that they currently work in cryosphere-related fields. Three respondents were "unsure" of their involvement in the field, and five explicitly stated that they do not work in it. This means that fewer than one-third of the group have direct engagement with the cryosphere.

The geographical context further complicates the analysis. Respondents come from Tajikistan (2), Kyrgyzstan (4), Kazakhstan (3), and Afghanistan (2), partially aligning with the analysis boundaries. However, current places of residence and employment extend beyond the region and include Afghanistan and even Austria. While 7 out of 11 individuals studied in Kazakhstan, two Afghan nationals are employed in Kabul, and one respondent from Kyrgyzstan currently works in Vienna. This falls outside the specified region and may influence perceptions of cryosphere-related challenges due to differing climatic and socio-economic conditions.

Respondents are employed in diverse organizations, ranging from international organizations and research institutes to private companies. Their positions vary from consultants and engineers to junior researchers and executive directors.

Therefore, this group of respondents has limited representativeness for analyzing stakeholders involved in cryosphere research and monitoring. For more accurate analysis, the sample should be complemented with specialists holding technical degrees and more extensive experience in the cryosphere field, as well as with a stronger geographic link to the Central Asian region.

Accordingly, the analysis and conclusions derived from this group will be interpreted with limitations.

1.2.4 University potential

In this study, the potential of Central Asian universities to train people for research, monitoring and management of the cryosphere is measured through a comprehensive analysis of human resources, technical base, educational programs and their attractiveness to students, which allows assessing the ability of universities to meet regional challenges in this area. For this purpose, faculty respondents were asked about the number of faculty members teaching cryosphere-related subjects and their qualifications, including the number of specialists without a degree, with the highest degree of secondary education, bachelor's, master's or doctoral degree. We also specified the English proficiency of faculty members, the annual number of new cryosphere faculty members and the universities from which they come, and the subjective assessment of faculty qualifications. In addition, data were collected on the equipment of universities with technical equipment (computers, printers), software and tools for field and laboratory work, the number of students studying cryospheric disciplines, and the compulsory conditions for admission to bachelor's, master's and doctoral programs. These questions provided a comprehensive picture of the human, infrastructural and educational potential of universities, identifying their strengths and limitations in the development of cryosphere-related sciences.

Educational level of respondents

Respondents were asked to indicate the number of faculty members with different educational qualifications. The overall regional picture shows that the majority of faculty members hold a

master's or doctoral degree, confirming a high level of qualification. In 40% of institutions, there are more than five faculty members with a doctoral degree or higher, while master's degree holders predominate in most institutions. At the same time, bachelor's and vocational education as the highest qualification are extremely rare: 80% of respondents stated that such faculty members are either absent or minimal in number. These findings highlight the high level of staff qualifications in educational institutions across the region.

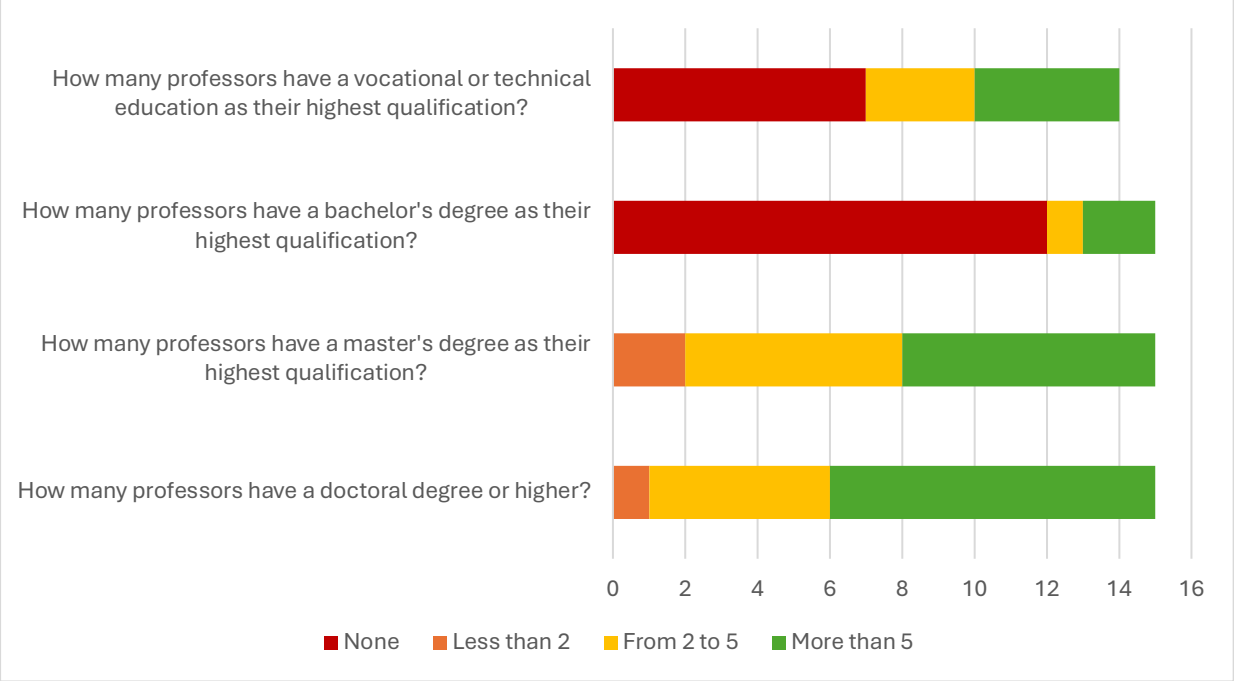


Figure 20. Distribution of faculty members by educational level based on responses from Questionnaire 2 country-specific profiles

The country profiles are as follows:

Kazakhstan: Faculty members with only vocational education are rare. At L.N. Gumilyov Eurasian National University (ENU), respondents indicated that there are 2 to 5 such faculty members, while at Kazakh-German University, their number exceeds 5. At Al-Farabi Kazakh National University (KazNU), respondents stated that no such teacher exist. Faculty members with only a bachelor's degree are almost absent. Respondents from ENU and KazNU reported that there are none, while Kazakh-German University has more than 5 such faculty members. Master's degree holders are the most common: KazNU and Kazakh-German University each have more than 5, while ENU has between 2 and 5. Faculty members with a doctoral degree or higher are also well-represented: KazNU has more than 5, while ENU and Kazakh-German University have 2 to 5.

Kyrgyzstan: Faculty members with master's and doctoral degrees are the most common. At Kyrgyz National University (KNU-KG), there are more than 5 faculty members with both qualifications (totaling more than 10). Faculty members with only a bachelor's degree are absent at KNU(KG) but one respondent noted that there are more than 5 teachers with a maximum level of education is secondary professional level of education. At the University of Central Asia (UCA), there are 2 to 5 faculty members with a master's degree and more than 5

with a doctoral degree, while there are none with only a bachelor's or vocational education. At the Central Asian Institute for Applied Earth Research (CAIAG), respondents indicated that faculty members hold only master's and doctoral degrees, with 2 to 5 faculty members at each level.

Tajikistan: At Tajik National University (TNU), master's and doctoral degrees are the most common. Respondents indicated that more than 5 faculty members hold these degrees, while other responses varied between 2 to 5 and fewer than 2. Faculty members with only vocational or bachelor's degrees are less common but still present. Their numbers vary, with some responses indicating more than 5, while others reported 2 to 5, and some respondents noted their absence.

Uzbekistan: Faculty members with master's and doctoral degrees are the most common. At National University of Uzbekistan (NUUz), one respondent reported that there are more than 5 master's degree holders, while another estimated fewer than 2. Doctoral degree holders were reported by two respondents to be between 2 to 5 and more than 5. Faculty members with only vocational education are less common, with numbers reported as 2 to 5 or more than 5. Bachelor's degree holders are absent, as confirmed by two respondents. At Tashkent Institute of Irrigation and Agricultural Mechanization Engineers (TIIAME), respondents indicated that there are 2 to 5 faculty members with master's degrees (reported by two respondents), and more than 5 with doctoral degrees (reported by two respondents). Faculty members with qualifications below the master's level (bachelor's and vocational education) are completely absent (both categories received two responses of "none").

Additionally, to assess the capabilities of current university faculty, information was collected regarding their level of English proficiency, although this remains a subjective assessment by respondents (Figure 21). Faculty members whose English proficiency is intermediate or above intermediate make up the majority (70%). Those with a below-intermediate level and elementary level - 18% and 12%.

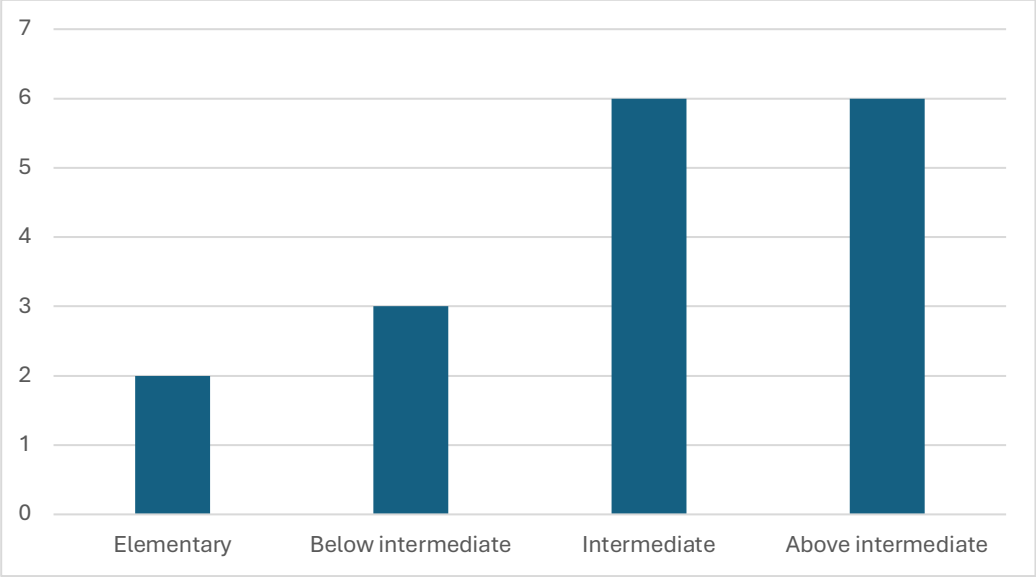


Figure 21. Level of english proficiency among faculty members

To evaluate how important cryosphere-related subjects and activities are in universities, respondents were asked how many new faculty members are hired each year in this field (Figure 22). The majority of departments hire very few new faculty members (the median value is 1**),** specializing in cryosphere studies. The largest group of universities (9 out of 17 responses) indicated a hiring range of fewer than 2. Only 2 respondents indicated hiring 2 to 5 faculty members per year. Only 1 respondent indicated hiring between 7 and 10 new faculty members annually. 2 respondents reported that no faculty members are hired annually. 3 respondents selected "Not sure."

It is important to note that there may be multiple reasons why universities hire new staff. Beyond the need to conduct more courses or research projects on cryosphere-related topics, another reason for hiring new staff could be retirement of senior faculty or faculty members leaving for other reasons.

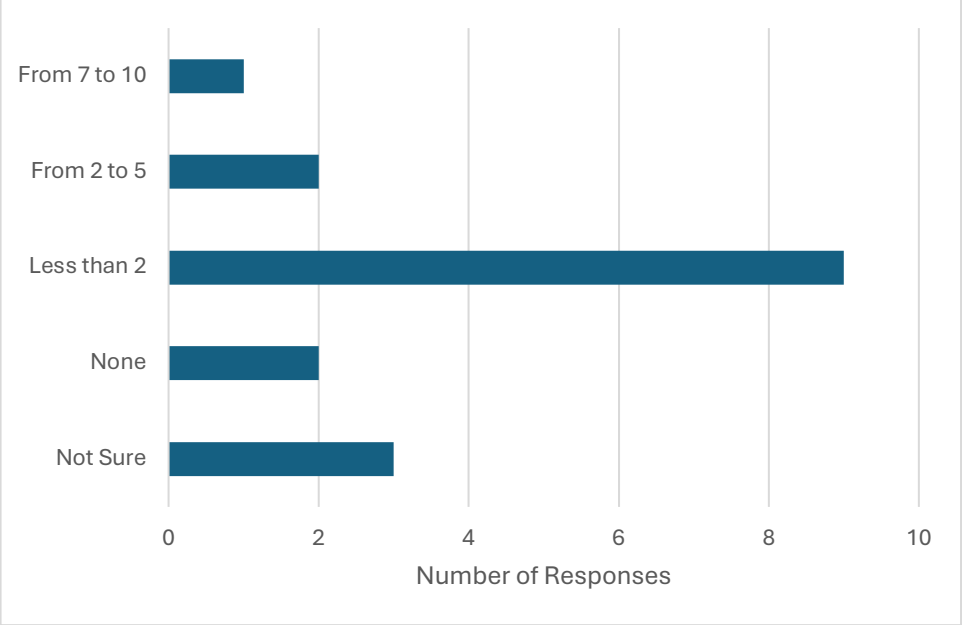


Figure 22. Number of new faculty members hired annually for cryosphere-related teaching

New candidates hired by universities typically have obtained their education in Central Asian countries as well as internationally in Russia, Germany, Switzerland, and China. The distribution of the most common universities from which new faculty members are recruited is described below.

Kazakhstan: Al-Farabi Kazakh National University (KazNU), L.N. Gumilyov Eurasian National University (ENU), K.I. Satpayev Kazakh National Research Technical University (KazNITU).

Kyrgyzstan: J. Balasagyn Kyrgyz National University, B.N. Yeltsin Kyrgyz-Russian Slavic University, Kyrgyz State University of Geology, Mining, and Natural Resources Development.

Tajikistan: Tajik National University (TNU), Tajik Agrarian University (TAU), Moscow State University Branch in Tajikistan (MGU)

Uzbekistan: Moscow State University (MSU), Potsdam Institute for Climate Impact Research, Institute of Atmospheric Physics of the Chinese Academy of Sciences, University of Freiburg.

Another subjective assessment conducted as part of the survey included evaluating the qualifications of university staff. The rating scale consisted of "Not sure," "Satisfactory," "Good," and "Excellent" (Figure 23). The majority of respondents (83%) rated their university's staff qualification as "Good" (59%) or "Excellent" (24%). However, 3 out of 17 respondents rated it as "Satisfactory" (18%). There were no responses indicating "Not sure."

Figure 23. Assessment the qualifications of university staff by respondents in Questionnaire 2

Technical capacity of universities

In general universities are better equipped with technical apparatus (computers, printers, etc.), with 76% of respondents giving positive ratings (Figure 24). However, the availability of tools for field and laboratory work is rated lower: one-third (31%) of respondents indicated a shortage. Opinions on software provision are mixed: only 41% of respondents consider it sufficient, while 24% noted poor software availability. However, a significant portion of respondents (35%) expressed uncertainty on this question, which may indicate a lack of awareness regarding this issue.

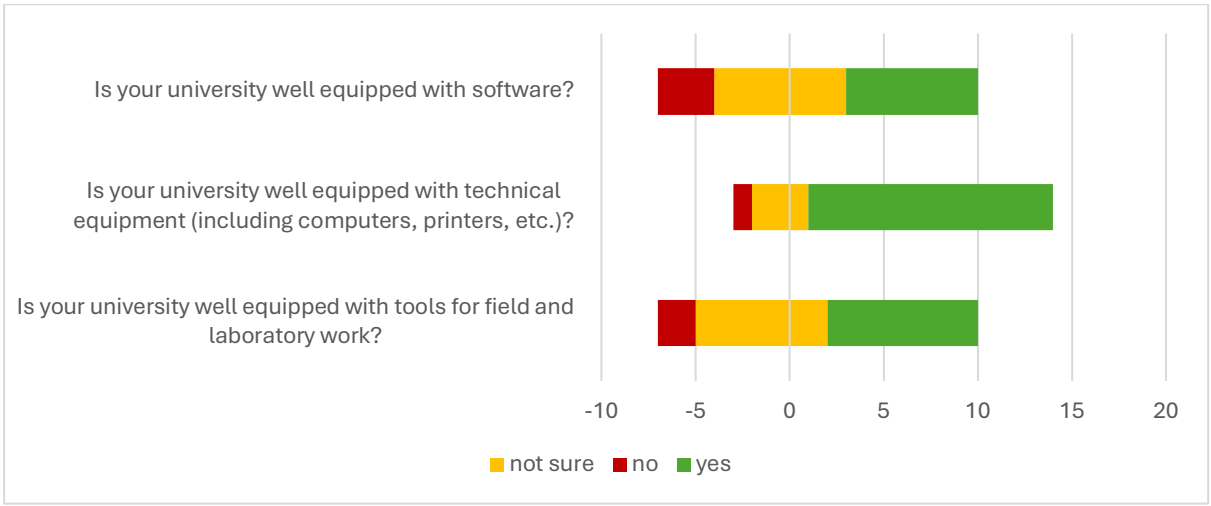


Figure 24. University equipment availability

Data on the number of students studying cryosphere-related subjects each year are inconsistent (Figure 25). These disciplines are taught at most universities, with approximately one-third of respondents indicating that more than 30 students study these subjects annually. However, at some universities, the number of students remains limited (fewer than 5 students**).** 6 respondents (the highest number) indicated that more than 30 students study cryosphere-related disciplines each year. 4 respondents noted that the number of such students is fewer than 5. The ranges "6 to 15" and "16 to 30" each received 2 responses.

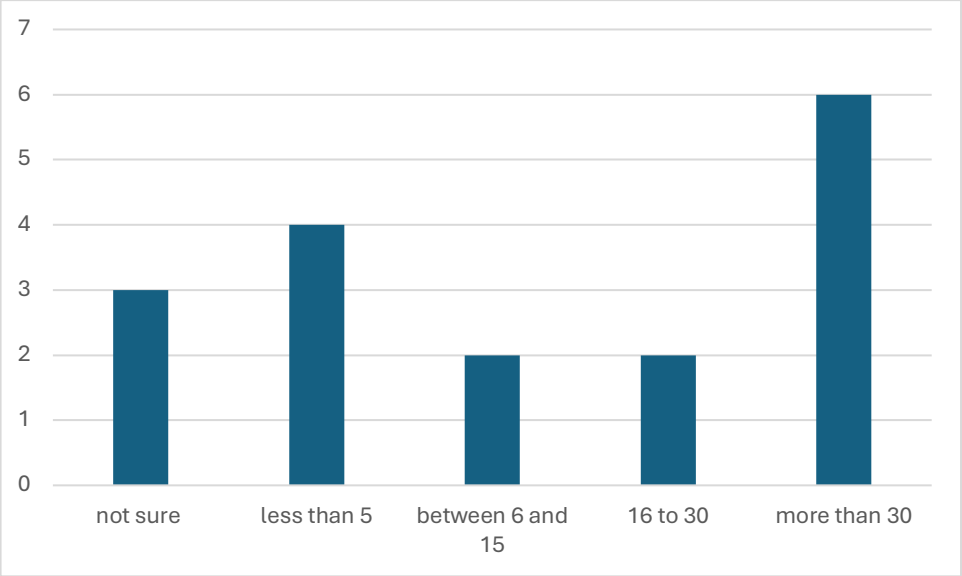


Figure 25. Number of students studying cryosphere-related subjects annually

The following universities reported having more than 30 students studying cryosphere-related subjects each year:

- Al-Farabi Kazakh National University (KazNU)
- University of Central Asia (UCA)
- Tajik National University (TNU)
- Mirzo Ulugbek National University of Uzbekistan (NUUz)
- Tashkent Institute of Irrigation and Agricultural Mechanization Engineers (TIIAME)

Existing admission requirements (prerequisites) for cryosphere-related programs to universities in Central Asia varies significantly, reflecting national education standards.

For admission to a bachelor's program at many universities in Central Asian countries, the following requirements typically apply:

- Successful completion of entrance testing (ENT in Kazakhstan, national testing in Tajikistan);
- Completion of secondary education (e.g., National University of Uzbekistan).

Master’s program admission standards:

- A bachelor's degree, passing subject-specific exams, and providing language proficiency proof (B1 level or higher), as required in Kyrgyzstan, Tajikistan, and Uzbekistan.
- Some universities require a written essay or an interview (e.g., Al-Farabi KazNU and ENU in Kazakhstan).
- Additional conditions, such as language proficiency or subject exams (e.g., Kazakh-German University requires English language proficiency).

Doctoral program admission requirements:

- A master's degree (universally required).
- Entrance exams in the chosen field and language proficiency (e.g., TIIAME, Tajik National University).
- Some universities, such as Al-Farabi KazNU, require work experience (minimum 9 months).

1.2.5 Capacity needs in organizations

To understand the current demand for graduates specializing in cryosphere-related fields, we asked industry professionals how many new graduates are typically hired each year (Figure 26).

In Kazakhstan, students most frequently come from Al-Farabi Kazakh National University (KazNU), K.I. Satpayev Kazakh National Research Technical University (KazNITU), L.N. Gumilyov Eurasian National University (ENU). These universities were mentioned by most respondents as the primary sources of students.

In Kyrgyzstan, the main universities supplying students are Jusup Balasagyn Kyrgyz National University (KNU), Kyrgyz-Turkish Manas University, I. Razzakov Kyrgyz State Technical University. Additionally, respondents mentioned Kyrgyz Mining and Geological Institute, International University named after Manas.

In Tajikistan, respondents highlighted Tajik National University (TNU), Tajikistan Pedagogical University, University of Central Asia.

In Uzbekistan, the primary source of students is Mirzo Ulugbek National University of Uzbekistan (NUUz) (mentioned in most responses). Other notable institutions include Tashkent Institute of Irrigation and Agricultural Mechanization Engineers (TIIAME), Moscow State University (MSU), University of Freiburg.

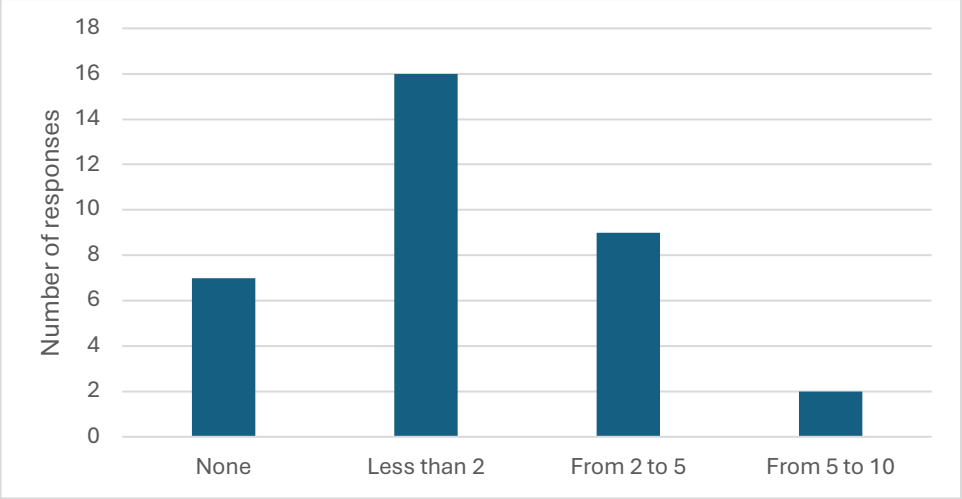


Figure 26. Annual employment of graduates in organizations

We also asked about the educational level of graduates who have the highest chances of being employed. The majority of responses indicate that graduates with master's and doctoral degrees are more likely to be hired (Figure 27). However, bachelor's degree graduates are also mentioned in a significant number of responses, either separately or in combination with master's or doctoral degrees. This suggests that some organizations are open to hiring specialists with basic higher education as well.

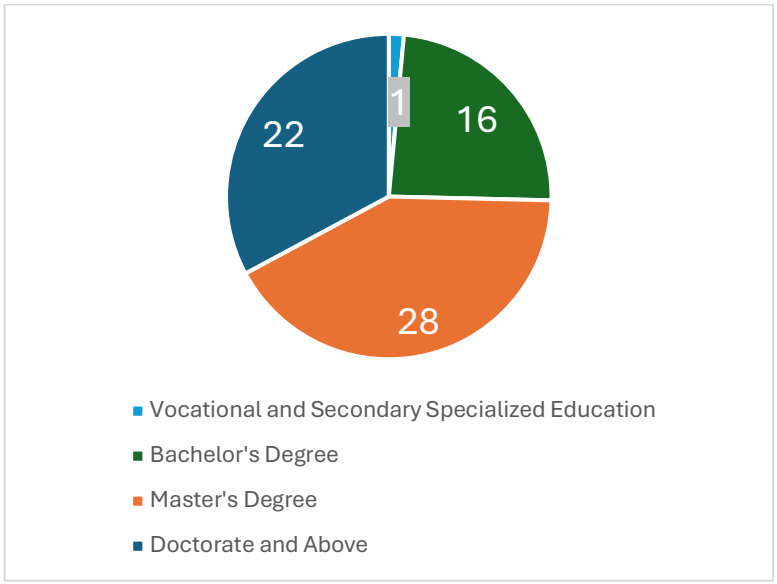


Figure 27. Educational level of recent graduates with the highest employment chances in cryosphere-related organizations

Respondents were also asked to provide a relative assessment of the knowledge level of new graduates entering the job market in cryosphere-related organizations. The knowledge of recent graduates working in the cryosphere field is primarily rated as "Satisfactory" (41%) and "Good" (38%). However, a notable proportion (17%) of negative evaluations suggests a need to improve the quality of specialist training in this field (Figure 28). 12 respondents rated graduates' knowledge as "Satisfactory", making it the most frequent evaluation. This indicates that graduates meet the minimum requirements but have room for improvement. 11 respondents

rated graduates' knowledge as “Good”, suggesting that some graduates exceed the minimum expectations, which is a positive sign. 5 respondents rated graduates' knowledge as “Poor”, highlighting concerns about the preparation of some specialists in the cryosphere field.

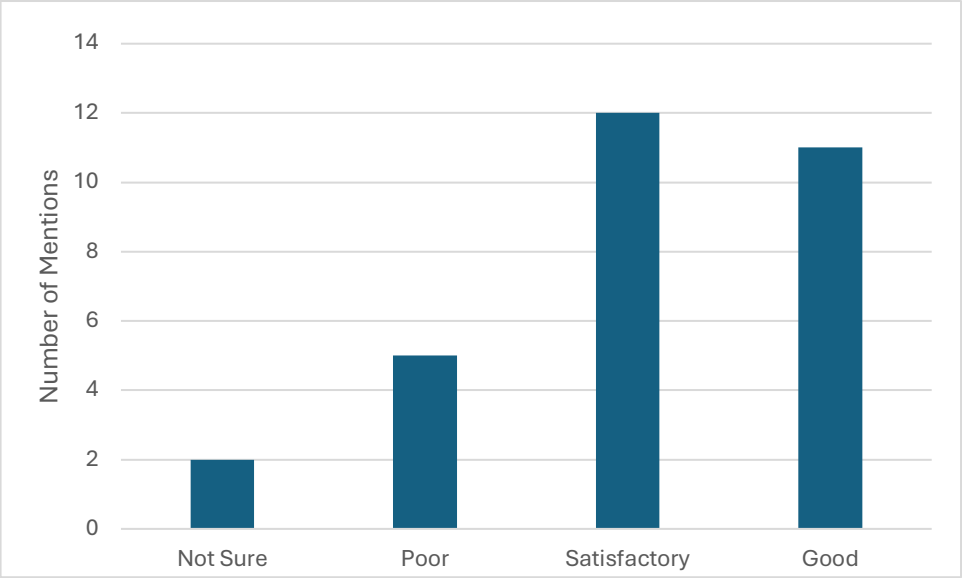


Figure 28. Assessment of knowledge levels of recent graduates entering the job market in cryosphere-related organizations

At the same time, we asked respondents whether they agree that recent graduates are well-prepared for successful work in their organization. Responses were divided equally among three categories: "Yes", "No", and "Not sure." This indicates the presence of both positive examples of graduate training and significant gaps in preparation. When analyzing responses by country the majority of respondents from Kazakhstan (5 out of 6) are either unsure or rate graduate preparation negatively. All respondents from Kyrgyzstan (7 out of 7) provided negative or uncertain assessments of graduate preparation. Opinions are divided, but the majority of Tajikistan respondents (5 out of 7) express uncertainty or a negative view of graduate preparation. The majority Uzbekistan of respondents (8 out of 14) provide a positive evaluation of graduate preparation.

1.2.6 Capacity evaluation by graduates

Overall, recent graduates tend to assess the quality of teaching staff and technical facilities as “satisfactory” or “good,” with fewer evaluations as “excellent” or “poor,” and some respondents indicated uncertainty. Most respondents (with few exceptions) reported that they apply more than 50% of the knowledge gained at university in their current work. In addition, the majority answered affirmatively when asked whether they would choose the same university again and whether they would recommend it to others.

Most graduates were able to find employment within five months or within one year after graduation, though some were employed in fields unrelated to their studies. Among the key skills considered most useful in the workplace, respondents frequently cited research skills, proficiency in GIS and remote sensing methods, project management abilities, and analytical thinking.

Some graduates highlighted the importance of more practice-oriented courses, such as field-based studies related to cryosphere monitoring. When asked how many of their cohort are currently working in their field of study or in cryosphere-related areas, the responses varied widely (from “1 out of 7” to “5–6 out of 17”), and some respondents were unsure of their classmates’ career trajectories.

It is worth noting that a number of graduates received degrees in social or adjacent disciplines and now reside outside the focus countries of the analysis (e.g., in Kazakhstan or Kyrgyzstan), which further limits the representativeness of their assessments regarding the technical capacity of relevant universities and may explain some of the uncertainty in evaluating the effectiveness of technical training.

1.3 Conclusion about representativeness of the sample

The sample covers a broad range of ages, qualifications, and employers, but it also demonstrates certain limitations in representativeness, particularly in terms of technical specializations among the “recent graduate” group. A gender imbalance is noticeable in Questionnaire 1, while the second and third questionnaires present a more balanced gender distribution. Most academic respondents hold high academic degrees, while among practitioners both Master’s and PhD holders are represented—although a high level of education generally prevails across both groups. Recent graduates mostly hold Master’s degrees; however, not all of them continue their careers in the cryosphere field, especially those who were trained in adjacent or socially oriented disciplines.

Chapter 2. Curricula and Methodologies

In Chapter 2, data on disciplines included in programs aimed at providing knowledge about the cryosphere are analyzed and summarized. The second part of the chapter is devoted to the study of methods used for such training. Data on laboratory work, field trips, and the ratio of engineering and social disciplines are presented. A connection is established between the desired disciplines, noted by practitioners, and the disciplines being taught.

2.1 Curricula

This analysis is performed at a generalized regional level, as the titles, structure and content of disciplines at each university may differ significantly. The curriculum has been generalized based on data from 9 educational institutions that participated in the study. A total of 23 disciplines and 3 types of fieldwork (practical training sessions) were included in the survey (Table 3). A combined curriculum table summarizing the curricula of the participating institutions is presented in Table 4. This table was compiled based on respondents' answers and additional interviews with respondents from Questionnaire 2 to clarify information. While course titles may differ slightly between universities or across different education levels, the general focus of each discipline remains consistent with its stated name. It is important to note that the subjects listed for CAIAG (Central Asian Institute for Applied Earth Research) are taught under contractual agreements for students from another university at the master's level, demonstrating potential and opportunities for collaboration at least at the national level.

At Kyrgyz National University (KNU-KG), the largest number of subjects from the selected sample is offered. A total of 21 out of 23 subjects are taught at KNU-KG, with the exception of Fundamentals of Programming and Modeling of Hydrological Processes. In addition to these subjects, KNU-KG conducts 2 out of 3 types of fieldwork for bachelor's degree students, excluding geophysics-related fieldwork. The following institutions also offer a significant number of subjects: Tashkent Institute of Irrigation and Agricultural Mechanization Engineers (TIIAME) – 20 out of 23 subjects, 1 out of 3 fieldwork types.

Tajik National University (TNU) – 19 out of 23 subjects, 2 out of 3 fieldwork types; KazNU – 19 out of 23 subjects, 1 out of 3 fieldwork types; NUUz and ENU – 18 out of 23 subjects, 1 out of 3 fieldwork types.

If we consider the table in terms of the representation of subjects, in general, basic subjects (1-6 from Table 3) are present in almost all universities, except for KNU and CAIAG. While CAIAG provides specialist training on its premises under a contractual agreement for another university, the evaluated specialty at KNU is not technical (IWRM).

Among the most represented subjects, include Fundamentals of GIS is taught in all universities at different levels. Followed by Geodesy, Cartography, and Climatology are offered in 7 out of 9 universities.

Among the least represented subjects are: Geocryology (Permafrost Studies) and Earth Materials and Geochemistry – only in one university; Fundamentals of Glaciology and Introduction to Geophysics – in 3 out of 9 universities.

Fieldwork in hydrology as part of training is conducted in almost all universities. Fieldwork in glaciology is conducted only at KNU-KG and TNU, and geophysics fieldwork is conducted only at UCA.

Table 3. List of disciplines included in the questionnaire

№	*Discipline*	*№*	*Discipline*
1	Physics	14	Meteorology
2	Mathematics	15	Climatology
3	Chemistry	16	Fundamentals of GIS
4	Hydrology	17	Remote sensing (RS)
5	Physical geography	18	Fundamentals of programming
6	General geology	19	Modeling of hydrological processes
7	Geocryology (Permafrost studies)	20	Data collection and processing
8	Fundamentals of glaciology	21	Statistical methods for data processing
9	Hazardous natural processes	22	Integrated Water Resources Management (IWRM)
10	Introduction to geophysics	23	Environmental protection law and policy
11	Earth materials and geochemistry	24	Fieldwork in hydrology
12	Geodesy	25	Fieldwork in glaciology
13	Cartography	26	Fieldwork in geophysics

Table 4. Courses in bachelor's, master's, and doctoral programs related to the cryosphere

Courses	Kazakhstan			Kyrgyzstan			Tajikistan	Uzbekistan	
	ENU	KazNU	KNU	KNU (KG)	UCA	CAIAG	TNU	NUUz	TIIAME
Physics	B	B		B	B		B	B	B
Mathematics	B	B		B	B		B	B	B
Chemistry	B	B		B	B		B	B	B
Hydrology	B, M	B, M	M	B	B		B, M	B, M	B
Physical Geography	B	B		B	B		B	B	B
General Geology	B, M	B		B	B	M	B	B	B
Geocryology (Permafrost Studies)				B					
Fundamentals of Glaciology				B			B, M	B	
Hazardous Natural Processes	B	B, M		B		M	B	B, M	B
Introduction to Geophysics				B				B	B
Earth Materials and Geochemistry				B					
Geodesy	B	B		B	B		B	B	B
Cartography	B	B		B	B		B	B	B
Meteorology	B, M	B		B			B	B	B
Climatology	B, M	B		B	B		B, M	B	B
Fundamentals of GIS	B	B	M	B, M	B	M	B, M	B, M	B
Remote Sensing (RS)	B, M	B, M, D	M	B, M	B		B, M	M	B
Fundamentals of Programming	B	B			B		B, M		B
Modeling of Hydrological Processes	B, M	B, M, D					B	M	B
Data Collection and Processing	B, M	B, M		B			B		B
Statistical Methods for Data Processing	B, M	B, M		B, M	B		B	B	B
Integrated Water Resources Management (IWRM)	B, M	B, M	M	M			M		B
Environmental Protection Law and Policy		B	M	B					B
Fieldwork in Hydrology	B	B	M	B	B		B, M	B	B
Fieldwork in Glaciology				B		M	B, M		
Fieldwork in Geophysics					B				

Acronyms

B = Bachelor's level	**M** = Master's level	**D** = Doctoral level

University Abbreviations

Kazakhstan		**Kyrgyzstan**	
L.N. Gumilyov Eurasian National University	**ENU**	Kyrgyz National University	**KNU(KG)**
Al-Farabi Kazakh National University	**KazNU**	University of Central Asia	**UCA**
		Central Asian Institute for Applied Earth Research	**CAIAG**
Kazakh-German University	**KNU**		
Tajikistan		**Uzbekistan**	
Tajik National University	**TNU**	Mirzo Ulugbek National University of Uzbekistan	**NUUz**
		Tashkent Institute of Irrigation and Agricultural Mechanization Engineers	**TIIAME**

Analysis of the distribution of responses across three groups of disciplines (natural sciences, technical (engineering), and socio-economic) shows that in educational programs related to the cryosphere, natural sciences dominate: the majority of respondents (7 people) indicate that the share of study hours exceeds 50%. Technical (engineering) disciplines most often occupy a "middle" niche: the highest number of responses (8 and 6 people, respectively) falls within the 16–30% and 31–50% ranges, while none of the survey participants allocate more than 50% of the total curriculum to engineering disciplines. Social and economic sciences are usually represented by a minimal block: 10 respondents indicate 0–15% of the total study hours. Thus, the majority of educational programs in cryosphere-related specialties prioritize natural science disciplines, moderately include engineering courses, and less frequently give significant attention to socio-economic aspects (Figure 29).

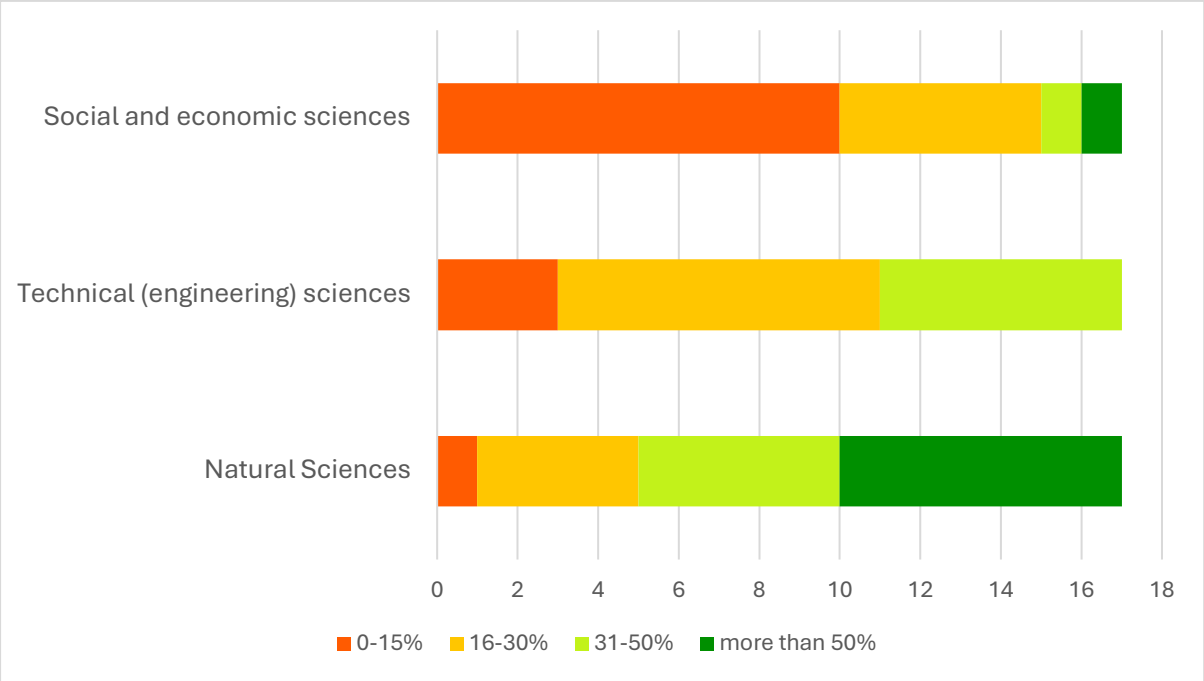


Figure 29. Distribution of study hours among natural, technical, and socio-economic disciplines in educational programs of cryosphere-related specialties

Among the specialized software for studying the cryosphere, the following are taught: GIS applications (ArcGIS, QGIS), modeling applications (MODFLOW, FEFLOW, SEAWAT, etc.), as well as programming languages and software packages for data analysis (Python, MATLAB, Fortran, R, or others). Respondents' answers indicate that universities place the greatest emphasis on GIS products (ArcGIS, QGIS) in educational programs, as these were mentioned the most times (17). Programming languages (Python, MATLAB, Fortran, R) rank second (5 mentions). Specialized software (MODFLOW, FEFLOW, SEAWAT) is mentioned only 3 times.

2.2 Methods

In this subsection, we assess how various teaching methods, such as fieldwork, laboratory work, and internships, are incorporated into the curriculum to strengthen practical understanding of cryosphere-related issues.

Fieldwork

Almost 90% of respondents stated that field excursions are included in the curriculum, and only one respondent out of 17 indicated that they either do not know or are unsure. Fieldwork generally constitutes a small proportion of total study hours (0–15%) (10 out of 16 responses).

Out of 16 mentions of fieldwork types, 9 are related to hydrology, 3 mentions are for geodesy and snow survey fieldwork, and 1 mention each for geophysics and glaciology fieldwork. Glaciology fieldwork was only mentioned by a CAIAG respondent, snow survey fieldwork is conducted at UCA, TNU, and NUUz, and geophysics fieldwork was mentioned by respondents from TNU.

These responses differ from Table 4 and require further analysis and verification. It is possible that some respondents did not mention all relevant types of fieldwork or provided incomplete information, leading to data inconsistencies.

Laboratory work

82% (14 out of 17) of responses indicate that laboratory work is included in the curriculum, 2 respondents are unsure, and only 1 answered that laboratory work is not included. In most programs where laboratory work is included, it occupies a relatively small proportion of study time (0–15% for seven respondents and 16–30% for five).

Based on the responses provided, the main goal of laboratory work in cryosphere-related educational programs is to develop students' practical skills necessary for conducting experimental research and analyzing obtained data. Most respondents emphasize the importance of mastering instrument operation techniques (hydrological, chemical, etc.), developing skills in setting up experiments and critical thinking, processing measurement results and field research data, as well as using modern technological tools (e.g., GIS systems). At the same time, some responses highlight specific aspects – from hydrochemistry and hydrological measurements to working in a research environment and building models.

Internship

A total of 65% of respondents indicated that internships are included in the curriculum. In most programs (8 mentions), internships occupy a minimal share of study time (0–15%), while several respondents (5) indicated a more significant proportion (16–30%).

According to the responses received, the most common model (8 mentions) assumes that the university is directly responsible for organizing internships, independently placing students in relevant organizations. At the same time, a significant number of respondents (7) pointed to a model where students have the right to choose their internship location themselves but can also rely on the university’s support and connections. A very small percentage (3) follow a fully independent approach, placing the responsibility for organizing internships entirely on the initiative of the students.

Interpersonal communication skills

Analysis of responses shows that most respondents include formal training in interpersonal skills in their programs. The greatest emphasis is placed on presentation skills (12 mentions), as well as the development of critical and analytical thinking and teamwork skills (9 mentions each). Communication skills are mentioned 8 times, and project management is mentioned 7 times.

Only three respondents indicated that such skills are not taught within the curriculum. Additionally, KNU(KG) notes that subjects such as cultural studies and sociology are included in the curriculum, within which interpersonal communication skills are taught.

Languages

In most universities in Central Asia, multiple languages are used for teaching, and almost all include either Russian or English (or both) alongside the national language of the respective country. In Kazakhstani universities (L.N. Gumilyov ENU, Al-Farabi KazNU, Kazakh-German University), Kazakh, Russian, and English are predominant, although in some programs, English may serve as the primary or additional language of instruction. At Kyrgyz National University (KNU(KG)) and CAIAG, Kyrgyz and Russian are most commonly used; in Uzbek universities (NUUz, TIIAME), Uzbek, Russian, and in some cases, English are present; at Tajik National University (TNU), Tajik is combined with Russian and often English. At the same time, there are programs where instruction is strictly in one language, such as Tajik at TNU and English at Kazakh-German University and the University of Central Asia. Thus, the vast majority of universities implement at least bilingual programs, utilizing a combination of the national language, Russian, and/or English in the educational process, with Russian being mentioned more frequently (in 14 out of 17 cases) than English (in 10 out of 17).

2.3 Knowledge requirements in organizations

We received a list of essential subjects, software (SO), fieldwork, and "soft" skills that a recent graduate should possess to be in demand in the cryosphere job market (Table 5, Table 6, Table 7, Table 8).

According to survey results, 30 out of 35 respondents indicated that proficiency in Russian, and 29 respondents noted that English is a necessary requirement for effective professional activity in organizations. In both cases, these languages are expected to complement national languages.

Table 5. List of disciplines and tools required for working in organizations in the field of cryosphere research and monitoring

Mandatory disciplines from the curriculum (number of mentions)	Additional subjects suggested by practitioners
Mountain Hydrology (Hydrology) (31/34)	English Language
Fundamentals of Glaciology (30/34)	Hydrology, Hydrometry, Hydro-physics
GIS and Remote Sensing (28/34)	Fundamentals of Modeling in Hydrology and Cryosphere
Meteorology (28/34)	
Data Collection and Processing (27/34)	
Climatology (26/34)	

Statistical Methods for Data Processing (24/34) Cartography (23/34) Geodesy (21/34) Hazardous Natural Processes (20/34) Fundamentals of Geophysics (19/34) Fundamentals of Programming (19/34) Geocryology (Permafrost Studies) (17/34) Fundamentals of Geology (15/34) IWRM (Integrated Water Resources Management) (11/34)	

Table 6. List of required software tools for employment in organizations in the field of cryosphere research and monitoring

Mandatory software from the curriculum (number of mentions)	Additional software suggested by practitioners
ArcGIS, QGIS (32/33) Python, MATLAB, Fortran, R or another programming language (21/33) MODFLOW, FEFLOW, SEAWAT or another modeling program (16/33) Geological modeling and visualization software for geological and geophysical data (14/33)	Cryosphere-related software (hydrological modeling, cryosphere forecasting, etc.) Drone (UAV) software

Table 7. Required field knowledge for employment in organizations in the field of cryosphere research and monitoring

Mandatory fieldwork	Additional fieldwork suggested by practitioners
Glaciology fieldwork (32/34) Hydrology fieldwork (31/34)	Drone (UAV) operations Hydrometry, hydro-physics

Snow survey fieldwork (24/34) Geophysics fieldwork (23/34)	Geodetic measurements using GPS

Table 8. Required soft skills for employment in organizations in the field of cryosphere research and monitoring

Required "soft" skills	Additional "soft" skills suggested by practitioners
Teamwork (29/34) Critical and analytical thinking (26/34) Presentation skills (26/34) Communication skills (24/34) Project management (19/34)	Collaboration with other organizations

2.4 Organizational needs compared to the existing curriculum

In this subsection, we establish a connection between the existing university curricula and the subjects necessary for entering the cryosphere-related job market.

Disciplines

Based on the analysis of data from Tables 4 and 5**,** conclusions can be drawn regarding the extent to which university curricula align with the needs of organizations engaged in cryosphere research and monitoring, as well as identifying gaps and areas for improvement. The comparison is conducted by correlating the subjects that organizations consider important **(**Table 5**)** with their presence in university curricula **(**Table 4**).**

Table 5 reflects the prioritization of disciplines necessary for work in the cryosphere field, based on the number of mentions by employees of specialized organizations (34 respondents). To illustrate their importance for research and monitoring in the cryosphere field, all disciplines can be conditionally divided into three categories based on their demand level, determined by the number of mentions by respondents. This categorization helps highlight the most and least in-demand disciplines based on the opinions of the majority of respondents.

High priority disciplines are those that were noted by more than 75% of respondents, making them the most in-demand from the perspective of practitioners and representing key competencies for work in the cryosphere field. This category includes mountain hydrology (hydrology), fundamentals of glaciology, GIS and remote sensing, meteorology, data collection and processing, and climatology. Most high-priority disciplines are well represented in universities across Central Asia. GIS and remote sensing have 100% coverage, mountain hydrology (hydrology) is represented in 89% of universities, climatology in 78%, and meteorology in 67%, making them widely available in curricula. However, data collection and processing are included in only 56% of universities, which is relatively low for a high-priority discipline (79.4% of respondents marked it as important). Fundamentals of glaciology is critically underrepresented

in university curricula. Although over 80% of respondents indicated its importance, it is taught in only 3 out of 9 universities (33%)—KNU(KG), TNU, and NUUz.

Medium priority disciplines are those that practitioners consider of moderate importance, as they were noted by 50% to 75% of respondents. This category includes statistical methods for data processing, cartography, geodesy, hazardous natural processes, fundamentals of geophysics, fundamentals of programming, and geocryology (permafrost studies). Medium-priority disciplines generally have good coverage. Geodesy and cartography are represented in all universities (100%). Statistical methods and hazardous natural processes are included in 78% of universities. Fundamentals of programming is covered in 56%, which aligns with its demand (55.9% of respondents).

Among underrepresented disciplines - Fundamentals of Geophysics (55.9% of respondents) is taught in only 33% of universities (KNU(KG), NUUz, TIIAME). Also, Geocryology (Permafrost Studies) (50% of respondents) is included in only 1 university (KNU(KG)) out of 9 evaluated.

Low priority disciplines are those noted by less than half (<50%) of respondents. These may be highly specialized or less relevant for most organizations. This category includes Fundamentals of Geology and IWRM (Integrated Water Resources Management).

Thus, while academic programs largely meet the needs of organizations, they require adjustments to eliminate gaps in key disciplines and increase practical orientation. Some notable gaps in university curricula include:

- Fundamentals of Glaciology – High priority (88.2%), but taught in only 3 out of 9 universities.
- Geocryology (Permafrost Studies) – Medium priority (50%), but available in only 1 university.
- Fundamentals of Geophysics – Medium priority (55.9%), but included in only 3 universities.
- Data Collection and Processing – High priority (79.4%), but coverage is lower than required based on respondent feedback (5 out of 9 universities).

Software

By comparing the data on taught (Questionary 2) and required (Questionary 1**)** software, we can assess how well software is integrated into the educational process and represented in curricula.

For analysis, data from two surveys were used, covering the following software:

- **ArcGIS, QGIS (GIS applications)** – Well represented in curricula (17 out of 18 responses) and highly demanded by organizations and practitioners (32 out of 33 mentions by respondents).

- **Programming languages (Python, MATLAB, Fortran, R)** – Poorly represented in curricula (5 mentions out of 18) but highly demanded by practitioners (21 out of 33 respondents).

- **Specialized modeling software (MODFLOW, FEFLOW, SEAWAT)** – Poorly represented in curricula (3 mentions out of 18) but required by half of the respondents (16 out of 33).
- **Software for geological modeling and visualization of geological and geophysical data** – Completely absent in university programs but required by practitioners (14 out of 33 mentions).
- **Additional software** (cryosphere-related software, drone-related software) – This software was not mentioned in the university survey but was identified as needed by practitioners and specialists in cryosphere research and monitoring.

Current university curricula show a strong alignment with organizational needs in GIS applications, which is a key strength and indicates a focus on applying these technologies in academic programs. However, significant gaps exist in the teaching of specialized modeling software, geological analysis tools, niche instruments, and programming languages. These gaps may limit graduates' readiness for employment in cryosphere research and monitoring, reducing their competitiveness in the job market and preparedness for practical work.

Fieldwork

Hydrology fieldwork – Well represented in university programs **(**9 out of 17 mentions**)** and highly in demand – 31 out of 34 practitioner respondents consider hydrology fieldwork mandatory**.**

Glaciology fieldwork – Mentioned only once (in CAIAG) in the survey and four times in Table 4 (CAIAG, KNU(KG), TNU), indicating its limited presence in curricula. However, 32 out of 34 practitioners marked glaciology fieldwork as mandatory, making it the most in-demand among all types of fieldwork in the survey.

Snow measurement fieldwork – Mentioned three times **(**in UCA, TNU, and NUUz**),** showing limited presence**.** However**,** 24 out of 34 practitioners consider this fieldwork mandatory**,** emphasizing its significance.

Geophysics fieldwork – Mentioned only once in the survey (TNU) and once in Table 4 (UCA), highlighting its weak representation. At the same time, 23 out of 34 practitioners consider geophysics fieldwork mandatory.

Additional fieldwork identified by practitioners as essential – Drone (UAV) operations, hydrometry, and hydro-physics. These types of fieldwork were not mentioned at all by university representatives.

From a practical training perspective, university curricula align well with industry needs for hydrology fieldwork. However, significant gaps exist in glaciology fieldwork, which is highly demanded by practitioners but is only conducted in a few universities (CAIAG, KNU(KG), TNU). Discrepancies between practical needs and education are also evident in snow measurement fieldwork, geophysics fieldwork, and specialized drone-related fieldwork.

Chapter 3. Regional and international cooperation

Regional and international cooperation was assessed by collecting information on joint projects between universities, including student exchanges, guest lectures, and partnerships between universities and organizations at the national, regional, and international levels.

3.1 University

Guest lectures and faculty exchange

82% of respondents answered "Yes" to the question of whether guest lectures by professors from foreign countries, Central Asia, or their own country are held at their universities. This indicates a high level of engagement with external lecturers and active involvement of specialists from other universities. According to respondents, guest lectures are not conducted only at TNU.

65% of respondents reported that they or their colleagues deliver guest lectures at other universities abroad, in Central Asia, or within their own country. While this percentage is lower than the one for receiving guest lecturers, it still reflects significant academic mobility among faculty members. Some respondents from TNU, ENU, and NUUz indicated that neither they nor their colleagues deliver guest lectures at foreign universities.

Interest in delivering lectures on cryosphere/glaciology

When asked about their potential interest in delivering guest lectures on cryosphere or glaciology, approximately half (9 out of 17 respondents) answered "Yes." This indicates a significant level of interest in spreading knowledge in this field. However, 6 respondents did not provide an answer, and only one respondent from TNU stated that they are not interested in delivering guest lectures on cryosphere topics in other Central Asian universities.

Research collaboration

88% of respondents expressed interest in collaborating with universities, consulting agencies, and government institutions in Central Asia for joint research related to the cryosphere. This high percentage highlights a strong potential for expanding regional and international research partnerships.

Student exchange

88% indicated that their universities have exchange students coming for a semester, short courses or other activities. This indicates an active practice of academic mobility. In addition, 4 out of 17 expressed a potential willingness to host students from Central Asian universities for short courses, lectures or excursions. However, 8 did not answer this question, and 2 respondents from TNU said that they were not ready to accept students from other Central Asian universities at all.

Mentorship programs

Nearly all respondents (94%) expressed willingness to participate as mentors in programs for students from their own universities and other institutions in the region. Only one respondent answered "Not sure." This demonstrates a high level of interest in supporting young professionals and advancing educational initiatives.

The collected data indicate that universities show a high level of activity and interest in regional and international cooperation, despite varying levels of engagement across different institutions and countries. This cooperation is reflected in student and faculty exchanges, willingness to engage in joint research, and participation in mentorship programs.

These trends create favorable conditions for the further development of educational and research programs in the cryosphere field, strengthening partnerships between universities and organizations both within and beyond the region.

3.2 Organizations

Interest in collaborating with universities and institutions

All 34 respondents (100%) answered "Yes" when asked about their organizations' potential interest in collaborating with universities, consulting agencies, and government institutions at the regional and local levels in Central Asia. No one selected "Not sure" or "No."

This demonstrates an exceptionally high level of willingness to engage in partnerships, providing a strong foundation for further collaboration.

Openness to Accepting Students for Internships

The majority of organizations (70.6%) are open to accepting students from Central Asia for internships, reflecting their support for practical training. However, 26.5% of respondents selected "Not sure," indicating potential challenges or uncertainties.

Only one respondent gave a negative response, suggesting that resistance to this initiative is minimal.

Participation in mentorship programs

The overwhelming majority (85.3%) expressed willingness to serve as mentors for students from Central Asia. The absence of negative responses highlights strong interest in sharing knowledge and experience with young professionals. The 14.7% of respondents who were unsure may face certain challenges, but overall, support for this initiative is very high.

Delivering guest lectures on glaciology

A significant proportion of respondents (82.4%) expressed interest in delivering guest lectures on topics related to the cryosphere and glaciology. This indicates a strong commitment to knowledge dissemination and support for academic programs at universities. The absence of negative responses and the relatively small proportion of undecided respondents (17.6%) further reinforce the positive attitude towards this form of collaboration. The data suggest a favourable environment for collaboration between specialized organizations and academic institutions in Central Asia. Organizations exhibit a high level of interest in partnerships and student support through internships, mentorship, and lectures, creating opportunities for the development of young professionals, particularly in the fields of cryosphere and glaciology. However, to fully realize this potential, it may be necessary to address certain uncertainties by establishing clear mechanisms for cooperation.

3.3 Opportunities

Both groups demonstrate a high level of interest in collaboration; however, organizations exhibit a slightly greater willingness to engage (100% compared to 88% among universities). The strong interest in mentorship (94% among universities and 85.3% among organizations) and knowledge exchange establishes a solid foundation for partnerships.

Universities possess a more pronounced intra-group potential due to established practices of student and faculty exchange. In contrast, organizations exhibit less evident internal collaboration due to the lack of available data on internal interactions. However, their willingness to engage in external partnerships could serve as a catalyst for fostering internal networks within the group.

There is considerable potential for collaboration between universities and organizations. Organizations can enhance the scientific and practical components of education (e.g., internships, research), while universities can provide the educational foundation and mobility opportunities. The minor differences in high levels of readiness (e.g., 88% for mobility and internships among universities versus 70.6% among organizations) indicate opportunities for integration and the development of cooperation through mobility and internship programs.

A comparative analysis of the data highlights that opportunities lie in joint research initiatives, educational programs, and student training. To fully realize this potential, it is essential to address uncertainties among organizations and synchronize efforts between both groups through clear cooperation mechanisms.

Chapter 4. Systemic Issues, Needs, and Challenges

This chapter presents an analysis of systemic issues, university resources, the skills of recent graduates, and the connection with practice through the lens of three different respondent groups: representatives of organizations and practitioners in the field of cryosphere research and monitoring, university representatives, and recent graduates.

4.1 Key findings

The analysis of responses from the three respondent groups—representatives of organizations and practitioners, university representatives, and recent graduates—reveals both common trends and significant differences in the perception of systemic issues, university potential, graduate skills, and the link between education and practice in the context of preparing specialists for cryosphere research and monitoring. These findings help identify priorities for strengthening higher education and improving staff qualifications in this field.

In the section on systemic issues, all groups agree on the significance of insufficient governmental support for specialists and education, which is perceived as a key barrier affecting the attractiveness of the profession and the quality of workforce training. The low interest of youth in studying and working in the cryosphere field is also recognized by all respondents as a general trend, reflecting difficulties in attracting a new generation to the sector. However, differences emerge in emphasis: practitioners and graduates more often highlight the impact of the overall low level of science and research, whereas university representatives tend to focus more on language barriers, especially the insufficient level of English proficiency. Issues related to critical thinking and communication skills are mentioned less frequently and perceived as less pressing, especially by graduates, which may indicate a lack of awareness about the importance of these competencies for professional activity.

The assessment of university potential reveals a significant gap between the expectations of practitioners and the internal perception of universities. Organizations and practitioners unanimously note the substantial impact of outdated teaching modules, low technical capacity, and the absence of specialized institutions on the quality of graduate training, which directly affects their work. Graduates generally support this position, particularly emphasizing the lack of specialized institutions and outdated curricula, although their assessments are less categorical, possibly due to limited experience. At the same time, university representatives exhibit greater restraint: they acknowledge the problem of the lack of specialized institutes but are less likely to agree with shortcomings in technical equipment or faculty qualifications, which may indicate a lack of feedback from the labor market or an overestimation of their own resources.

Regarding the skills of recent graduates, practitioners identify weak proficiency in modern software as the most critical gap, highlighting its direct impact on work efficiency. The lack of basic knowledge about the cryosphere and technical skills is also seen as important, though less acute. Graduates largely share this concern, particularly regarding software, which points to gaps in practical training during their studies. University representatives show moderate agreement with these issues; however, their assessments are more balanced, and the high level of uncertainty in their responses may suggest insufficient awareness of the real needs of graduates in the workplace.

The connection between education and practice remains one of the most problematic areas. Practitioners emphasize a systemic gap between university training and market requirements, especially pointing to weak practical skills among graduates and the absence of professional standards in the cryosphere field. Graduates are generally in agreement, particularly stressing the mismatch between curricula and current professional tasks, as well as weak coordination between universities and employers. Universities acknowledge the lack of practical orientation and communication with employers but are less likely to agree with the irrelevance of programs, which may reflect either confidence in the current curriculum or a limited understanding of market expectations.

Summarizing the trends, it can be noted that all respondent groups agree on the recognition of systemic barriers related to insufficient support and the weak practical orientation of education. However, differences in the perception of specific issues point to a gap between labor market expectations and the capabilities of the educational system. Practitioners tend to assess the situation more critically, focusing on the direct impact of training deficiencies on their work, while universities display greater uncertainty and perceive some gaps less acutely. Graduates occupy an intermediate position, confirming many problems but with less certainty about their scale, which may be due to limited professional experience.

4.2 Systemic issues

The following were included in the survey as systemic issues:

- Low interest of youth in studying and working in the field of the cryosphere
- Insufficient governmental support for specialists and education related to the cryosphere (low salaries, limited social benefits)
- Overall low level of science and research
- Inadequate level of English language proficiency
- Low level of critical and analytical thinking skills
- Weak teamwork and communication skills.

Among the three respondent groups, two (university representatives and recent graduates) were asked to indicate their level of agreement or disagreement with the impact of these issues on the successful management of the cryosphere. Meanwhile, the group of respondents representing organizations and practitioners in the field of cryosphere research and monitoring were asked to assess the extent to which these issues affect their work.

Representatives of organizations and practitioners

The majority of respondents in this group (on average 70–80% across all items) indicated that the listed issues have at least a moderate impact on their work. This suggests that systemic issues in the cryosphere sector are perceived as significant and require attention. Some problems are reported to have a more pronounced “strong impact,” while others are more frequently evaluated as having a “moderate impact.”

Systemic issues identified as having a strong impact by representatives of organizations and practitioners (Figure 30):

- **Insufficient governmental support for specialists and education** (15 out of 34 respondents indicated “strong impact”),
- **Low interest of youth in studying and working in the field of the cryosphere** (11 out of 34),
- **Inadequate level of English proficiency** (10 out of 34).

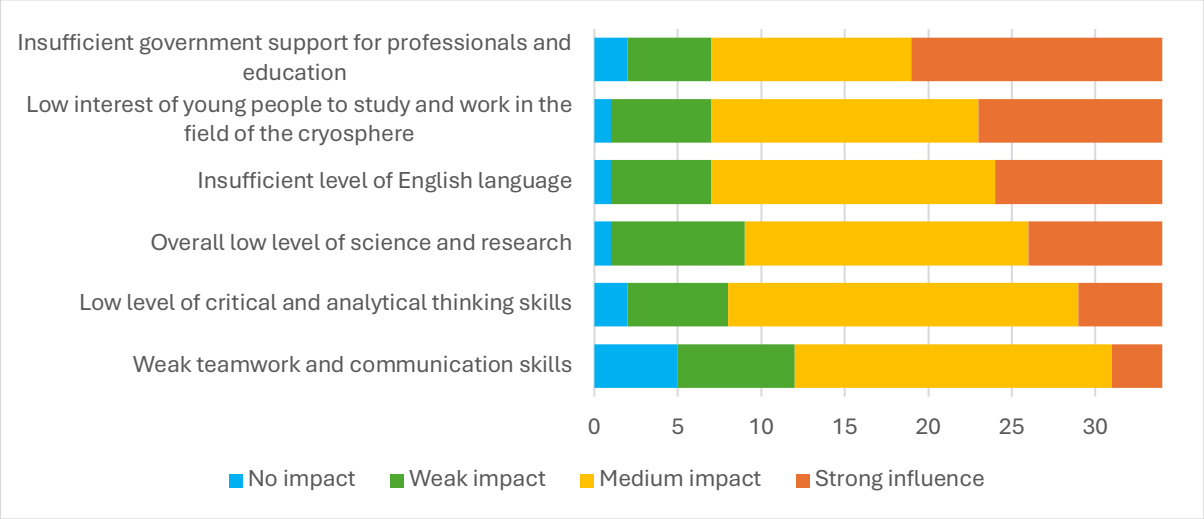


Figure 30. Evaluation of systemic challenges in cryosphere research and monitoring by organizations and practitioners.

University representatives

We surveyed representatives of universities in Central Asian countries, asking them to indicate their level of agreement or disagreement with systemic issues that hinder the successful management of the cryosphere. Based on the collected data, conclusions can be drawn regarding their perception of such issues (Figure 31).

The most significant systemic issues according to university representatives:

- **Insufficient governmental support** – with the highest level of agreement (76.5%) and a high number of “Strongly agree” responses (8), this issue is identified as the most critical.
- **Low interest of youth** – 70.6% agreement indicates challenges in attracting the younger generation to the field of cryosphere research.
- **Inadequate level of English proficiency** – 64.7% acknowledge this issue, underscoring the need to improve language training for better integration into the global scientific community.

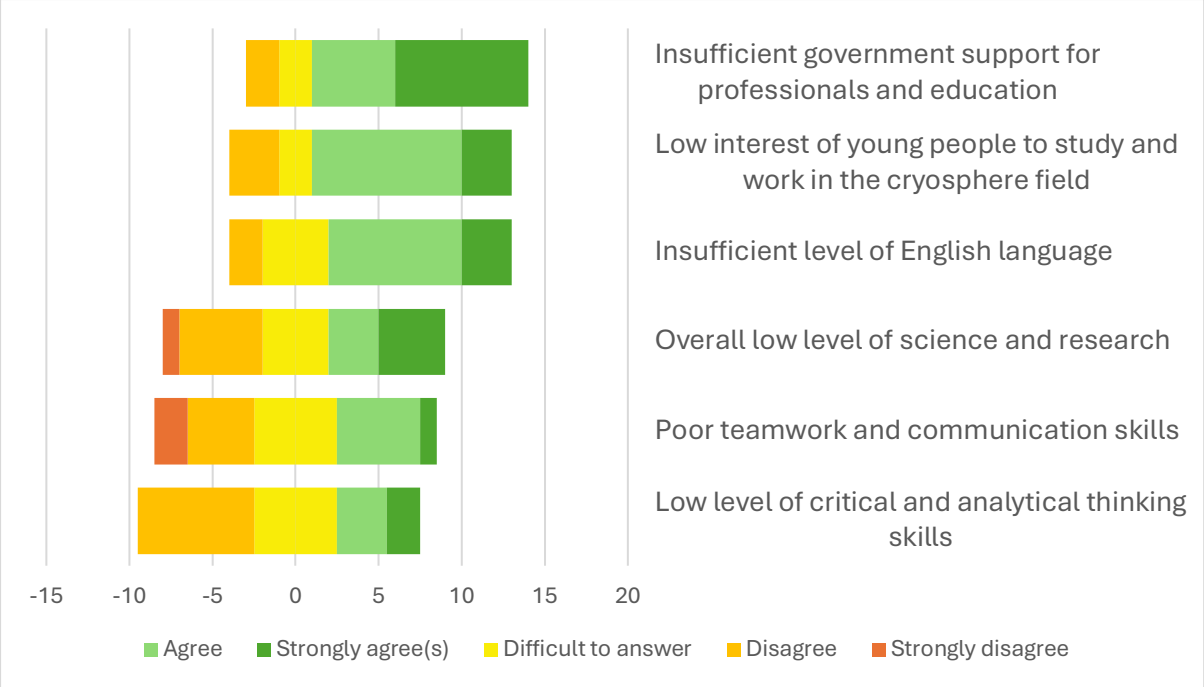


Figure 31. Perception of systemic issues hindering effective cryosphere management by university representatives

Recent graduates

We surveyed recent graduates of universities in Central Asian countries whose academic programs included disciplines related to the cryosphere, and who are currently working in the fields of cryosphere and water resources. Respondents were asked to indicate their level of agreement or disagreement with systemic issues hindering the effective management of the cryosphere (Figure 32). It is important to note that not all respondents had technical backgrounds, and not all are directly employed in cryosphere research and monitoring; many work in broader areas related to water resource management. Thus, caution is advised in interpreting the data.

The following issues were identified by recent graduates as the most significant in hindering the successful management of the cryosphere:

- **Insufficient governmental support** – the most unanimously acknowledged issue (75% agreement, 0% disagreement). Low salaries and weak institutional support are clearly felt by graduates regardless of their field of work.
- **Overall low level of science and research** – tied with government support, 75% consider the level of scientific research to be inadequate.
- **Inadequate level of English proficiency** – 58.3% view English language skills as an issue, though a high proportion of "Unsure" responses (33.3%) may reflect varying language demands between technical and managerial roles.

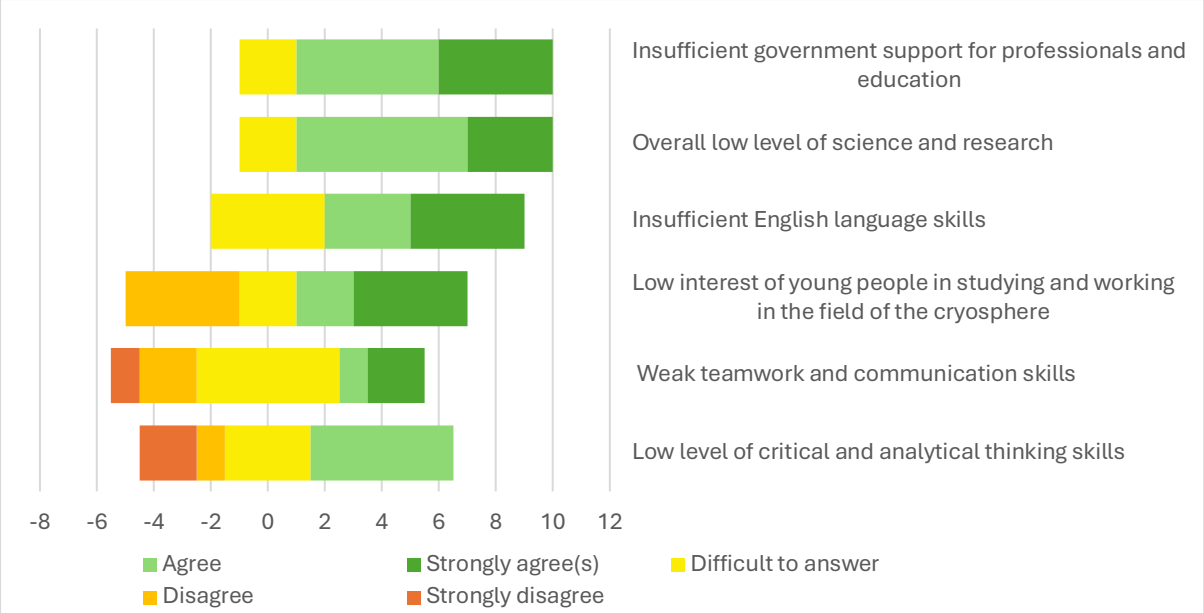


Figure 32. Perception of systemic issues hindering effective cryosphere management by recent graduates

4.3 University potential

To assess the potential of universities, we asked two groups of respondents (university representatives and recent graduates) to express their agreement or disagreement with the following statements related to the successful management of the cryosphere:

- Outdated academic modules
- Low technical capacity of universities
- Low qualification of academic staff
- Absence of a specialized institute in the field of cryosphere

In addition, the group of respondents representing organizations and practitioners in the field of research and monitoring was asked to assess the extent to which these issues affect their work.

Representatives of organizations and practitioners

Respondents from this group consider almost all of the listed statements to have a significant impact. Between 73.5% and 85.3% of respondents believe that each of the problems exerts either a moderate or strong influence on their work.

The most critical issues according to representatives of organizations and practitioners are as follows:

- **Outdated modules and low technical capacity** lead in terms of overall "Significant impact" (85.3%), highlighting their broad effect on the work of organizations (Figure 33).
- **The absence of a specialized institute* and the low qualification of academic staff** stand out in terms of "Strong impact" responses (15 out of 34). Practitioners clearly feel the lack of specialized training.

*In this context, a specialized institute refers to an institution that provides targeted training for specialists in the field of cryosphere research and monitoring.

The high percentage of “Strong impact” (41.2–44.1%) across all items indicates that these problems directly affect the ability of graduates to meet the requirements of organizations engaged in cryosphere research and monitoring.

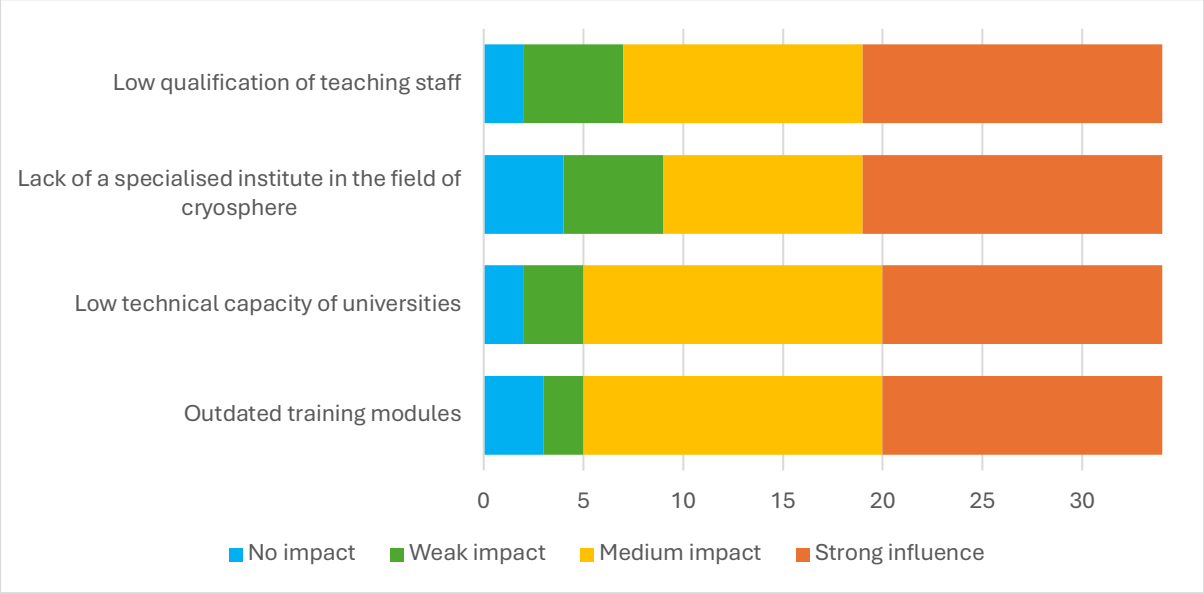


Figure 33. Assessment of university resources by organizations and practitioners

Representatives of universities

Statements ranked by level of agreement according to university faculty (Figure 34):

- **Lack of a specialized institute in the field of the cryosphere** (8/17). Agreement at 47.1% and a low level of disagreement (17.6%) indicate that university representatives view the lack of specialized institutions as a key barrier to training personnel in the field of the cryosphere.
- **Low technical capacity of universities** (7/17). 41.2% agreement versus 23.5% disagreement shows that the absence of modern equipment is perceived as a significant issue, although a third of respondents (35.3%) remain undecided.
- **Outdated training modules** (5/17) and **Low qualification of academic staff** (5/17). Both issues have a low level of agreement (29.4%), with the qualification of faculty more often being disagreed with (35.3%).

The share of “Not sure” responses ranges from 35.3% to 47.1%, which is higher than in other groups (e.g., practitioners). This may reflect a lack of objective information and requires further clarification.

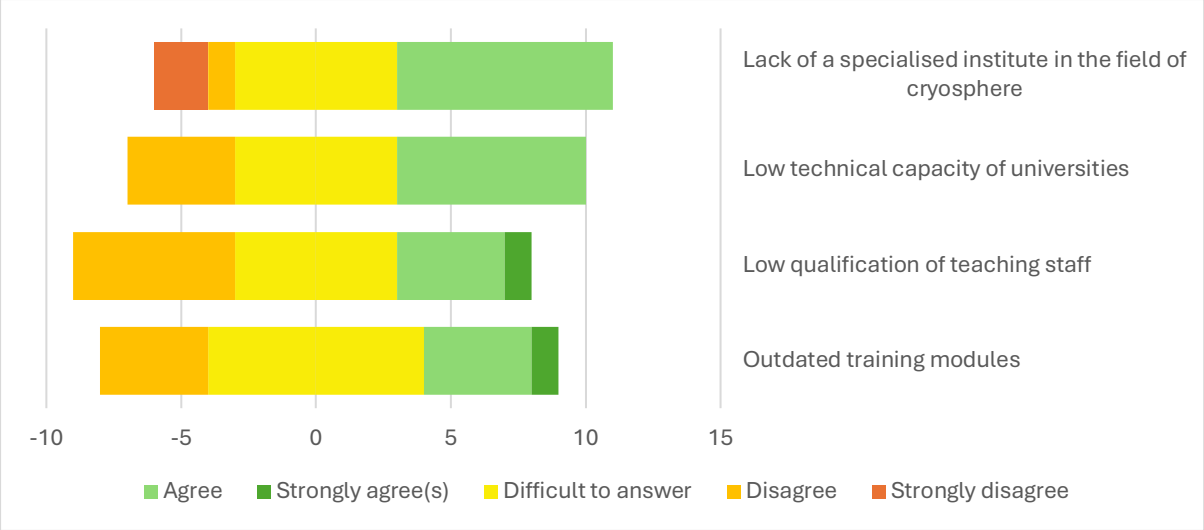


Figure 34. Perception of university resource issues by university representatives

Recent graduates

Statements ranked by level of agreement according to recent graduates (Figure 35):

- **Lack of a specialized institute in the field of the cryosphere** (7/11). Agreement at 63.6% and a low level of disagreement (9.1%) indicate that graduates consider the lack of specialized institutions a key barrier to training in the field of the cryosphere.
- **Outdated training modules** (6/11). 54.5% acknowledge the problem, pointing to dissatisfaction with the content of the programs, which likely do not meet the current requirements of their work.
- **Low technical capacity of universities (4**/11). Only 36.4% agree with the statement on low technical capacity, while a high share of "Not sure" responses (45.5%) may be due to the fact that not all respondents graduated from technical programs and were therefore unable to provide an objective assessment.
- **Low qualification of academic staff (2**/11). Only 18.2% agree, while 27.3% disagree, and 54.5% are uncertain. This may also be linked to the limited representativeness of the respondent sample for evaluating technical disciplines in universities.

The share of "Not sure" responses ranges from 27.3% to 54.5%, particularly high for the items on faculty qualifications and technical capacity. This may reflect a lack of objective information and requires clarification.

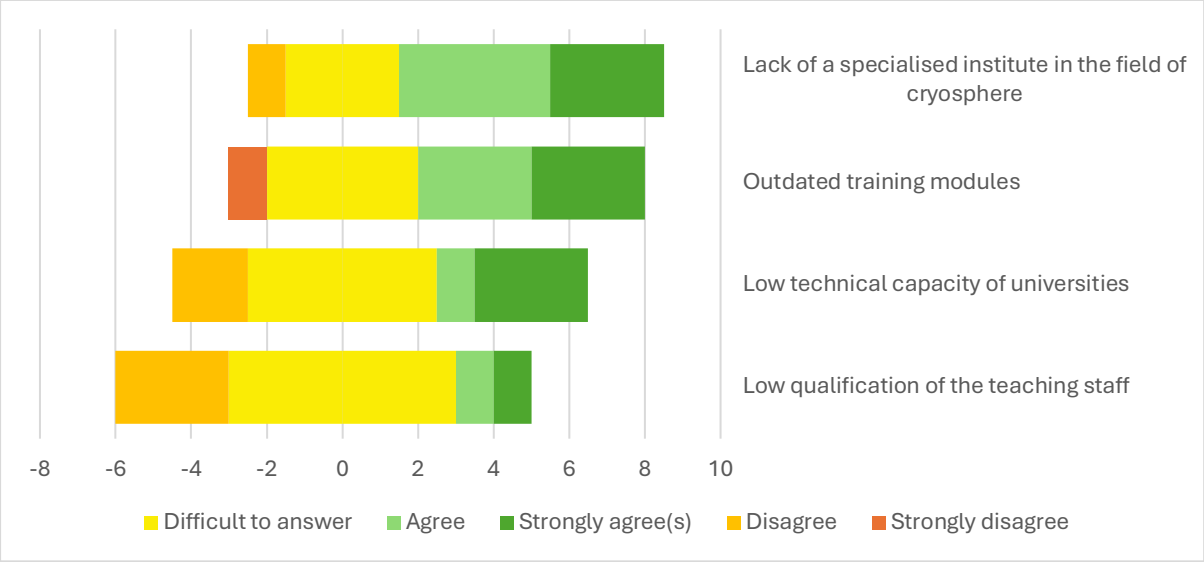


Figure 35. Perception of university resource issues by recent graduates

4.4 Skills of recent graduates

To assess the skills of recent graduates, we asked two respondent groups (university representatives and recent graduates) to express their agreement or disagreement with the following statements related to the effective management of the cryosphere:

- Poor knowledge of modern software (e.g., for modeling, database management, etc.);
- Weak technical knowledge and skills;
- Insufficient knowledge of key concepts related to the cryosphere.

The group of respondents representing organizations and practitioners in the field of cryosphere research and monitoring was asked to assess the degree of impact of these issues on their work.

Representatives of organizations and practitioners

Between 85.3% and 91.2% of respondents consider each issue on the list to have a moderate or strong impact. The ranking of problems by level of impact according to representatives of organizations and practitioners is as follows (Figure 36):

- **Poor knowledge of modern software.** The vast majority (91.2% – Moderate + Strong impact) consider poor software skills to be a significant issue, with 16 out of 34 respondents (47.1%) rating the impact as strong — the highest "Strong Impact" rate among the listed problems.
- **Insufficient knowledge of key concepts related to the cryosphere.** 85.3% consider the lack of basic cryosphere knowledge a significant issue, with 41.2% identifying it as having a strong impact. This underscores the importance of fundamental knowledge among graduates needed for carrying out practical tasks.
- **Weak technical knowledge and skills.** 85.3% see weak technical competence as a problem, with 29.4% indicating a strong impact.

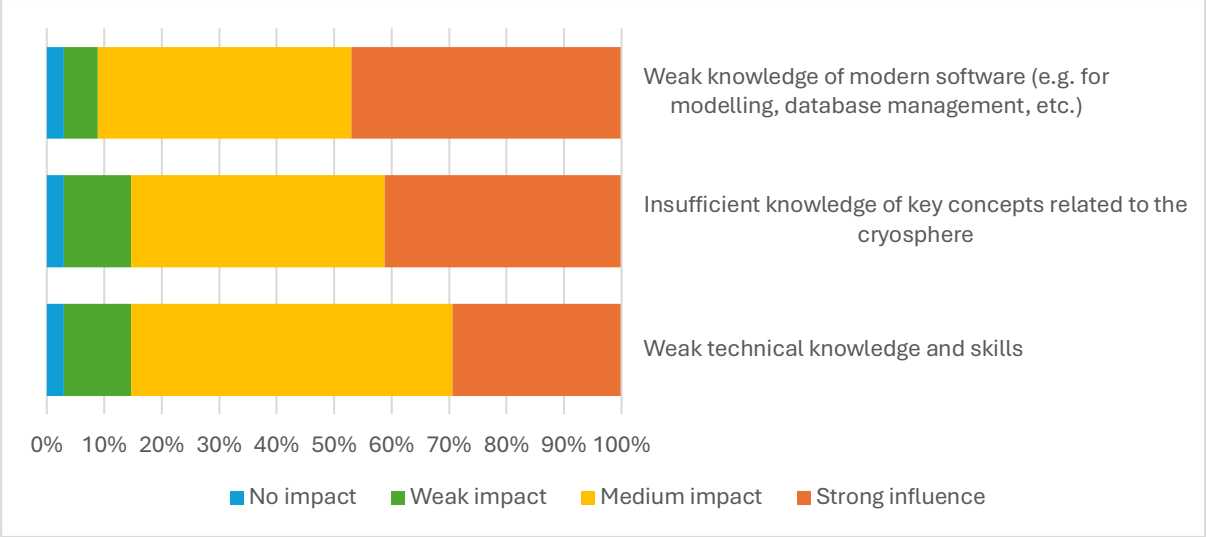


Figure 36. Perceived problems related to graduate skills by organizations and practitioners

University representatives

The ranking of issues by level of agreement according to university faculty (Figure 37):

- **Poor knowledge of modern software (10/17).** Agreement at 58.8% indicates that universities acknowledge weak preparation of graduates in terms of modern software skills, which may be linked to insufficient emphasis on practical tools.
- **Weak technical knowledge and skills (9/17).** 52.9% agreement combined with high uncertainty (29.4%) suggests that technical preparation is perceived as problematic, though not uniformly so.
- **Insufficient knowledge of key concepts related to the cryosphere (8/17).** 47.1% agreement versus 35.3% disagreement indicates divided opinions. Universities may consider the theoretical foundation sufficient, although this view is not universally shared.

The share of “Unsure” responses ranges from 17.6% to 29.4%, which is lower than in some other surveys, yet still reflects a lack of full confidence in evaluating graduate skills.

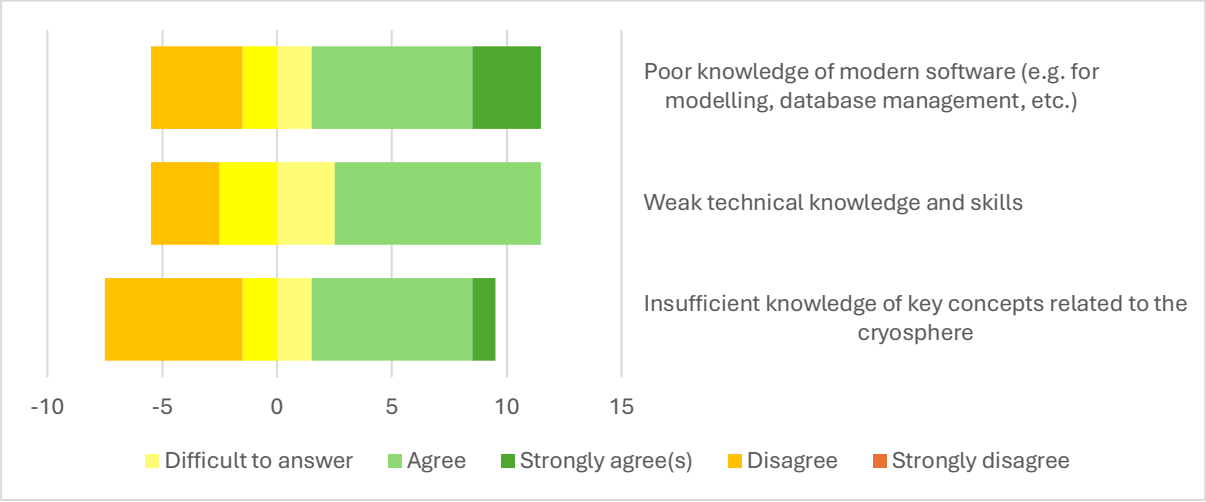


Figure 37. Perceived problems related to graduate skills by organizations and practitioners

Recent graduates

Statements ranked by level of agreement according to recent graduates (Figure 38):

- **Poor knowledge of modern software (7/11).** Agreement at 63.6% indicates that graduates most frequently perceive a lack of skills in using modern software, likely due to insufficient practical training at universities.
- **Weak technical knowledge and skills, as well as insufficient understanding of key concepts related to the cryosphere (6/11).** Both issues have a 54.5% agreement rate, indicating moderate but significant dissatisfaction with their own preparation in these areas. This may reflect gaps in both the practical and theoretical components of training.

Only 9.1% disagreed with the existence of these problems, which indicates an almost unanimous recognition of shortcomings in their education among those who provided an opinion. At the same time, the share of "Unsure" responses ranges from 27.3% to 36.4%, especially high for technical skills and cryospheric concepts. This may be due to limited work experience and the low representativeness of the respondent sample for assessing their own technical competencies, which warrants further clarification.

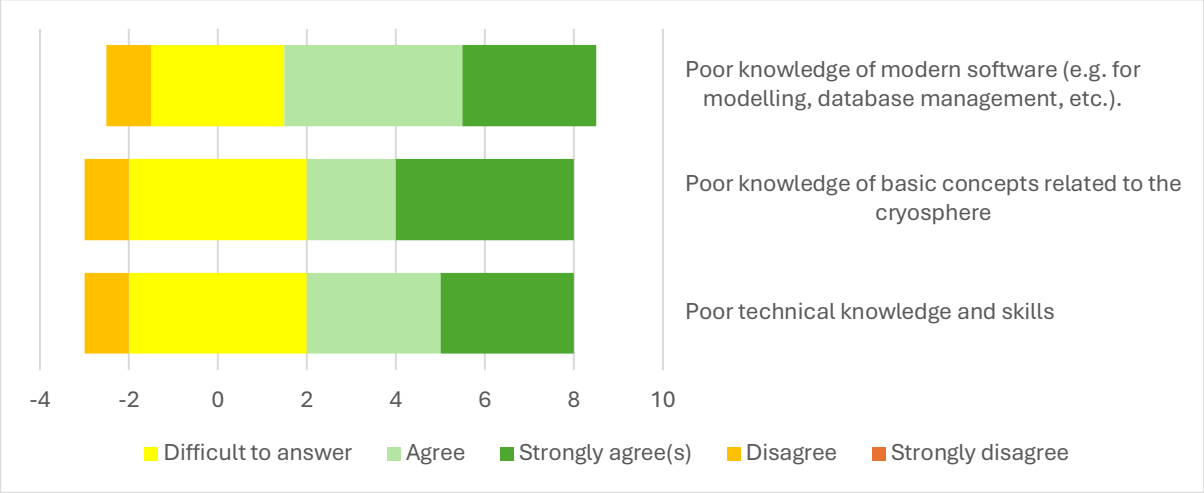


Figure 38. Self-assessment of skill-related problems by recent graduates

4.5 Connection with practice

To assess the connection between education and practice, we asked two respondent groups (university representatives and recent graduates) to express their agreement or disagreement with the following statements that may influence effective cryosphere management:

- Weak practical work skills;
- Weak coordination and communication between educational institutions and employers;
- Mismatch between academic programmes and labour market needs;
- Absence of professional and educational standards in the field of cryosphere.

The group of respondents representing organisations and practitioners in the field of cryosphere research and monitoring was asked to assess the degree to which these problems affect their work.

Representatives of organizations and practitioners

Between 79.4% and 85.3% of respondents consider each of the listed issues to have at least a moderate or strong impact. This indicates a systemic gap between university preparation and practical needs. The ranking of issues by impact level according to representatives of organisations and practitioners is presented in Figure 39.

- 85.3% consider **weak practical skills** a significant problem, with 13 out of 34 (38.2%) rating the impact as strong. This indicates that graduates' lack of preparedness for real-world work substantially hinders the work of organisations.
- 82.4% identify the **absence of professional** and **educational standards in the field of cryosphere** as a problem, with 38.2% reporting a strong impact—on par with practical skills. This suggests that the lack of regulated requirements for training has a serious effect on operations.
- 82.4% see a problem in **weak coordination** and **communication between educational institutions and employers**, with 32.4% indicating a strong impact. This highlights a gap between university training and labour market needs, which hinders the adaptation of curricula to the needs of practitioners.
- 79.4% believe **academic programmes do not correspond to labour market needs**, with 26.5% indicating a strong impact. While this is the least critical issue in terms of "strong impact," it is still significant for the majority.

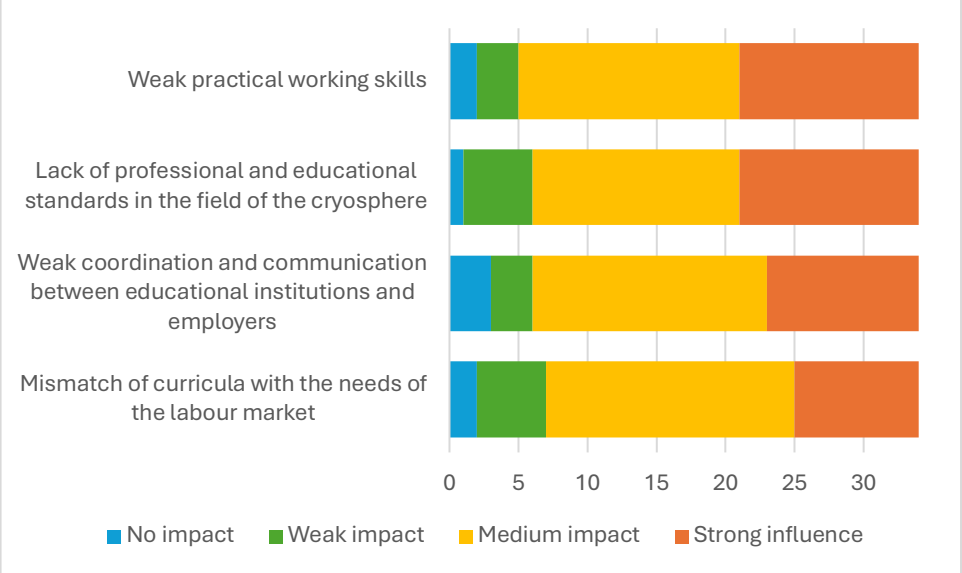


Figure 39. Evaluation of the education-practice link by organizations and practitioners.

University representatives

In this respondent group's answers regarding the "connection with practice," the proportion of "Not sure" responses ranges from 17.6% to 41.2%, with the highest uncertainty related to programmes and standards. Taking this into account, the statements are ranked by level of agreement as follows (Figure 40):

- The highest level of agreement (64.7%) is with the statement about **weak coordination and communication between educational institutions and employers,** with moderate

disagreement (17.6%). This suggests that universities largely acknowledge weak employer engagement as a barrier.

- More than half (58.8%) of university representatives recognise **weak practical skills among graduates** as a problem, with minimal disagreement (11.8%). This indicates an awareness of the lack of practical training, although one-third of respondents were undecided.
- 41.2% see the **lack of professional and educational standards in the cryosphere** field as a problem, while an equal share were unsure. This reflects moderate recognition of the issue, but with uncertainty about its significance.
- Only 23.5% agree that **academic programmes do not meet labour market needs**, while 35.3% disagree and 41.2% are uncertain. This is the least acknowledged problem among this respondent group, which may reflect either confidence in current curricula or a lack of feedback from the labour market.

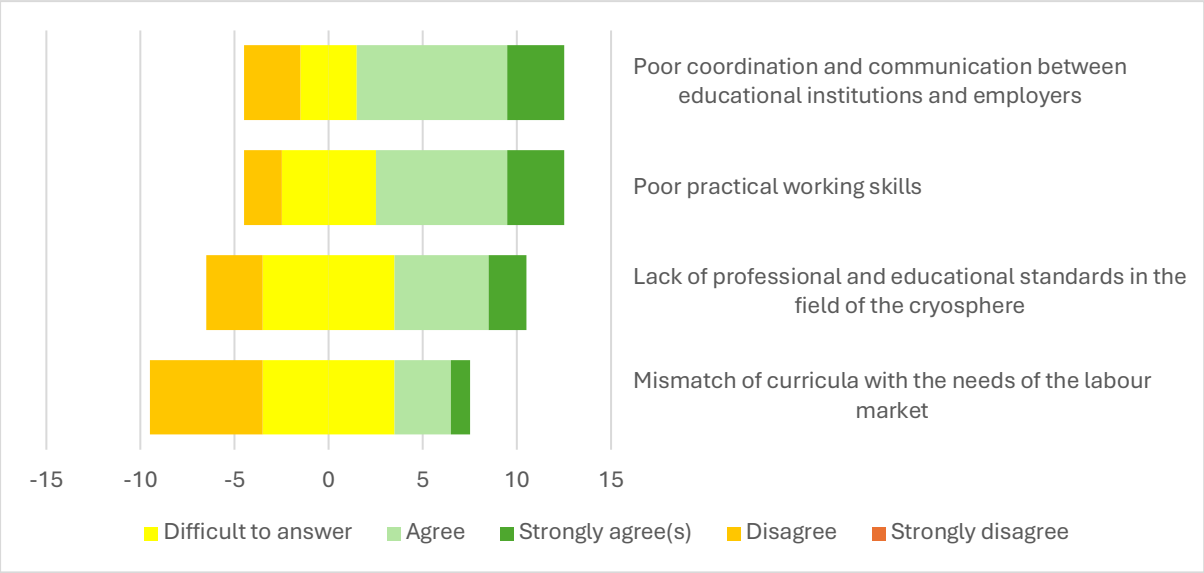


Figure 40. Perception of education-practice linkage issues by universities

Recent graduates

Disagreement with the listed issues is almost absent among this group of respondents (0–9.1%), which highlights a general acknowledgment of the problems among those who provided their opinion. Below is a ranked list of issues based on the level of agreement among recent graduates (Figure 41):

- 63.6% fully agree **that academic programmes do not meet labour market needs**, with no respondents disagreeing. This underscores dissatisfaction with the relevance of education, although one-third were unsure. At the same time, this issue received the highest number of "strongly agree" responses.
- The highest overall agreement (total "strongly agree" + "agree" responses) — 72.7% — was regarding the issue of **weak coordination and communication between educational institutions and employers**. The absence of disagreement indicates that graduates unanimously perceive weak university–employer engagement as a significant barrier.

- More than half (54.5%) of graduates acknowledge **weak practical skills** as a problem, with minimal disagreement (9.1%). A high degree of uncertainty (36.4%) may indicate differences in experience or expectations of training. This may also be due to the low representativeness of the respondent sample in evaluating practical skills, which requires clarification.
- Only 36.4% agree that the **absence of professional and educational standards in the cryosphere field** is a problem, with high uncertainty (54.5%). This is the least acknowledged issue, possibly due to limited experience or understanding of standards, which may also be related to the limited representativeness of the sample.

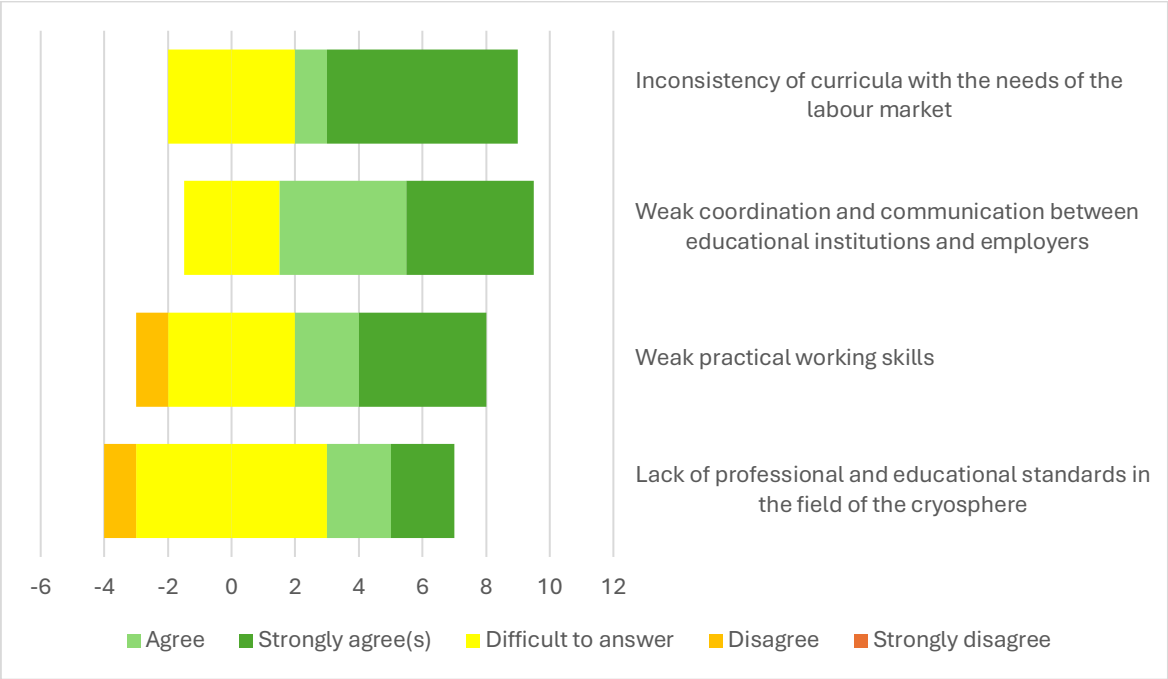


Figure 41. Perception of education-practice linkage issues by recent graduates

Chapter 5. Recommendation

To strengthen higher education in the field of the cryosphere, it is proposed to focus efforts on two key areas: the modernization of educational programmes and the creation of regional specialized institutions or programmes. These areas are complemented by measures to enhance cooperation between universities and employers, the development of professional standards, and support for internship programmes. The main directions and recommendations are presented below.

Direction 1: Modernizing curricula with a focus on practical skills and modern tools

Recommendation 1.1: Development of a module on core cryosphere concepts for bachelor's level

Develop and implement a mandatory module on cryosphere fundamentals at the undergraduate level in all relevant university programmes to increase students' understanding of key cryosphere-related concepts. Introducing this module at the undergraduate level will lay the foundation for further learning and practical training, making cryosphere knowledge accessible to all students in related fields. The module may include a theoretical component—basic cryosphere concepts (glaciology, permafrost studies, climatology), its role in the climate system, and research methods—as well as a practical component, such as working with open data (e.g., satellite imagery), basic field data collection, and processing skills.

Recommendation 1.2: Development of professional training standards

Create an online resource for universities and organizations to access educational programmes, best practices (e.g., in software use), and data. Hold regular forums to synchronize educational processes. Ongoing dialogue is needed to keep curricula up to date and strengthen coordination between training and labour market needs.

Recommendation 1.3: Creation of a regional specialization in cryosphere through inter-university collaboration and cooperation with applied organizations

Establish regional educational standards based on the list of disciplines (see Chapter 2.4), and include certification based on practical modules (e.g., Python proficiency or glaciological survey skills).

> ***High priority:*** glaciology, GIS, meteorology, data collection and processing—compulsory modules with practical components (fieldwork, data analysis).
> ***Medium priority***: geophysics, programming, permafrost studies—additional modules based on regional needs.

Recommendation 1.4: Creation of a regional cryosphere specialisation based on inter-university collaboration and engagement with practical organizations

Develop and implement a regional master's degree in cryosphere studies, combining the resources of Central Asian universities at both regional and national levels, as well as practical organizations, with the potential to establish a professional development centre within a specialized institution.

Regional universities should join efforts to design a shared curriculum based on professional training standards and engage research institutes and hydrometeorological services to provide internship opportunities, conduct workshops, and teach modern cryosphere monitoring methods.

Direction 2: Establishment of a regional specialized institute or program for capacity building

Recommendation 2.1: Establishment of a professional development center for specialists

Create a regional centre offering short-term courses for professionals and master's students in software (Python, GIS), technical skills (sensor and drone operation), and field methods (glaciology, snow surveying). The centre should help bridge the gap between university education and practice.

Recommendation 2.2: Support for internship programs at national and regional levels

Develop internship programmes within relevant institutions (hydrometeorological services, research institutes) focused on the cryosphere through student and specialist exchanges across Central Asian countries, supported by international partners.

Conclusion

Strengthening higher education in the field of the cryosphere requires a comprehensive, integrated approach that combines curriculum modernization with the creation of specialized regional institutions or programs. The proposed measures aim to address existing gaps in the training of specialists. Implementation of these recommendations will only be possible through close collaboration among universities, research institutes, hydrometeorological services, and government bodies. Only through joint efforts can highly qualified personnel be trained to effectively address cryosphere research and monitoring, which is especially important for the sustainable development of Central Asia under climate change conditions.