GREENDT

D2.1. SURVEY AND SWOT ANALYSIS REPORT

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This project has received funding from the European Union under grant agreement No GA 101179013. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

Co-funded by the European Union

EXECUTIVE SUMMARY

This report analyzes the key environmental challenges emerging in the context of Uzbekistan's rapidly developing industrial sector—specifically, air, water, and soil pollution, as well as issues related to waste management. Within the framework of the European Union's Erasmus+ programme, the GREENDT project aims to address these challenges by enhancing master's-level education in environmental engineering and developing practical, science-based solutions. The report evaluates the current state of the education system through a SWOT analysis and offers targeted recommendations to strengthen international integration, promote hands-on learning, and foster closer collaboration between academia and industry.

Deliverable ID	D2.1. Survey and SWOT analysis report
WP number	WP2
Lead Partner	JizPI
Due date	[M6]
Date of submission	[M6]
Type of deliverable	R
Dissemination level	PU

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REVISION HISTORY

Version	Date	Author	Document history/approvals
0.1	20.05.2025	J.Abdunazarov, U.Rahmatov, M.Tirkasheva Kh.Kiryigitov G.Khudayberdiyeva	First version sent for interval review.
0.2	25.05.2025	J.Abdunazarov, U.Rahmatov, M.Tirkasheva Kh.Kiryigitov G.Khudayberdiyeva	Changes implemented based on IPVS and KIUT's feedback.
1.0	28.05.2025	J.Abdunazarov, U.Rahmatov, M.Tirkasheva Kh.Kiryigitov G.Khudayberdiyeva	Document submitted.

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1. Introduction

This section analyzes the environmental problems arising as a result of the development of Uzbekistan's industry. At the same time, the role of the higher education system in terms of environmental protection and sustainable development is highlighted. The general context of the report and the scientific and practical foundations of the GREENDT project are revealed.

1.1. Purpose and Significance of the Report

This section sets out the main objectives of the report - assessment of the educational potential in environmental engineering in Uzbekistan, identification of existing problems, and the need to form master's programs based on them. It also indicates the practical and strategic significance of the report and the expected benefits for stakeholders.

1.2. Rationale for the Study in the Context of the GREENDT Project

The section analyzes the goals and objectives of the GREENDT (101179013) project. The necessity of adapting the European Union's experience in green transformation to the conditions of Uzbekistan is substantiated. In addition, the role of scientific research, surveys, and SWOT analysis in this project, as well as the expected results from them, will be highlighted.

1.3. Main Environmental Issues and Priority Directions of Uzbekistan:

Main Problems:

Water Scarcity and the Aral Sea Crisis: The irrational use of water resources has led to the drying up of the Aral Sea, resulting in severe ecological consequences;

Drought and Desertification: Uzbekistan is facing worsening drought conditions due to climate change, which contributes to desertification and negatively impacts agriculture;

Rising Temperatures: Climate change causes an increase in temperatures, altered precipitation patterns, heatwaves, and higher evaporation rates, all of which put additional stress on water resources;

Loss of Biodiversity: Environmental degradation leads to a decline in biodiversity, including habitat loss, pollution, and overexploitation, all adversely affecting various species;

Industrial Activity, Agriculture, and Poor Waste Management: Insufficient control over industrial operations, agricultural practices, and waste disposal causes air pollution, posing significant risks to human health.

Soil Degradation and Salinization: This is a particularly serious problem in the regions of Karakalpakstan and Bukhara.

Air Pollution: The levels of air pollutants such as SO_2 and NOx released by the chemical, oil and gas, and energy industries remain high. The continued use of outdated technologies has resulted in an increase in the emission of harmful gases into the atmosphere. Additionally, in the capital city, Tashkent, air pollution is regularly observed during the summer months. This phenomenon is usually caused by thermal inversion events, which trap pollutants close to the ground, leading to a deterioration in air quality.

1.3.1. The Adverse Environmental Impact of Industrial Activities

Emissions of pollutants into the atmosphere from stationary sources. Although the development of Uzbekistan's industry is important for the economy, its impact on the environment is also of great importance. According to 2022 data, the total volume of pollutants released into the atmosphere in our country amounted to **874 thousand tons**. A significant portion of this pollution

comes from key industries such as oil and gas, energy, metallurgy, and construction. The following table shows the share of Uzbekistan's industrial sectors in atmospheric pollution for 2022, which is an important source in shaping environmental protection and sustainable development strategies.

Table 1 Amount of industrial waste

№	Sectors	Percent (%)	Atmospheric pollution (thousand tons)
1	Oil and gas	40,0	360,5
2	Energy	22,8	200,0
3	Metallurgy	21,2	185,5
4	Construction	2,8	25,0
5	Other networks	11,7	103,0
	Total	**100**	**874.0**

The following graph shows the contribution of Uzbekistan's industrial sectors to air pollution in 2022. The oil and gas industry stands out as the largest polluting industry, accounting for 40% of total emissions. Metallurgy, construction, and other industries also contribute significantly to air pollution.

These indicators play an important role in assessing the environmental consequences of industrial activity, ensuring environmental safety, and forming a sustainable industrial policy. In particular, these shares serve as the main analytical indicator when analyzing the effectiveness of modern technologies and alternative solutions aimed at reducing the volume of waste.

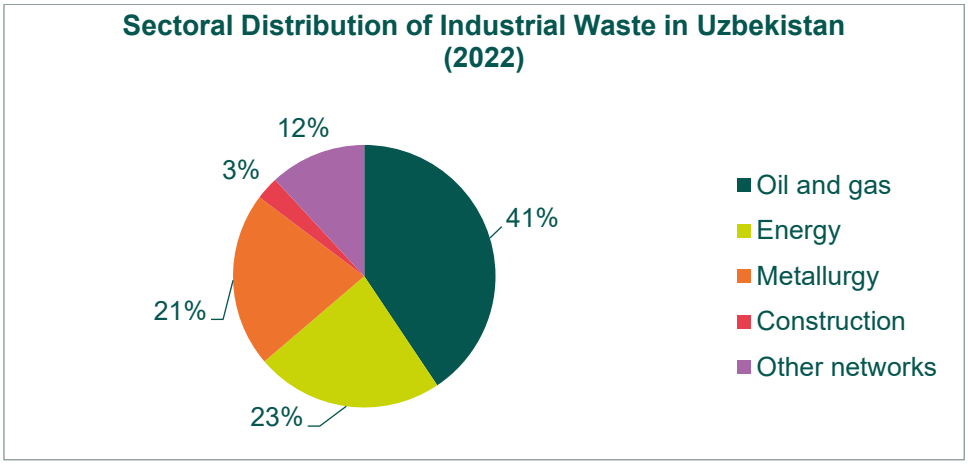

Figure 1. Sectoral Distribution of Industrial Waste in Uzbekistan (2022)

Thermal power plants (TPPs) and cement manufacturing enterprises have the greatest impact on the volume of air pollutants emitted into the atmosphere in Uzbekistan. Currently, there are a total of 12 thermal power plants operating across the country. Among them, the coal-based “Angren” and “Yangi Angren” thermal power plants are of particular significance, as they are recognized as the largest atmospheric polluters in the industrial sector.

In addition, 36 cement manufacturing plants are currently in operation in Uzbekistan, and this industrial sector also plays a significant role in air pollution. Furthermore, there are 15 oil and gas processing facilities and 4 metallurgical plants, all of which have a considerable environmental impact.

In order to reduce the volume of emissions produced by these industrial enterprises and to ensure environmental safety, it is crucial to implement advanced technologies, promote waste recycling, and improve energy efficiency.

Data shows that the amount of pollutants emitted into the atmosphere from stationary sources decreased by 1.1% in 2022 compared to 2018 (Table 1.2). The dynamics of pollutant emissions are directly linked to the development of industrial production in the country, and emission levels are not evenly distributed across different regions. Some enterprises still lack sufficiently effective and appropriate air purification equipment, and many of the existing systems are outdated and have not been upgraded for a long time. Moreover, proper technical maintenance of such equipment is often neglected—for example, timely cleaning or replacement of filters and other necessary services.

To reduce pollutant emissions from industrial enterprises, it is necessary to upgrade and modernize a total of 1,071 filters currently installed in 270 facilities.

Emissions of pollutants into the atmospheric air from mobile sources. Today, there are about 4 million cars in the country, of which 100 thousand are faulty, which leads to an increase in pollutant emissions. They emit an average of 1.3 million tons of harmful substances per year, which is 63% of the total emissions. The largest share of emissions from mobile sources falls on the city of Tashkent (88% of all emissions from mobile sources), Tashkent, Fergana, and Samarkand regions, and the smallest share - on the Syrdarya region. An increase in the number of personal vehicles is observed, which leads to an increase in emissions from vehicles. As a result of the daily increase in the number of vehicles, emissions in 2022 increased by 26.6 thousand tons compared to 2021.

Table 2 Dynamics of pollutant emissions into the atmosphere for 2012-2022 (thousand tons/year)

Years	Pollutants		Pollutants	
	From stationary sources	From portable sources	Carbon monoxide	Nitrogen oxide
2012	817,6	1,181,141	90,7	10,3
2013	855,2	1,253,739	65,5	12,4
2014	1162,1	1,277,315	71,0	13,8
2015	975,1	1,269,633	79,7	14,3
2016	1008,2	1,355,331	79,5	14,3
2017	853,5	1478,0	79,5	14,8
2018	883,7	1521,2	85,9	15,8
2019	952,8	1494,3	81,2	14,7
2020	924,4	1330,7	68,2	13,2
2021	908,7	1270,3	71,0	21,2
2022	874,0	1296,9	-	-

Source: Ministry of Ecology

As a result of the rapid development of industrial sectors in Uzbekistan, a serious degree of air, water, and soil pollution is observed. According to the State Statistics Committee, in 2023, industrial enterprises released a total of **763.2 thousand tons** of pollutants into the atmosphere, which negatively affects environmental sustainability.

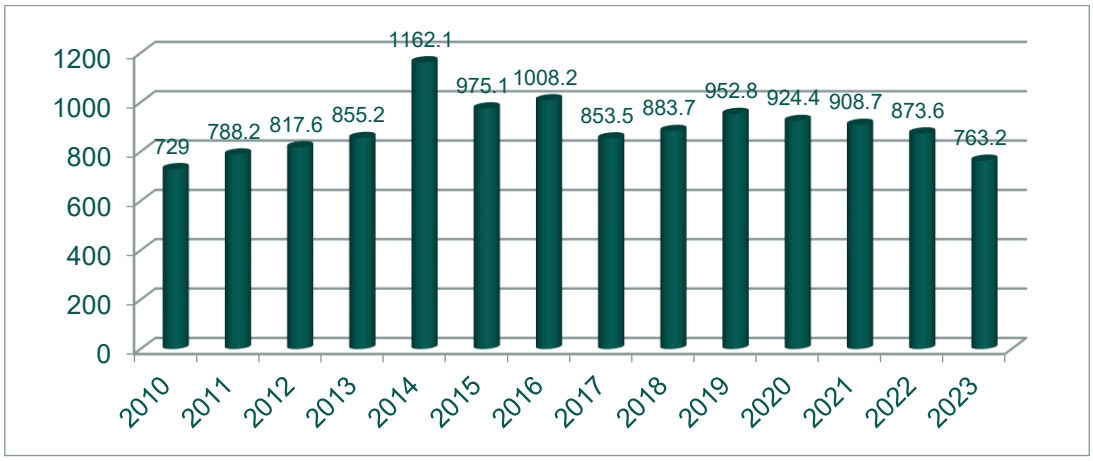

Figure 2. Amount of pollutants emitted into the atmosphere by industrial enterprises of Uzbekistan (thousand tons)

SO_2, NO_x, and other toxic gases are detected at a high level, especially in the chemical, energy, and oil and gas industries. Nitrogen oxide emissions doubled between 2012 and 2021, from 10.3 thousand tons to 21.2 thousand tons. The amount of solid particles (PM) increased from 160.3 thousand tons to 188.6 thousand tons.

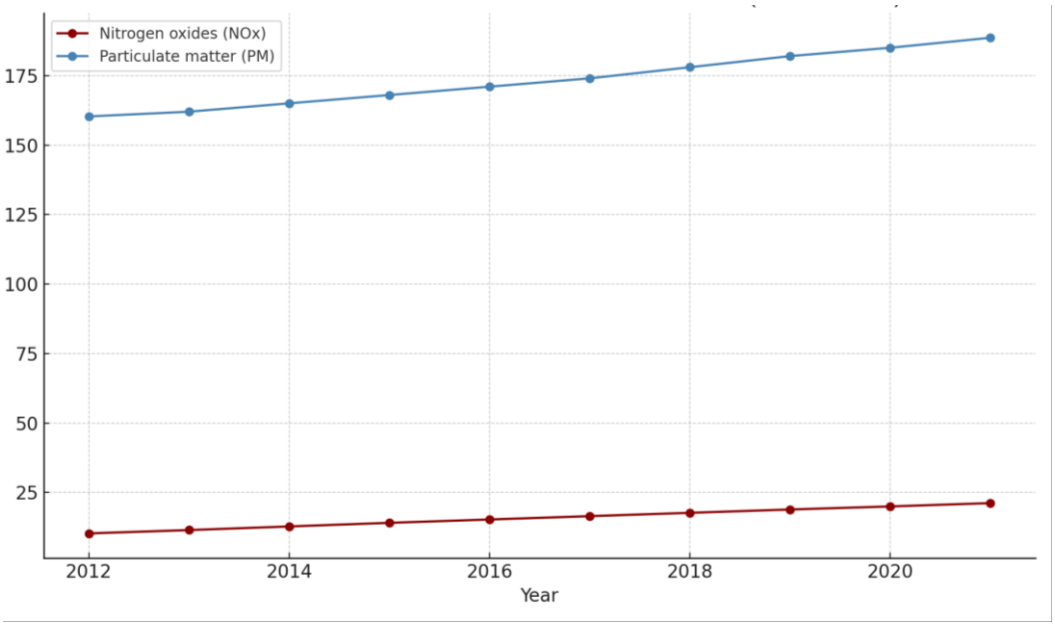

Figure 3. Changes in industrial emissions of nitrogen oxides (NOx) and particulate matter (PM) in Uzbekistan from 2012 to 2021 (in thousand tons)

1.3.2. Barriers to the Implementation of Environmental Engineering in Industry

1. Financial Barriers

• **High Initial Investment Requirements**: Environmentally friendly technologies, waste recycling facilities, and gas purification systems require substantial financial investment.

• **Lack of Government Subsidies**: Many industrial enterprises lack financial support from the state in implementing environmental technologies, which slows down their efforts toward sustainable development and environmental protection.

• **Short-Term Profit Orientation**: Enterprises tend to prioritize short-term economic gains over long-term environmental benefits.

2. Technological Barriers

• **Lack of Modern Technologies**: Many industrial enterprises still operate with outdated technologies.

• **Weakness of Local Technological Solutions**: The domestic market does not adequately supply technologies related to environmental engineering.

• **Shortage of Technical Services and Specialists**: There is a lack of qualified specialists capable of operating and maintaining modern equipment.

3. Organizational and Managerial Barriers

• **Absence of Environmental Management Systems**: Many enterprises do not have dedicated environmental management departments.

• **Insufficient Environmental Responsibility among Management**: The majority of industrial managers do not consider environmental protection a strategic priority, which reduces attention to environmental safety, sustainable production, and the adoption of green technologies.

• **Lack of Inter-Enterprise Information Exchange**: There is no effective system for sharing environmental experiences and best practices among enterprises.

4. Human Resources and Scientific-Educational Barriers

• **Shortage of Specialists**: There is a lack of qualified professionals in the field of environmental engineering within the industrial sector, which hinders the effective implementation of environmental protection and sustainable development projects.

• **Weak Professional Development System**: There are insufficient structured and regular training and retraining programs on environmental technologies for industrial personnel.

• **Weak Link Between Research and Practice**: Scientific research conducted in higher education institutions often does not align with the real needs and challenges of industry, which slows the practical implementation of innovations.

• **Educational Programs Not Aligned with Industry Needs**: University curricula in environmental engineering are not fully adapted to the demands of modern industry. The lack of practical, hands-on approaches and insufficient integration with real production environments hinders graduates from acquiring essential practical skills and competencies.

2. Research Methodology

This chapter outlines the development and implementation of a survey aimed at identifying the needs related to master's education in environmental engineering in Uzbekistan. It also describes the methods used for analyzing the data collected. The methodological approach was developed in line with the objectives of the GREENDT project and enabled a systematic analysis of the perspectives of various stakeholders.

2.1. Survey Design and Structure

The questionnaire was compiled separately for two main groups - **Higher educational institutions (HEIs)** and **industrial enterprises** - in accordance with the main directions of the GREENDT project. Each group consisted of 25 and 10 questions, respectively, covering the following areas:

Table 3. Grouping of Questions Administered at Higher Education Institutions

Direction	Number of questions	Description
Overview	3	Respondents' opinions on environmental problems and the role of social networks were studied.
Legislation in this area	2	The effectiveness of environmental laws and

Direction	Number of questions	Description
		ecological policies was evaluated.
Education	9	The preparedness of students, the state of educational resources, and infrastructure conditions were analyzed.
Industrial integration	6	Scientific research and industrial integration, problems and solutions were studied..
Jobs	5	An analysis was conducted on cooperation with industry and employment opportunities.

Table 4. Grouping of questions asked at enterprises and organizations.

Direction	Number of questions	Description
Condition and needs of enterprises	5	Scope of activity, environmental policy, key challenges and transformation status
Personnel qualifications and necessary skills	2	Requirements for knowledge and practical skills of environmental engineers
Master's degree program	2	Priority areas related to the content of education, disciplines, and practical components.
The Integration of Education and Industry	1	Practical training, workshops, and startup programs in partnership with companies
Innovation and international approaches	(decisive)	Intersection of ISO standards, digital technologies, and modern solutions.

2.2. Participant selection and statistical data

In the survey, the selection of participants was carried out using the method of targeted sampling. A total of 1907 respondents participated, including:

- **1,834 representatives of universities** (students, teachers, administrative staff);
- **73 industrial enterprises** (managers, technical specialists, environmentalists).

Participants came from various regions of Uzbekistan, in particular, industrially developed regions (Tashkent, Fergana, Jizzakh, Bukhara, Karakalpakstan). Among the survey participants were young people, experienced engineers, university teachers, and politicians, which made it possible to obtain diverse opinions.

2.3. Methods of data collection and analysis

The data collection process was carried out online (Google Forms) and in person in March-April 2025. The analysis process was carried out in two stages:

- **Quantitative analysis:** General trends were identified based on diagrams, tables, and percentages. Microsoft Excel and SPSS programs were used.
- **Qualitative analysis:** During the qualitative analysis based on open-ended questions, key topics, recurring points, and problem areas in the participants' opinions were identified. These data were systematically analyzed in relation to the categories of SWOT analysis (S, W, O, T).

This methodological approach made it possible to draw deep conclusions about the state and prospects of environmental engineering education in Uzbekistan.

3. Analysis of the survey results

This section analyzes the main results of the survey conducted within the framework of the GREENDT project. Respondents included higher education institutions (HEIs), industrial enterprises, and other stakeholders, whose opinions provided important information on the quality of education, practical opportunities, training, and labor market needs in the field of environmental engineering.

3.1. Answers of higher educational institutions

Of the 28 higher educational institutions of Uzbekistan that participated in the survey, 1834 people (students, teachers, education management employees) emphasized the relevance of environmental education. The following main points are noted:

1. Overview

Respondents were asked to select three environmental problems in Uzbekistan. The following results will help identify the most urgent issues:

Table 5. Respondents' Assessment of Uzbekistan's Environmental Problems

Environmental problem	Number of people marked	Percentage (%)
Air pollution	1360	74,2%
Water pollution and scarcity	884	48,2%
Global warming and climate change	616	33,6%
Waste management	486	26,5%
Excessive use of resources	261	14,2%
Deforestation	220	12,0%
Soil degradation	162	8,8%
Noise	99	5,4%

According to the survey results, the population of Uzbekistan considers three environmental problems to be the most urgent:

1. Air pollution - 74.2% of respondents acknowledged this problem as the most critical. The deterioration of air quality stems from industrial emissions, vehicles, and other sources.
2. Water pollution and scarcity - 48.2% of respondents identified the limitation and contamination of water resources as the primary ecological issue. Water scarcity poses a significant concern for agricultural and population needs.
3. Global warming and climate change - 33.6% of people cited climate change and global warming as an environmental threat. This situation is negatively impacting the natural environment and the economy.

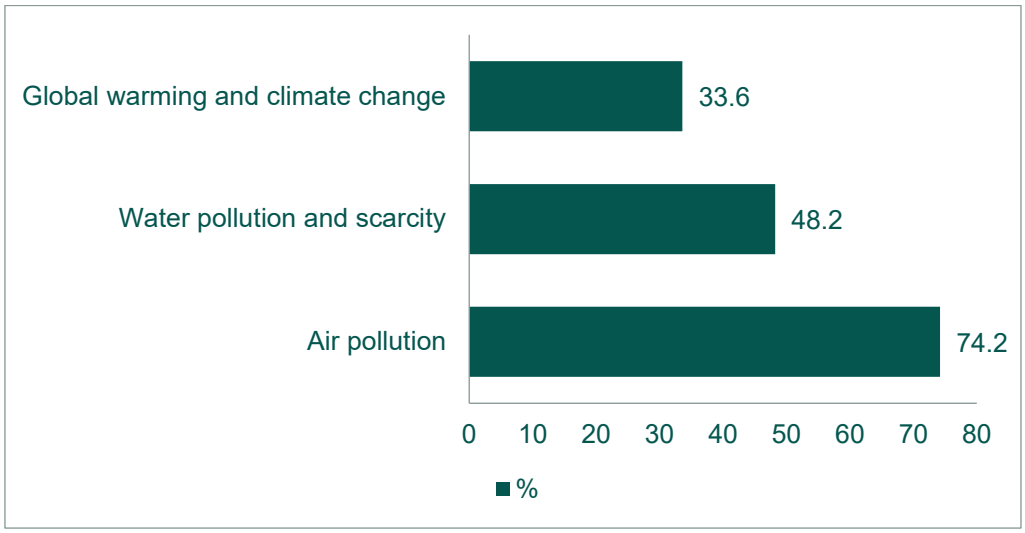

Figure 4. Ecological threats deemed most important by survey participants

These three issues are currently considered the most urgent and serious environmental problems in Uzbekistan. To address them, specific measures at the national level and international cooperation are necessary.

2. Legislation in this area

According to the survey results, a large portion of respondents - 72.8% - are well-versed in the law "On Nature Protection."

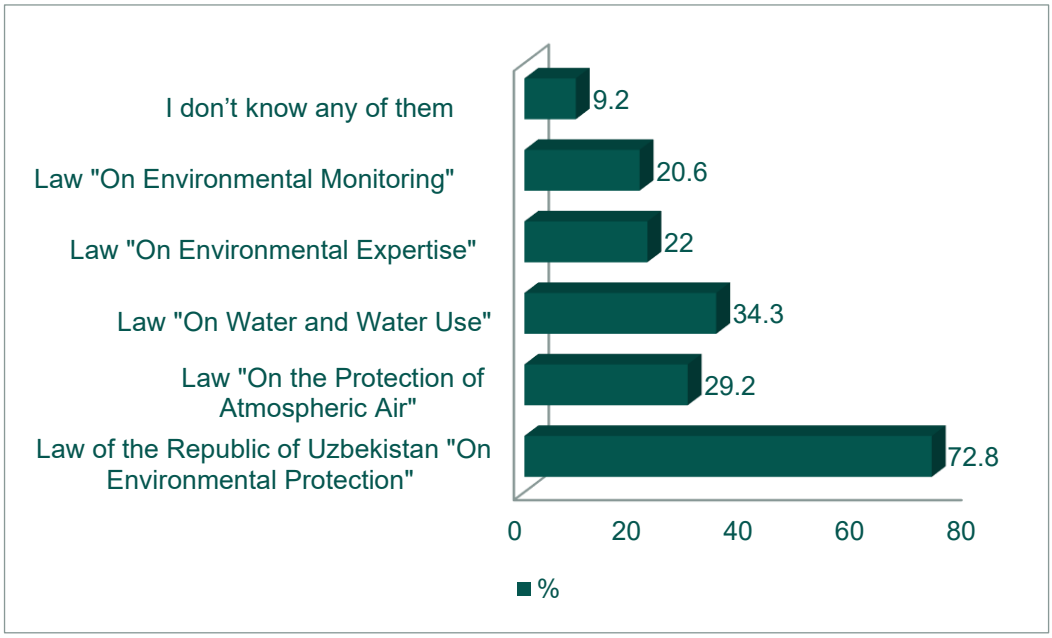

Figure 5. Respondentlarning ekologik qonunlarga oid bilim darajasi

At the same time, 9.2% of participants indicated that they are not familiar with any laws whatsoever. This highlights the necessity to improve legal literacy regarding environmental legislation.

3. Education

According to the survey results, respondents expect the government to implement strict standards for integrating education in ecology and environmental protection with the industrial sector (54.6%), promote the green economy (49.5%), and establish a mandatory training system for specialists (51.3%). This indicates the importance of direct government involvement and strong political will.

Although 54.2% of respondents reported participating in environmental programs, trainings, or events, interest in this field is considerably high: 53.7% expressed a desire to obtain a master's degree in "Environmental Engineering," while another 29% chose the answer "maybe." The main motivations for interest in master's programs were cited as contributing to environmental policy and sustainable development (43.6%), conducting scientific research (16.6%), and advancing education and advocacy in the field (27.2%).

Table 6. Most Demanded Subjects in the Master's Program

Science	Percentage (%)
Environmental policy and law	65,8
Waste management	55,2
Air pollution and climate change	54,3
Water and soil protection	49,1
Environmental protection technologies	41,7

4. Industrial integration

Effective integration with the industrial sector is necessary for the development of environmental engineering. This integration, on the one hand, contributes to the achievement of environmental sustainability by industrial enterprises, and on the other hand, allows higher educational institutions to implement curricula based on practical experience, modern technologies, and real problems.

- In the educational process, it is proposed to introduce environmental problems in industry mainly through practical exercises (55.3%) and scientific research (29%).
- Environmental education contributes to increased safety (44%) and resource saving (32%) in production.
- The chemical, oil and gas, automotive, and energy industries were identified as the most problematic sectors.
- Environmental technologies (30%) and filtration systems (21%) are used as the main measures at enterprises, but there are also those who do not take measures (4.6%).
- The public (31%), government bodies (24%) and industry leaders (22%) play an important role in solving environmental problems.
- Renewable energy (51%) and waste recycling (46%) were identified as priority areas for the green economy.

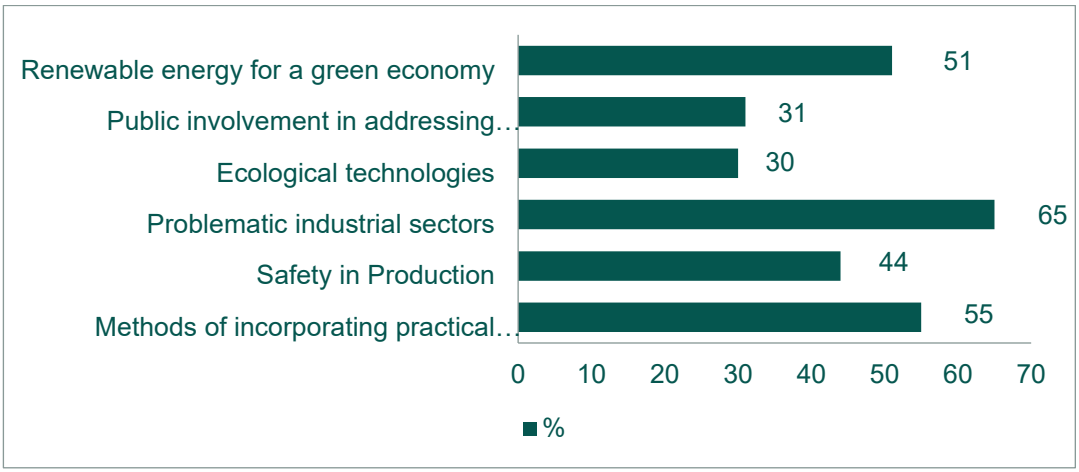

Figure 6. Graphical analysis of industrial integration

5. Job positions (organizations and cooperation)

According to the survey results, job opportunities for specialists trained in environmental engineering are assessed relatively positively. 57% of respondents believe that there are enough jobs in this field and there are opportunities for career growth. At the same time, 27.6% of respondents noted insufficient attention to this area and the difficulty of career growth, although it is possible to find a job. Only 14.2% of respondents indicated that opportunities for employment and growth are limited due to low demand and attention to this area..

The main areas of work for specialists are:

• According to the survey results, the most indicated areas of work for environmental engineering specialists are state environmental authorities (59.3%) and higher educational institutions (57.8%), which are distinguished as the main sectors of employment in this area.

• The industrial and manufacturing sector (33.6%) is also considered a significant area;

• The energy sector, international organizations, construction, and consulting also have certain opportunities.

In terms of strengthening cooperation between education and production, more than half of the respondents (51.9%) supported the inclusion of environmental problems in production in the curriculum. Initiatives such as the creation of state programs (36.3%) and the provision of environmental benefits (11.6%) were also put forward.

3.2. Perspectives of Industrial Enterprises and Other Stakeholders

Representatives of 73 large industrial enterprises, including specialists in the energy, chemical, oil and gas, and construction sectors, participated in the survey. They focused on the following problems:

1. Condition and needs of enterprises

According to the survey results, almost half of the respondent enterprises (45.2%) operate in the machine-building industry. In second place is the service sector - 15.1%, followed by construction (8.2%), energy (5.6%), chemical (5.5%), and food (4.1%) industries. The remaining 16.4% of enterprises are engaged in other activities.

This distribution shows that the important needs of the machine-building industry - such as industrial waste management, air and water monitoring, and digital transformation - are prioritized in the development of the master's program. Practical skills in environmental engineering (laboratory

work, project experience) are also of great importance in the service and construction sectors. In the energy, chemical, and food sectors, issues of implementing environmental safety policies and adapting them to international standards are a priority.

2. Personnel qualifications and necessary skills

The following table shows the most essential skills for environmental engineering masters and their respondent ratings (in percentages):

Table 7. Master's Skills and Percentage Score (%)

Necessary skills	Percentage (%)
Knowledge of environmental monitoring and analysis methods	78,1
Technical knowledge	69,9
Design experience	61,6
Knowledge of international standards	54,8
Digital monitoring technologies	47,9

3. Master's degree program

A number of important disciplines have been selected as core components of the Master's program in Environmental Engineering. According to survey results, the following subjects should receive special focus within the program:

Table 8. Master's degree subjects in highest demand at companies

Subject name	Percentage (%)	Comment
Waste management and recycling	58,9	Environmental pollution protection and waste management
Environmental policy and legislation	54,4	National and international environmental laws and governance systems
Air pollution and climate change	53,4	Sources of air pollution and climate change problems
Smart Environmental Monitoring Systems	45,2	Monitoring using digital technologies, such as sensors, IoT, GIS

These disciplines serve to improve the quality of scientific and practical training of the master's program and ensure the training of qualified and modern personnel in the field of environmental engineering..

4. The Integration of Education and Industry

Effective integration between education and production plays an important role in the master's program in environmental engineering. According to the survey results, the following areas are considered an integral part between enterprises and educational institutions:

• Practical and laboratory classes (69.9%) - allow students to work not only with theoretical knowledge, but also with experience and equipment at real enterprises. This increases the readiness of specialists for work.

• Innovative projects and startups (65.8%) - further enliven the educational process by developing new technologies and innovative solutions in the educational process, creating projects aimed at solving real problems, and encouraging students to think ahead.

• Joint research (61.6%) - R&D between enterprises and universities plays an important role in studying industry problems and implementing innovations. This collaboration not only deepens theoretical knowledge, but also.

Thus, these integration mechanisms between education and production will improve the quality of the master's program and contribute to the formation of modern and in-demand personnel in the field of environmental engineering..

5. Innovation and international approaches

Depending on the spheres of activity of enterprises, the main solutions are considered to be the early detection of new technologies and environmental problems. Based on the survey results:

• 30.1% of respondents consider the introduction of new technologies relevant,

• Also, 30.1% of enterprises considered it important to identify environmental problems in advance and take preventive measures.

Large sectors, such as the machine-building industry, require innovations to make waste management and monitoring effective. In the energy and construction industries, innovative solutions are needed to increase energy efficiency and environmental safety. attracting industry specialists (19.2%) and adapting to international standards (12.3%) were also recognized as solutions.

3.3. Education, practice, technical capabilities and labor market needs

The survey results show that environmental engineering education does not fully meet the requirements of modern industry. The main shortcomings are:

• **Gaps in personnel training:** Programs are insufficiently aligned with production realities and environmental safety standards.

• **Lack of practice and laboratories:** Most students cannot conduct practical classes in real ecological conditions in production.

• **Limited technical resources:** Many universities do not have modern laboratories for environmental monitoring, waste recycling, and air quality assessment.

• **Labor market needs:** There is a shortage of specialists in areas such as environmental technologies, waste management, and energy efficiency.

This situation emphasizes the need for deep integration of approaches related to production needs, practical training, and technical infrastructure in the new master's programs being developed within the framework of the GREENDT project.

4. SWOT analysis

4.1. S –Strengths

• **Legislative awareness:** 72.7% of participants are aware of basic environmental laws.

• **Increased attention to sustainable development and environmental protection:** The government is developing green economy and environmental strategies.

• **Focus on education:** Most respondents emphasized the importance of environmental engineering education.

• **Government support:** There is government support for sustainable agriculture and water resource management.

• **High social interest:** 54% of participants want to pursue a master's degree, while 43.5% cited environmental policy and contributing to sustainable development as their motivation.

• **Opportunities for higher education:** There is an opportunity to develop master's programs in environmental engineering.

• **Suggestions for educational subjects:** Environmental policy and law, Air pollution and climate change, Waste management are considered important

• **Opportunities for international cooperation:** Opportunity to develop joint programs with international universities and organizations.

• **Participation in international environmental projects:** Uzbekistan actively participates in international environmental projects.

• **Implementation of environmental standards:** Increasing attention to environmental safety requirements at industrial enterprises.

Requirement for practical training: 55.5% of respondents indicated that the master's program should have internships and laboratories.

4.2. W –Weaknesses

• **Lack of organic connection between industry and education:** There is no systematic cooperation between higher education and industrial enterprises.

• **Lack of demand and awareness:** 42.2% indicated awareness, and 40% indicated a lack of demand in the labor market as a problem.

• **Lack of resources and infrastructure:** 34.4% of respondents indicated limited funds and infrastructure as a problem.

• **Limited workplaces:** Limited workplaces are a problem for 24% of respondents.

• **Insufficient state policy and incentives:** 30.9% of respondents believe that the current policy and incentives are insufficient.

• **Financial problems:** Limited state grants and high tuition fees reduce interest in master's education.

• **Requirement for foreign language certificates:** The absence of a language certificate required for admission to master's programs makes admission difficult.

• **The problem of research and innovation financing:** Lack of scientific research and laboratories.

• **Non-compliance with environmental safety requirements:** Industrial enterprises do not fully comply with environmental safety requirements.

4.3. O – Opportunities

• **International cooperation:** 59.2% of respondents want to develop master's programs with the European Union.

• **Financed projects:** Positions and projects focused on the environment are available from the Asian Development Bank and other structures.

• **Development of a green economy:** Energy efficiency (51.2%) and waste recycling (46.2%) are considered as priority areas.

• **Large waste generation projects:** In 2024, Uzbekistan announced $1.3 billion worth of projects, which will allow for the processing of 4.7 million tons of waste.

• **Availability of jobs:** Jobs are increasing through environmental projects in the public and private sectors.

• **Integration of industry and education:** There is an opportunity to develop cooperation with industrial enterprises.

• **Support for practical training:** 55.5% of respondents supported the inclusion of industrial practical training in the educational process.

• **Environmental Impact Study:** 51.9% of respondents want to include the study of the environmental impact of production processes in the curriculum.

4.4. T – Threats

• **Lack of attention to environmental issues:** 19.6% of respondents rated environmental measures in industry as insufficient.

• **Environmentally hazardous industries:** Chemical (64.8%), oil and gas (57.7%), automotive and energy (42.1%) industries are indicated as the most dangerous.

• **Non-compliance with environmental standards:** Environmental standards are not being observed at manufacturing enterprises.

• **Climate change and environmental problems:** There are risks such as rising temperatures, desertification, and biodiversity loss.

• **Limited jobs and economic incentives:** 24.2% of participants indicated a shortage of jobs for environmental engineers in industrial and government organizations 30.9% indicated the weakness of state policy and incentives.

• **Environmentally hazardous industries remain a priority:** The chemical (64.8%), oil and gas (57.7%), and energy (42.1%) industries are indicated as the most problematic industries - this poses a threat if environmental technologies are not implemented.

4.5. S – Specificity

• Along with the development of industry, Uzbekistan's environmental impact is also growing.

• Many industrial enterprises still do not fully comply with environmental standards, which leads to problems such as air and water pollution and waste management.

Especially:

• **Industrial sectors** (chemical, oil and gas, energy) are among the environmentally hazardous industries.

• **The Aral Sea crisis:** turned Uzbekistan into a center of environmental crises on an international scale.

• These circumstances require training in master's degree programs based on real environmental problems.

4.6. Environmental Engineering Education: European Experience and Analysis of the Situation in Uzbekistan.

The rapid development of Uzbekistan's industry increases the need for qualified specialists who ensure environmental safety. However, the existing education system does not fully meet this need. In the context of the GREENDT project, the need to improve the quality of education, expand a practice-oriented approach, and strengthen cooperation with industry is being identified through the study of the experience of European countries. The following comparative table serves to substantiate this.

Table 9. Analytical table comparing with the European experience

Routes	European Union experience	Situation in Uzbekistan
1. Content and methods of education	Modular, PBL (project-based learning), practice-oriented	Components aimed at the formation of practical skills in education are insufficiently developed.

Routes	European Union experience	Situation in Uzbekistan
2. Special subjects	Climate change, waste recycling, ISO 14001, GIS, IoT, environmental economics	General ecological sciences are available, special sciences are scarce or insufficient
3. Practice and laboratory	There is internship in the industry every semester, modern laboratories.	In many higher educational institutions, the modern ecological laboratory base has not been sufficiently formed.
4. Integration with industry	Universities work closely with industry, there are joint projects and internships.	Close and systematic cooperation with industry has not yet been fully established.
5. Connection with the labor market and financing	Master's degree students are being prepared for the industrial sector, with special job openings created for this purpose. The educational process is funded through grants, scholarships, and international project resources.	There are significant gaps in the process of training qualified specialists who meet labor market demands. The number of state grants is limited, and scholarship programs are insufficiently developed.
6. Integration with environmental policy	Education integrated with political strategies	Educational programs are insufficiently aligned with the priorities of environmental policy, which leads to a fragmented approach in the field..

Analysis of the table shows that the use of European experience in the modernization of environmental engineering education in Uzbekistan has great potential. In particular, practical training, industrial integration, and the effective implementation of digital technologies in the educational process are considered important strategic directions.

5. Analytical conclusions and recommendations

5.1. Conclusion

Uzbekistan's achievement of the Sustainable Development Goals is directly linked to the system of training qualified specialists with ecological potential. The results of this study show that the implementation of a master's program in environmental engineering is an important strategic step in accordance with the country's environmental safety, industrial sustainability, and international obligations. According to the results of the survey analysis, representatives of society, the state, and industry expressed a real need for this area, and the need to take into account the opinions of these stakeholders when forming the educational program was determined.

Through SWOT+Specificity analysis, the strengths and weaknesses of environmental engineering education in Uzbekistan, existing opportunities and potential risks were identified, and the presence of institutional foundations in this area was confirmed. This ensures a realistic picture and a well-founded approach to the development of new educational programs.

5.2. Recommendations

Based on these findings, the following **recommendations** are proposed:

• The master's program should be developed in alignment with European Union best practices, with particular emphasis on practical components such as laboratory sessions, internships, and project-based learning.

• It is recommended to include modules on environmental legislation, monitoring and analysis technologies, sustainable production, green energy, as well as adaptation and protection strategies related to climate change.

• The orientation of national policy towards environmental education should be strengthened, with particular support provided through international grants and technical assistance programs.

• The integration of education and practice should be enhanced through the implementation of applied projects and internships in collaboration with industry and local self-governing bodies.

• Increasing environmental awareness in society and fostering ecological thinking among youth and professionals should be an integral part of the educational program.

If these strategic directions are implemented step by step, Uzbekistan can develop an advanced master's program model in the near future—one capable of preparing competitive specialists for the international labor market and addressing complex environmental challenges.

6. List of references

6.1. References

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7. Appendices

7.1. Sample Survey Questions

Section 1: General Information

1. What environmental problems in Uzbekistan concern you the most? (Select up to three)
• Air pollution
• water pollution and scarcity
• Soil degradation
• Deforestation
• Global warming and climate change
• Waste management

• Overexploitation of resources
• Noise pollution

2. What is the role of social media in solving environmental problems in Uzbekistan?

• Good
• Satisfactory
• Bad

3. Do you know the difference between the terms “ecologist” and “environmental engineer”?

• The ecologist is more concerned with scientific research and monitoring, while the environmental engineer is concerned with solving problems using technical and engineering approaches.
• An ecologist and an environmental engineer have the same educational program, only the name in the diploma differs.
• An environmental engineer works only in laboratories and does not conduct research related to nature.
• An ecologist studies only plants and animals, while an environmental engineer works only with technical devices

Section 2: Legislation in the field (resolutions, strategies, international relations)

4. Which environmental protection laws do you know well? (Multiple answers can be selected)

- Law of the Republic of Uzbekistan "On Environmental Protection"
- Law "On the Protection of Atmospheric Air"
- Law "On Water and Water Use"
- Law "On Environmental Expertise"
- Law "On Environmental Monitoring"
- I don’t know any of them

5. On a scale of 1-5, how effective are current environmental policies in Uzbekistan?

Bad 1 2 3 4 5 Best

Section 3: Education (demand and interest, preparedness and resources, laboratory, personnel and infrastructure)

6. What role should the government play in integrating environmental and environmental engineering education into the industrial sector? (Select up to three)

• Establishing stricter environmental regulations standards
• Providing financial incentives for green businesses
•Introduce mandatory training for the younger generation and enterprise specialists on issues of developing environmental and nature conservation sustainability in industry.
• Creating industry-specific environmental certification programs
•Others;

7. Have you participated in environmental programs, trainings or events?

• Yes
• No

8. Do you want to get a master's degree in environmental engineering in Uzbekistan?
• Yes
• No
• Maybe

9. If yes, what would be your primary motivation?

• Contributing to environmental policy and sustainable development
• Conducting scientific research
• Promoting education and advocacy in the field of environmental engineering
• Increase knowledge in order to accomplish legislation requirements

10. What are the biggest obstacles to the development of Environmental Engineering education in Uzbekistan?(Select up to three)

• Lack of awareness among students

•Limited funds and resources
• Insufficient government policies and incentives
• Slowness of the chain "network-enterprise-university"
• Low demand for specialists in " environmental engineering " in the labor market
• Limited jobs
• Lack of programs in this area
•Others;

11. Would you be interested in a scholarship program for Environmental Engineering?

• Yes, absolutely – I would not be able to study without financial support.
• Yes, if it covers partial costs – I can contribute some expenses but need assistance.
•Maybe – It depends on the scholarship conditions.
• No, I can afford the costs without a scholarship.
• No, I am not interested in this program.

12. Which subjects do you think are the most relevant to include in a master's program in Environmental Engineering? (Select up to four)

• Environmental policy and law
• Air pollution and climate change
• Waste management and recycling
• Water resources and soil conservation
• Renewable energy sources
• Community-based approaches to environmental education
• Industrial ecology and environmental safety
• Environmental assessment
• Intelligent environmental monitoring systems
• Environmental technologies
•Others;

13. Which organizations should participate in the development of the Master's degree program in environmental Engineering?

- Higher education institutions and research institutes
- Government agencies
- Environmental NGOs
- Private enterprises
- Industrial enterprises
- Others;

14. In your opinion, which countries should Uzbekistan cooperate with in developing environmental engineering education programs? (Up to three possible)

- European Union (Portugal, Spain, etc.)
- United States, Canada
- Eastern Asia (Japan, South Korea, etc.)
- Others;

Section 4. Industrial Integration (Scientific Research, Challenges, Solutions, etc.);

15. How can environmental issues in the industrial sector be integrated into the educational process?

- Through practical training and laboratories
- Through research and scientific work
- Through seminars and training
- Others;

16. What is the impact of ecology and environmental education on the industrial sector?
- Improving environmental safety in production processes
- Saving resources and waste management
- Introducing new environmental technologies
- Others

17. In which areas of industry environmental problems are most common? (You can select more than one option)

- Chemical industry
- Oil and gas industry
- Energy (thermal power plants)
- Textile and light industry
- Automotive industry
- Construction industry
- Food industry
- Others;

18. What measures are being taken to reduce ecological and environmental risks in industrial enterprises

- Introduction of modern environmental technologies
- Filtering and selection reduction systems are used

• Enhanced environmental monitoring and control
• Few measures to reduce environmental risks
• No action is being taken
• I do not know about this

19. Who has the most important role in solving environmental problems in industry?

• Industry leaders
• Government and state bodies
• Research institutes
• Community and environmental organizations
• Our personal role is also important

20. What are the main actions that you think should be taken to develop a green economy? (There may be few options)

• Energy efficiency and transition to renewable energy sources
• waste management
• water and wastewater management
• Environmental protection policies
• Industry and production with ecological features
• Air quality management
• Others;

Section 5. Job Positions (Organizations and Partnerships)

21. What do you think are the employment opportunities for professionals educated in the field of the environment and the role of this field in society? (Please choose one of the following options)

• Very good –This field is experiencing significant growth, with ample job opportunities and great potential for career advancement
• Good –The environmental sphere occupies an important place in a society with employment and career opportunities
• Medial – Attention to the field is not enough, it is possible to find a job, but career growth is more difficult.
• Bad –Job opportunities in the field are limited, community attention to ecology is low, career opportunities are low
• Very bad –In society, the field of ecology is practically neglected, it is almost impossible to find a job and career growth.

22. In what field do you think there are job opportunities for graduates of the Master's degree in Environmental Engineering? (Select up to three)

• Higher education institutions
• State environmental authorities
• NGOs and international organizations
• Energy and renewable energy sources
• Construction and infrastructure projects
• Industry and manufacturing fields
• Consulting and project management
• Others;

23. What initiatives do you support to strengthen cooperation between industry and education in the field of environment?

• Creating state programs in environmental engineering
• Inclusion of topics related to the impact of production processes on the environment in the curricula of educational institutions
• Introduction of environmental certificates and awards for enterprises
• Others;

24. Ecological and environmental engineering education impacts my personal life in the following ways:

- I will learn to conserve water
- My interest in protecting the environment will increase
- I will learn waste management
- I will set an example in sustainable resource management
- Others;

25. Where are you participating in this survey?

• Andijan
• Bukhara
• Fergana
• Jizzakh
• Karakalpakstan Republic
• Kashkadarya
• Khorezm
• Namangan
• Navoiy
• Samarkand
• Sirdarya
• Surkhandarya
• Tashkent
• European Union

SURVEY (for Industrial Enterprises)

1. Field of activity of your enterprise:
• Energy industry
• Chemical industry
• Food industry
• Mechanical engineering industry
• Service sector
• Construction industry
• Other;

2. Does your enterprise have environmental engineering specialists adapted to green and digital transformation?
• Yes
• Partially
• No

3. Does your company have an internal policy on environmental safety and sustainability?
• Yes
• Partially
• No

4. Which of the following areas should masters in environmental engineering be well-versed in? (Choose up to three)
• Knowledge of environmental monitoring and analysis methods (water treatment, air purification)
• Design experience (waste management and others)
• Technical knowledge (environmental processes, systems, technology)
• Knowledge of international standards (ISO 14001 and others)
• Digital monitoring technologies (sensors, IoT, GIS)
• Other;

5. Which of the following is considered important when developing a master's degree program? (Choose up to three)
• Theoretical knowledge
• Practical and laboratory classes
• Learning digital technologies
• Innovative project work
• Conducting internships in collaboration with companies and addressing industry-specific challenges

6. What skills should environmental engineers possess when working with laboratory equipment? (Up to three possible)
• Knowledge of the operating principles of laboratory equipment
• Understanding of chemical and biological processes
• Ability to analyze mathematical and physical processes
• Knowledge of measurement accuracy and calibration methods
• Familiarity with environmental legislation and standards
• Knowledge of safety regulations
• Other
7. Which subjects do you think are the most relevant to include in a master's program in Environmental Engineering? (Select up to four)

• Environmental policy and law
• Air pollution and climate change
• Waste management and recycling
• Renewable energy sources
• Community-based approaches to environmental education
• Industrial ecology and environmental safety
• Environmental assessment
• Intelligent environmental monitoring systems
•Environmental technologies
Water resources management
•Others;

8. What is the most urgent environmental problem for your company?
• Waste management
• Wastewater generation

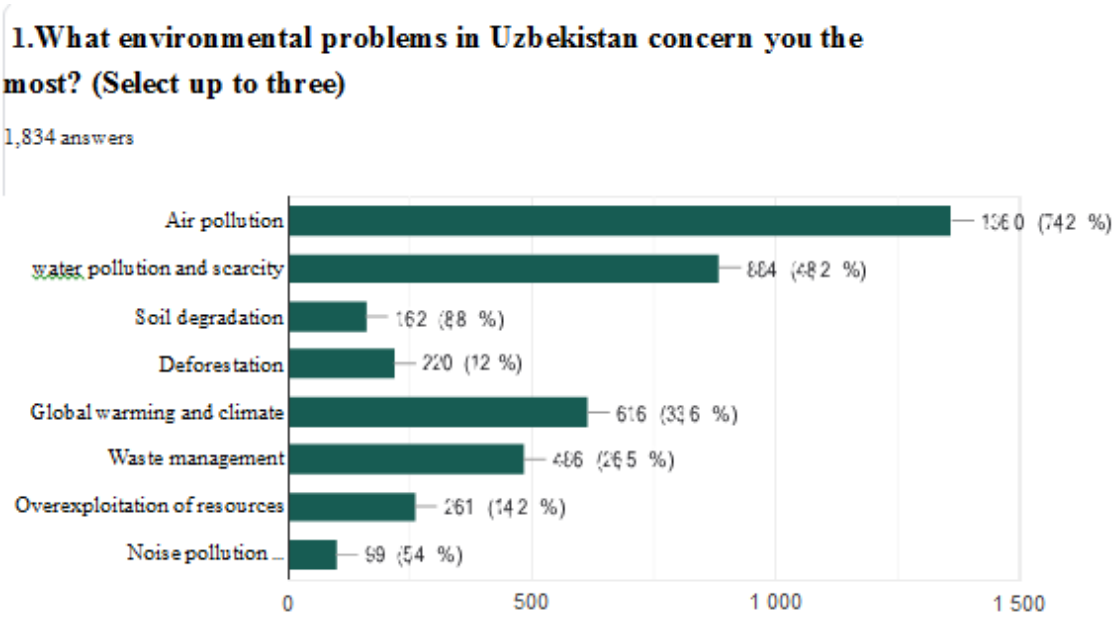
• Air pollution
• Energy efficiency
• Others

9. What solutions do you consider necessary to address existing environmental problems in your company?
• New technologies
• Engaging industry specialists
• Utilizing government programs
• Early identification of environmental issues and implementing preventive measures
• Adapting to international environmental standards (ISO 14001 and others)
• Others

10. What integration programs between production and education in environmental protection do you consider necessary? (Choose up to four)
• Conducting joint research
• Preparation and financing of innovative and startup projects in solving enterprise problems
• Conducting practical and laboratory classes using the existing laboratory bases of the enterprise.
• Organization of environmental trainings and seminars for enterprises
• Retraining and advanced training of enterprise employees on environmental training
• Attracting enterprise specialists to the higher education system (conducting lectures or seminars for masters)
• Employment of master's graduates based on competitive recruitment mechanisms

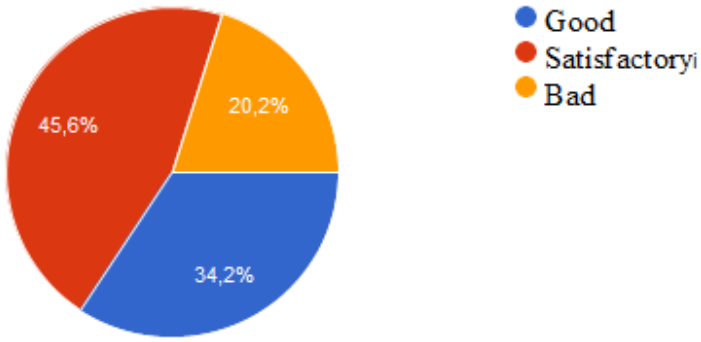
7.2. Statistical Tables and Charts

7.2.1. Statistical Tables and Graphs of Survey Results from Higher Education Institutions



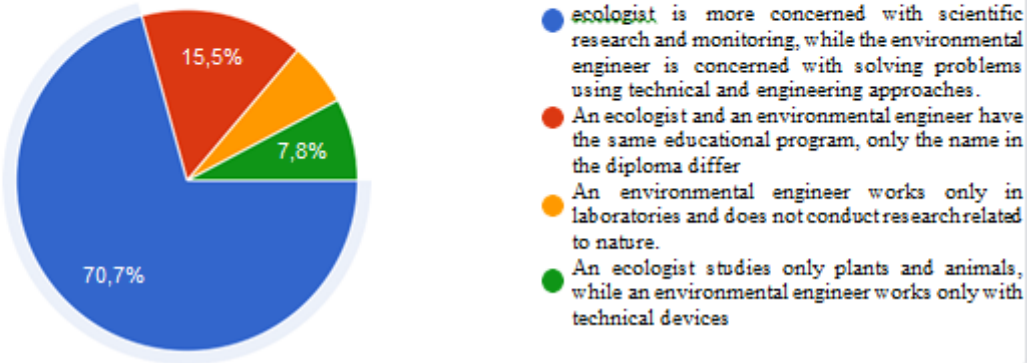
2. What is the role of social media in solving environmental blems in Uzbekistan?

1,834 answers



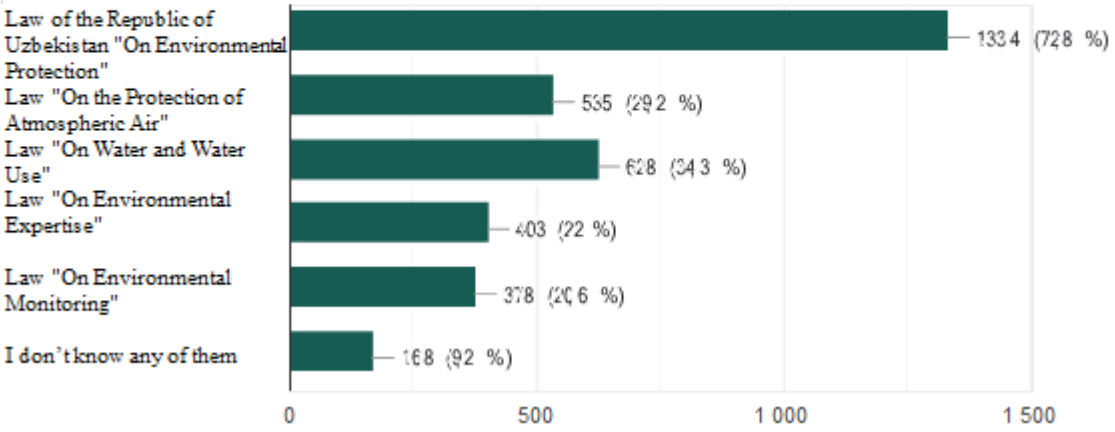
3. You know the difference between the terms "ecologist" and vironmental engineer"?

1,834 answers



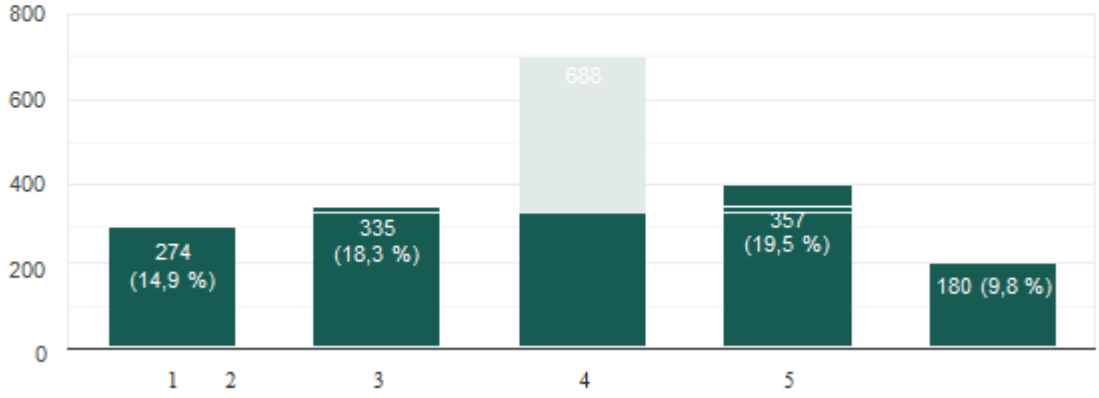
4. Which environmental protection laws do you know well? (Multiple answers can be selected)

1,833 answers



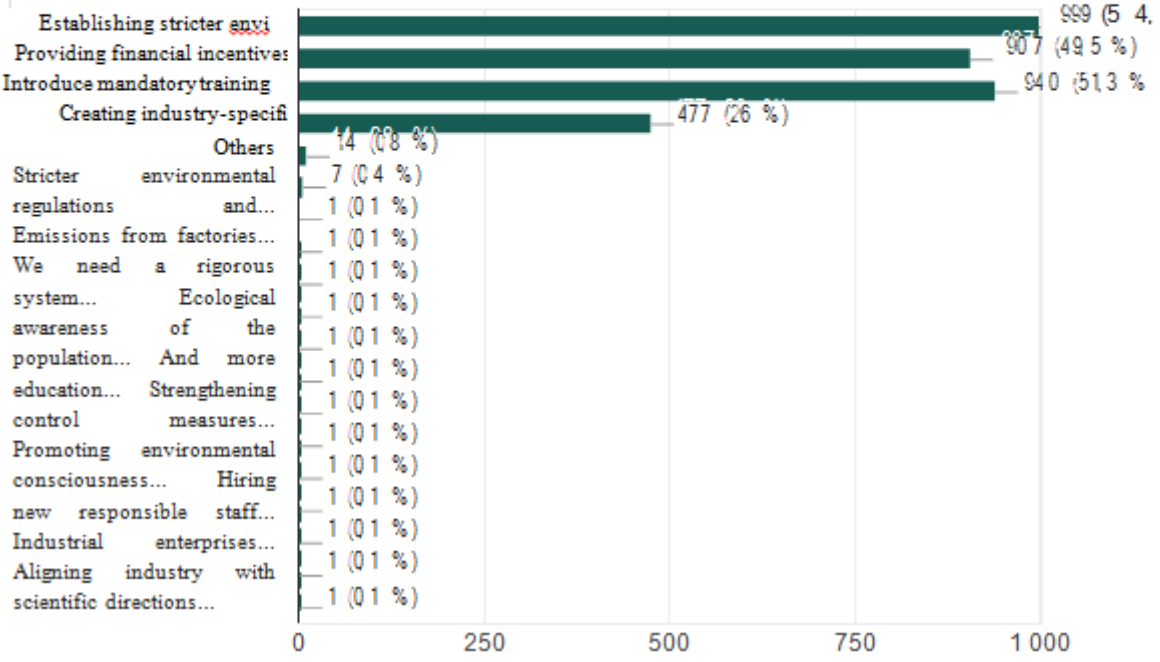
5. On a scale of 1-5, how effective are current environmental policies in Uzbekistan?

1,834 answers



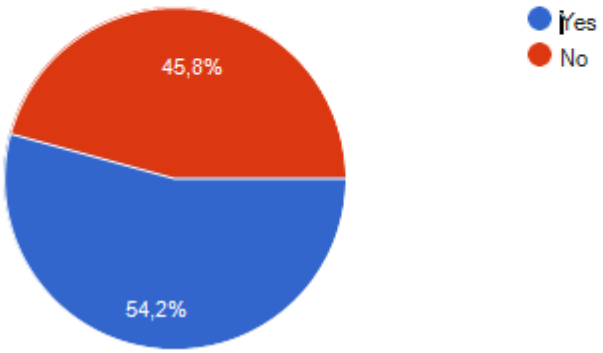
6. What role should the government play in integrating environmental and environmental engineering education into the industrial sector? (Select up to three)

1,834 answers



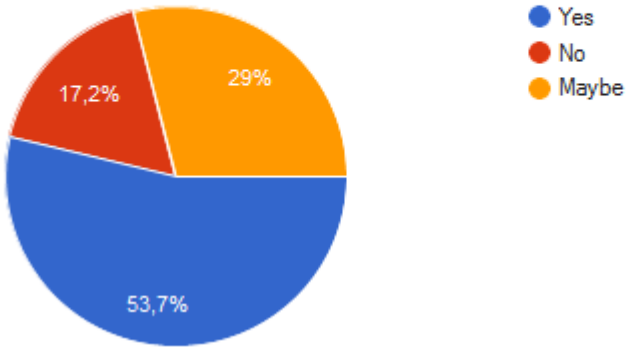
7. Have you participated in environmental programs, trainings or events?

1 833 answers



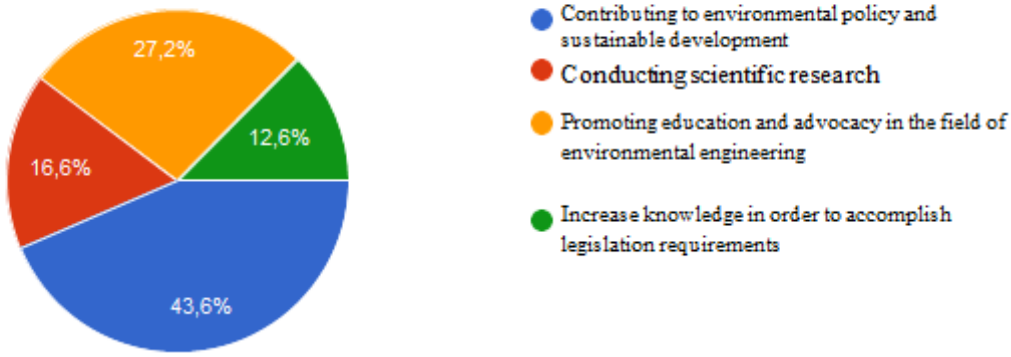
8. Do you want to get a master's degree in environmental ineering in Uzbekistan?

1 833 answers



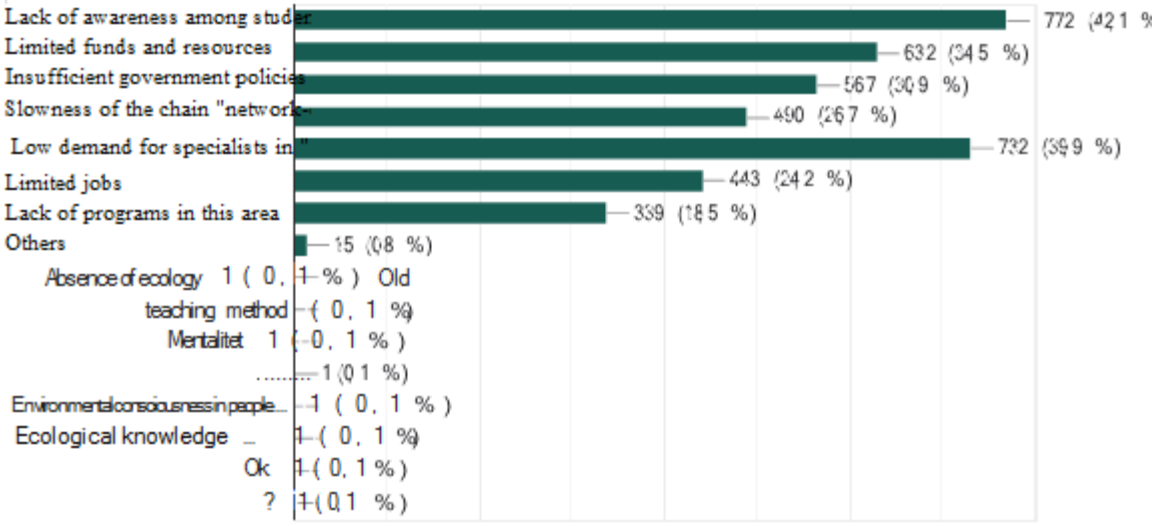
9. If yes, what would be your primary motivation?

1 779 answers



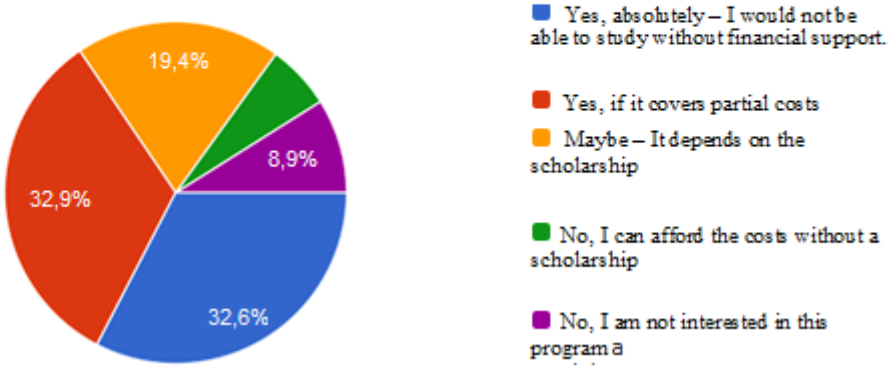
10. What are the biggest obstacles to the development of Environmental Engineering education in Uzbekistan?(Select up to three)

1 834 answers



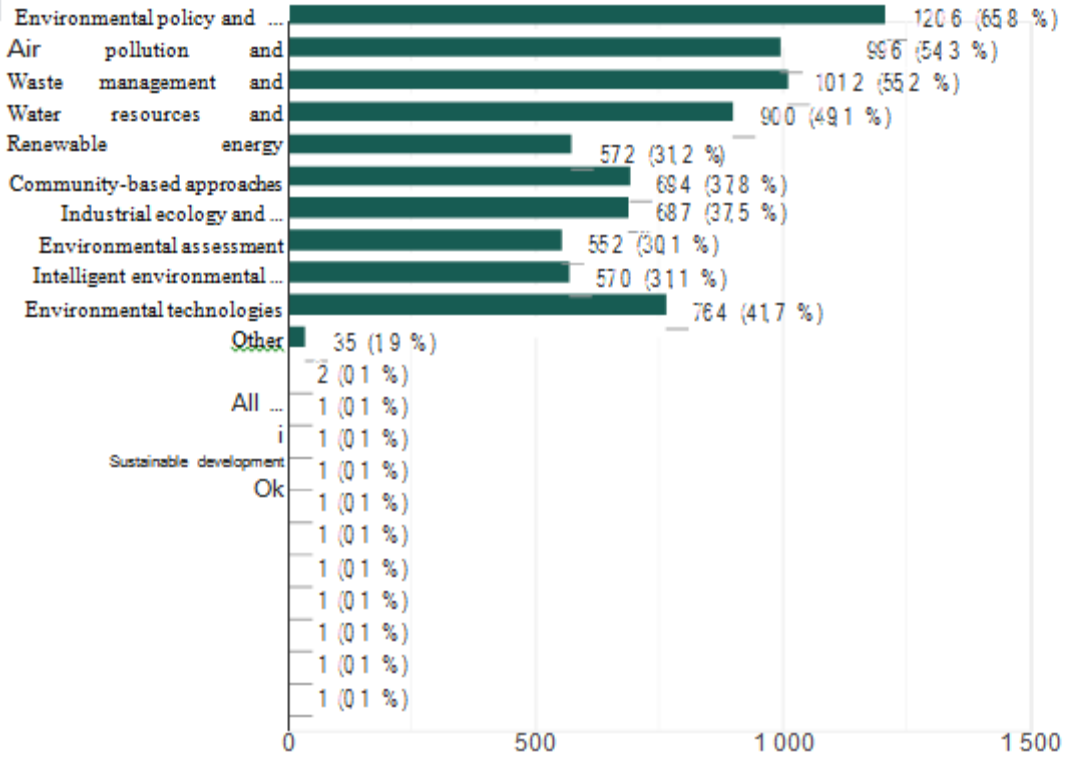
11. Would you be interested in a scholarship program for Environmental Engineering?

1 834 answers



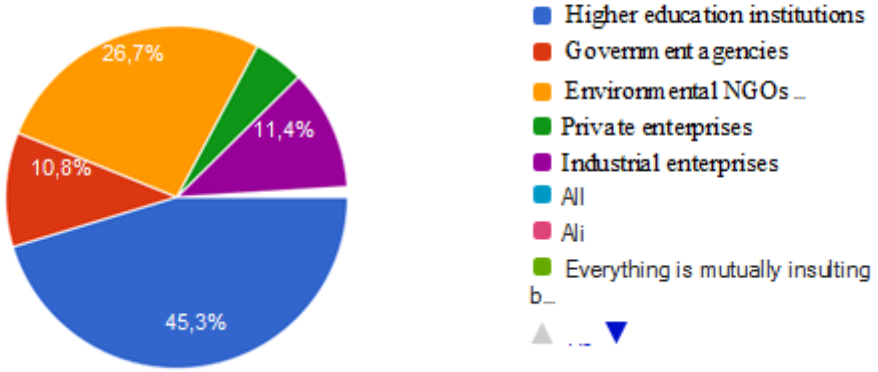
12. Which subjects do you think are the most relevant to include in program in Environmental Engineering? (Select up to four)

1 834 answers



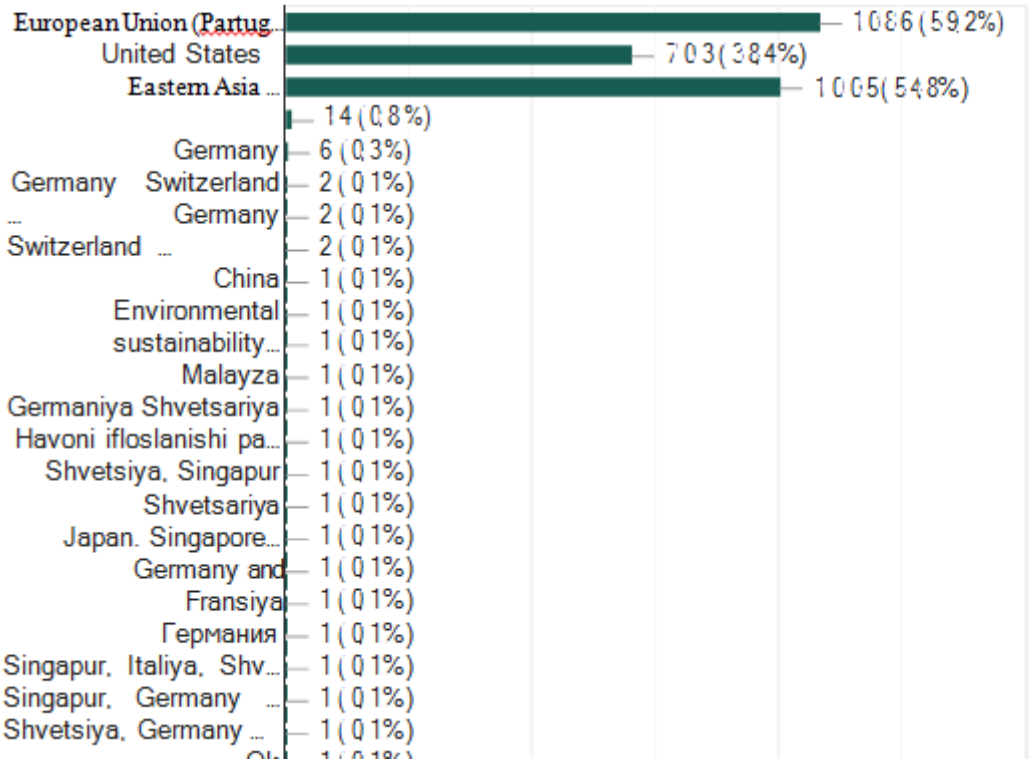
13. Which organizations should participate in the development of the Master's degree program in environmental Engineering?

1 834 answers



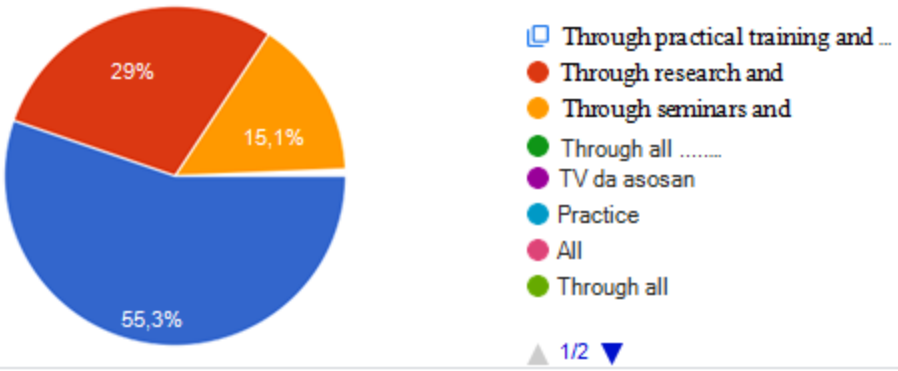
14. In your opinion, which countries should Uzbekistan cooperate with in developing environmental engineering education programs? (Up to three possible)

1 833 answers



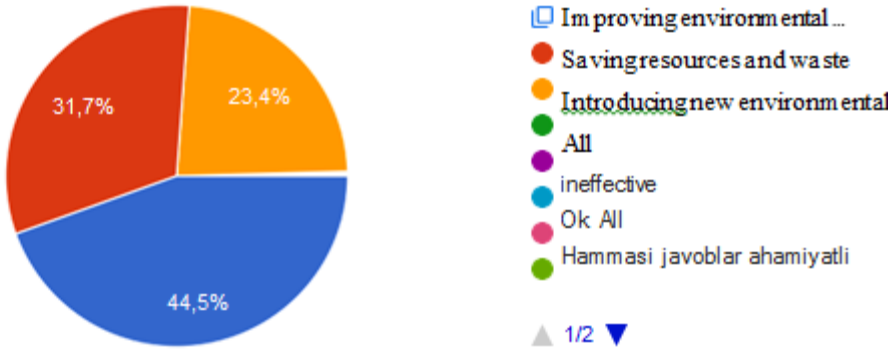
15. How can environmental issues in the industrial sector be integrated into the educational process?

1 834 answers



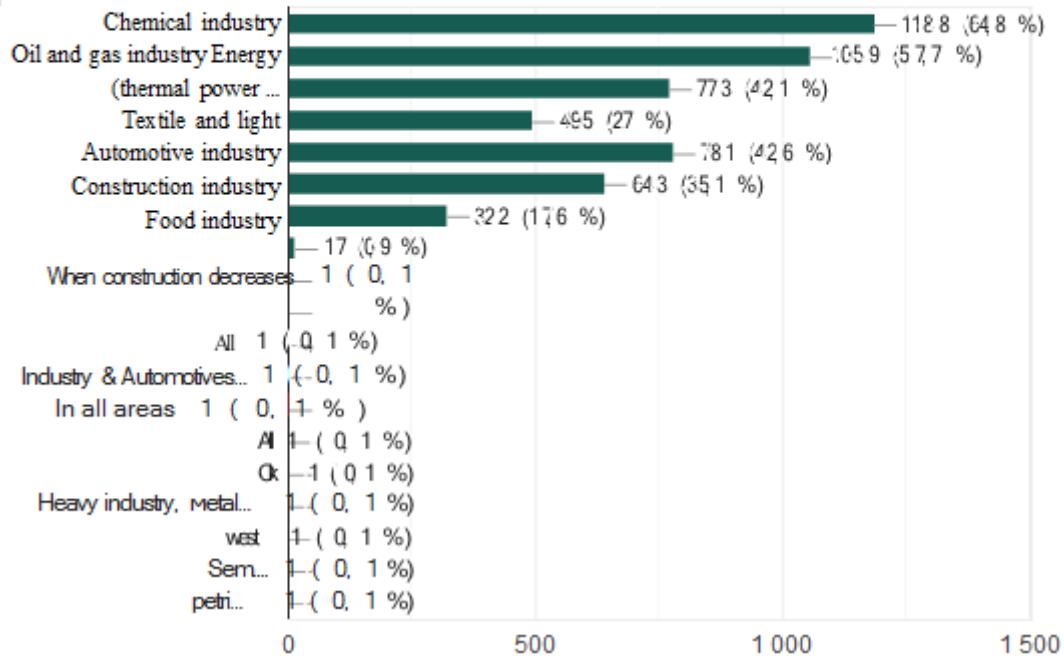
16. What is the impact of ecology and environmental education on the industrial sector?

1 834 answers



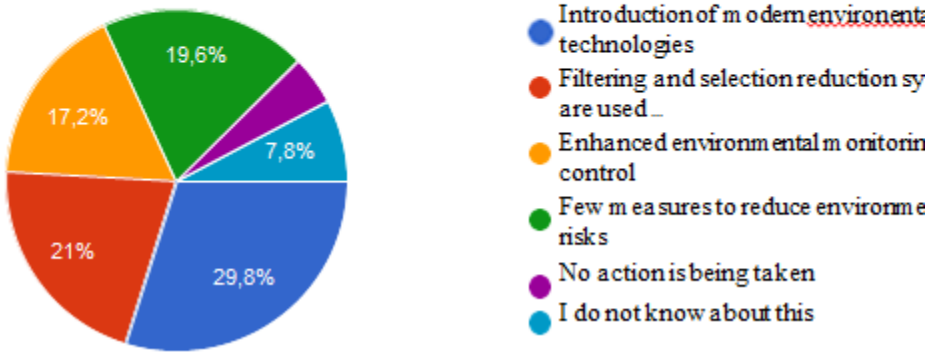
17. In which areas of industry environmental problems are most common? (You can select more than one option)

1 834 answers



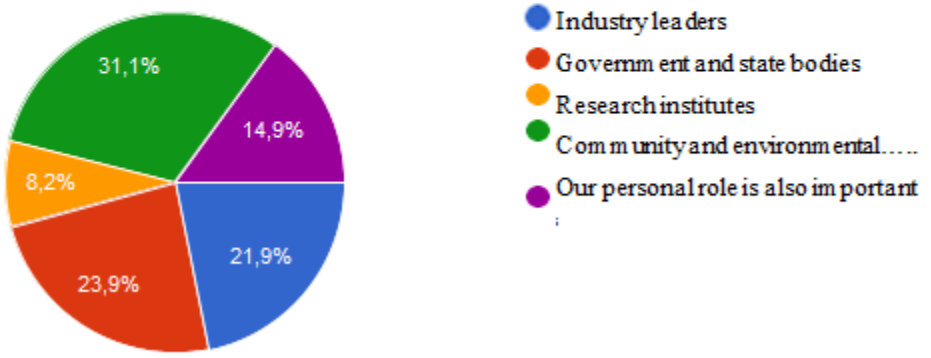
18. What measures are being taken to reduce ecological and environmental risks in industrial enterprises?

1 834 answers



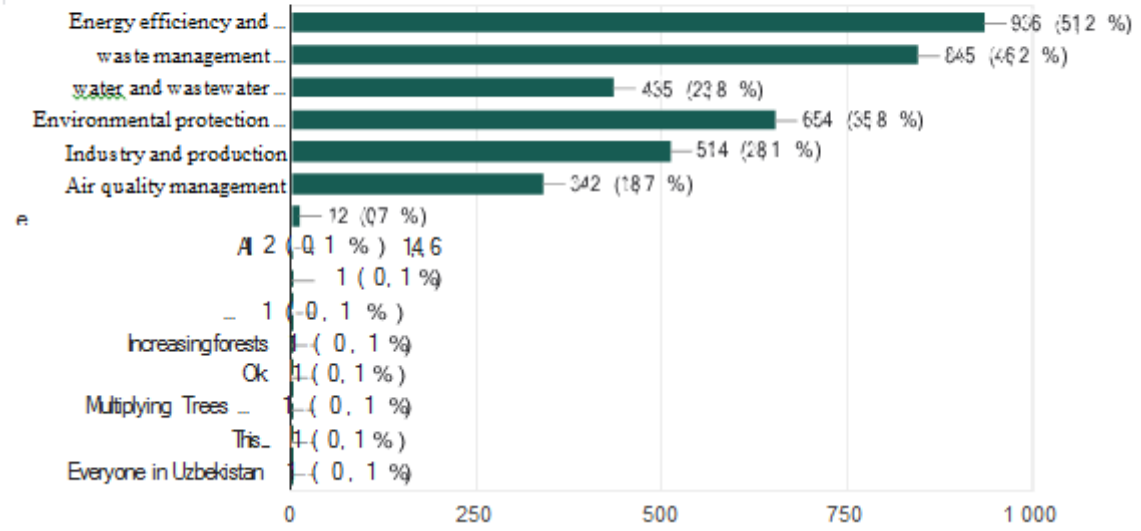
19. Who has the most important role in solving environmental problems in industry?

1 833 answers



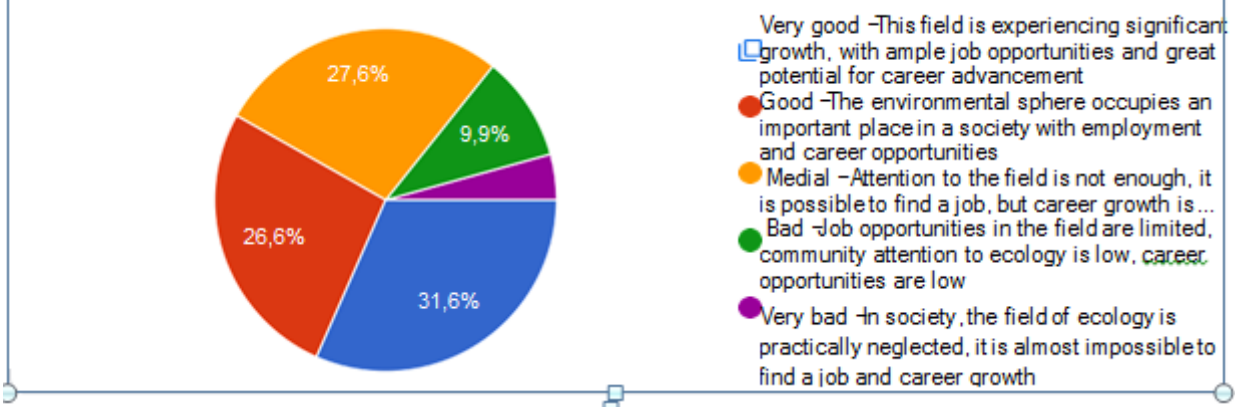
20. What are the main actions that you think should be taken to develop a green economy? (There may be few options)

1 828 answers



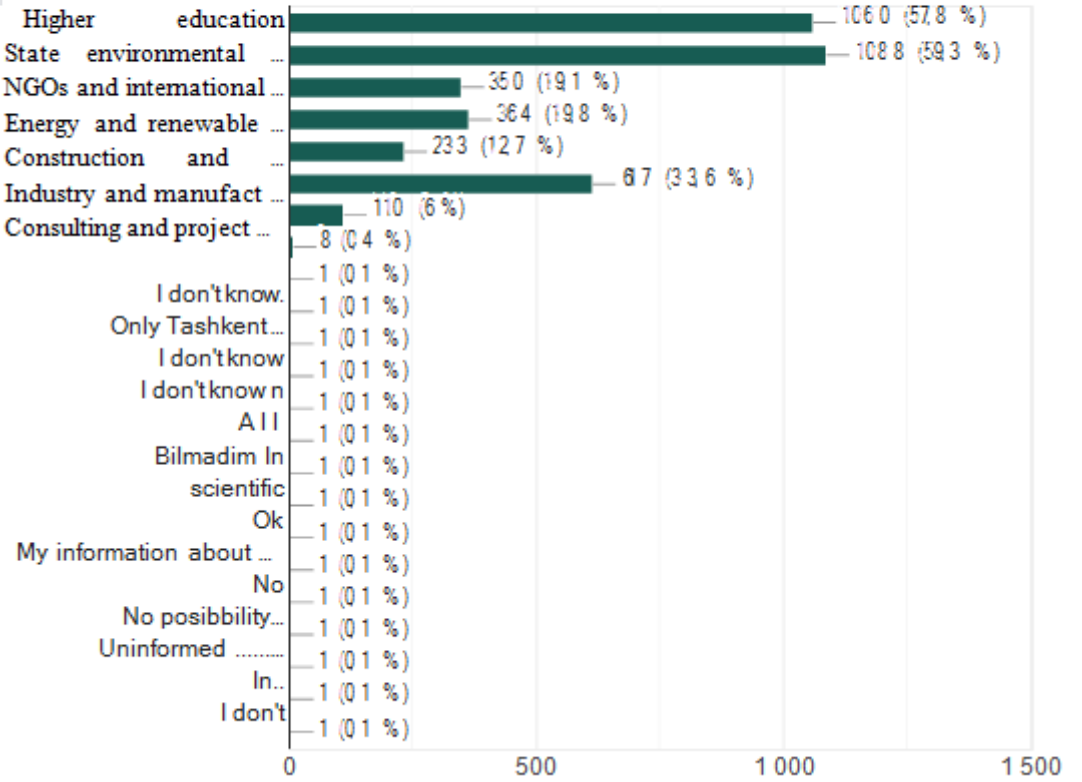
21. What do you think are the employment opportunities for professionals educated in the field of the environment and the role of this field in society? (Please choose one of the following options)

1 834 answers



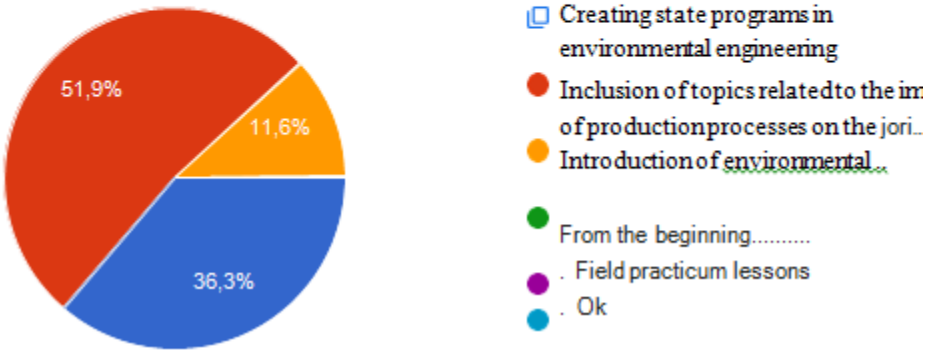
22. In what field do you think there are job opportunities for graduates of the Master's degree in Environmental Engineering? (Select up to three)

1 834 answers



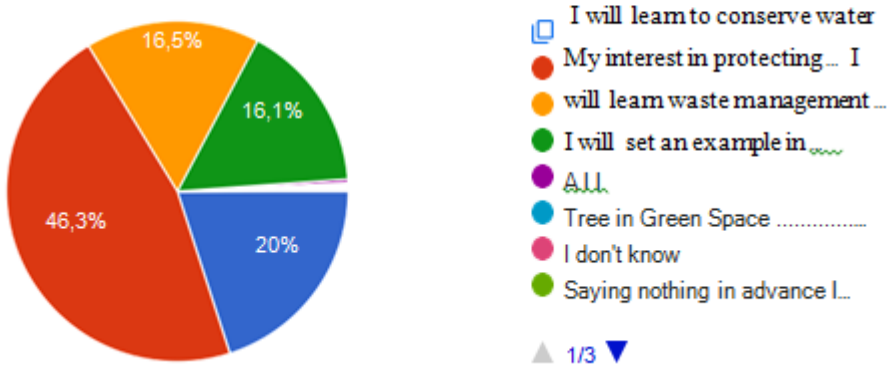
23. What initiatives do you support to strengthen cooperation between industry and education in the field of environment?

1 833 answers



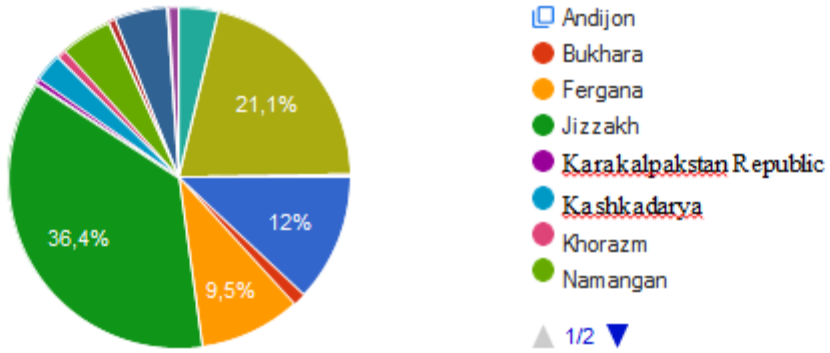
24. Ecological and environmental engineering education impacts my personal life in the following ways:

1 833 answers



25. Where are you participating in this survey?

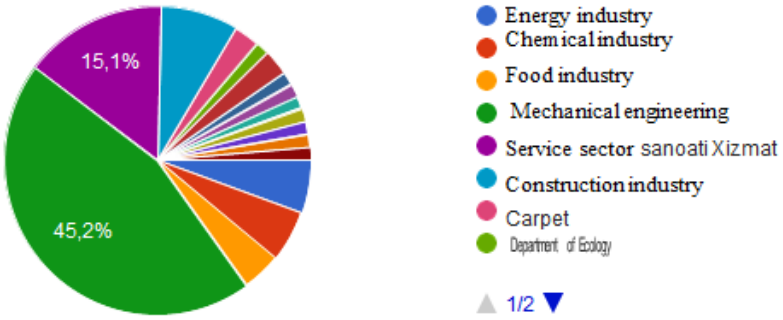
1 833 answers



7.2.2. Statistical Tables and Graphs of Survey Results from Enterprises

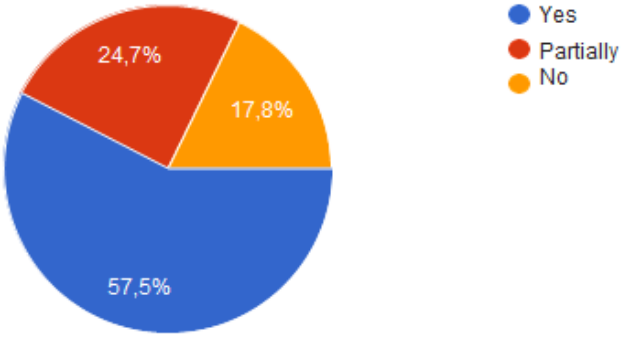
Question 1. Field of activity of your enterprise:

73 answer



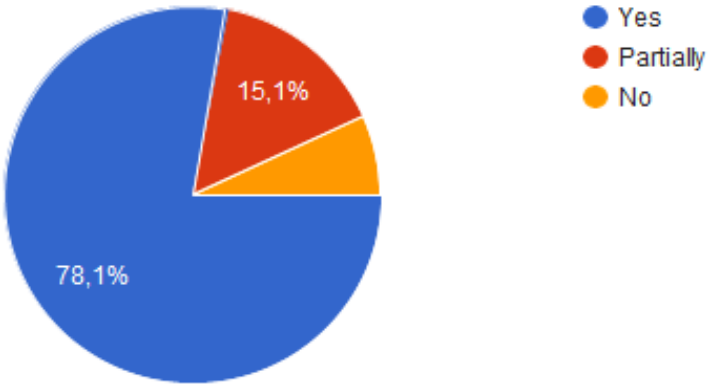
Question 2. Does your enterprise have environmental engineering specialists adapted to green and digital transformation?

73 answer



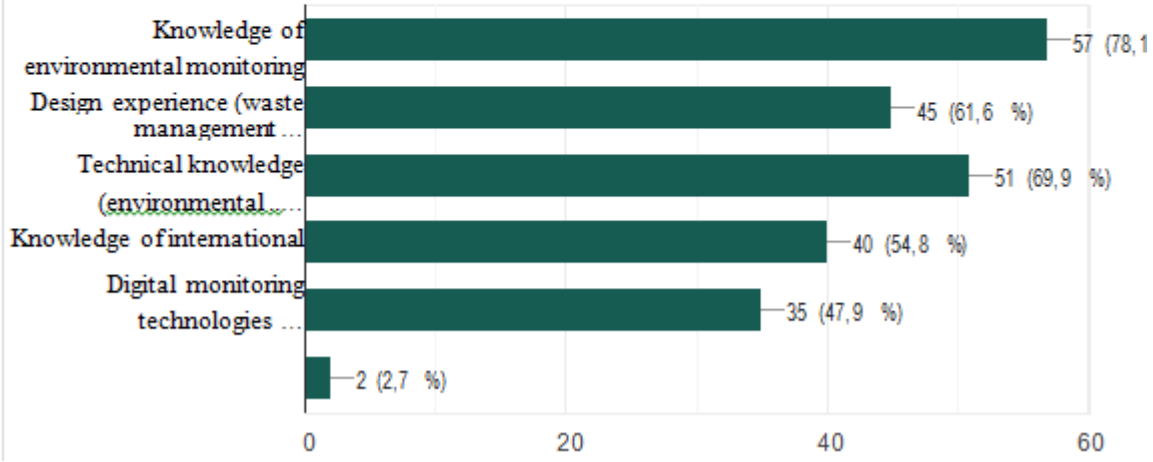
Question 3. Does your company have an internal policy on environmental safety and sustainability?

73 answer



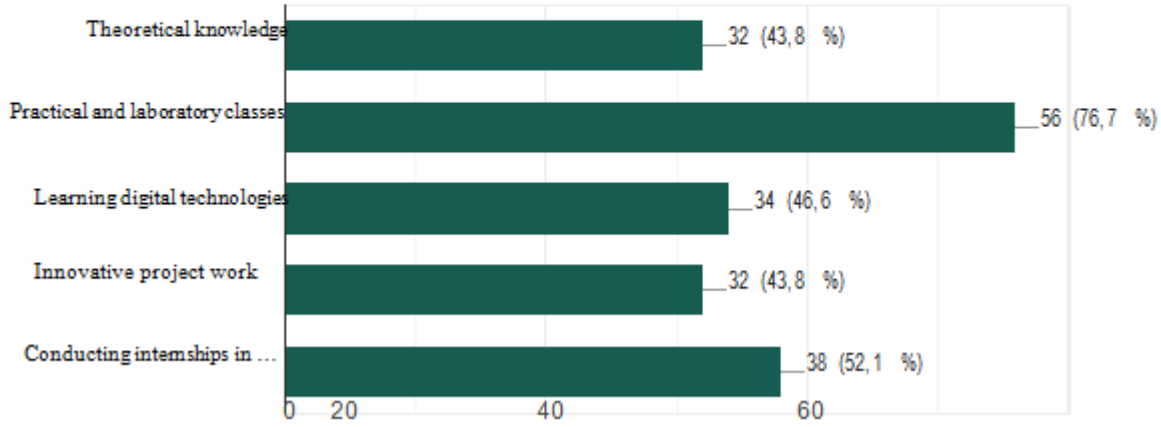
Question 4. Which of the following areas should masters in environmental engineering be well-versed in? (Choose up to three)

73 answer



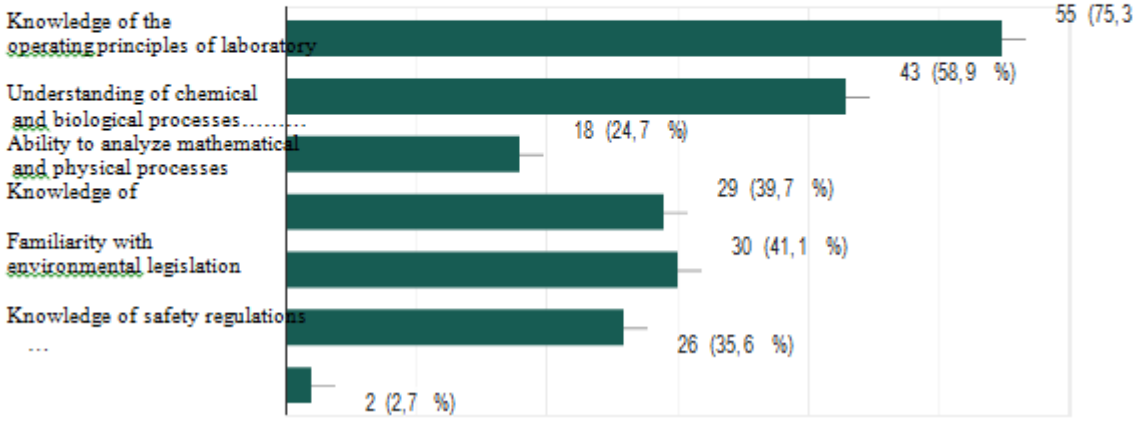
Question 5. Which of the following is considered important when developing a master's degree program? (Choose up to three)

73 answer



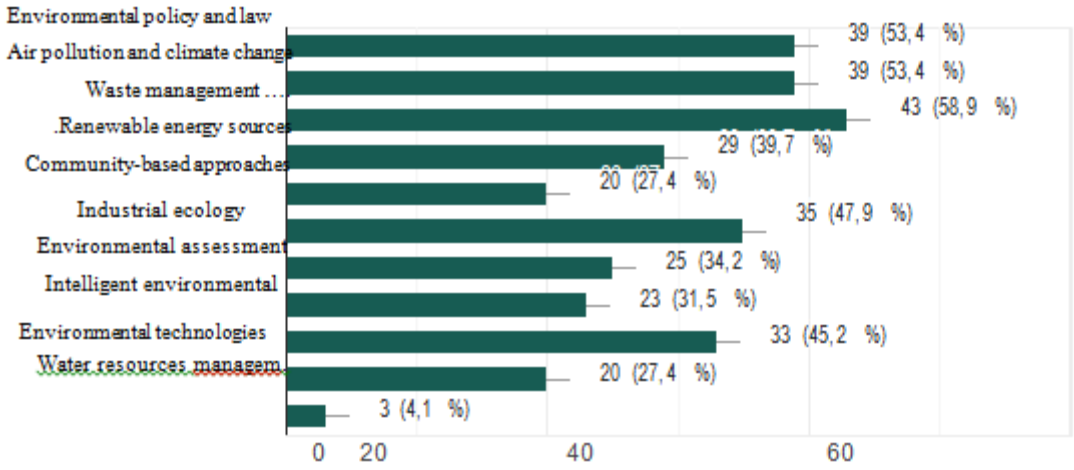
Question 6. What skills should environmental engineers possess when working with laboratory equipment? (Up to three possible)

73 answer



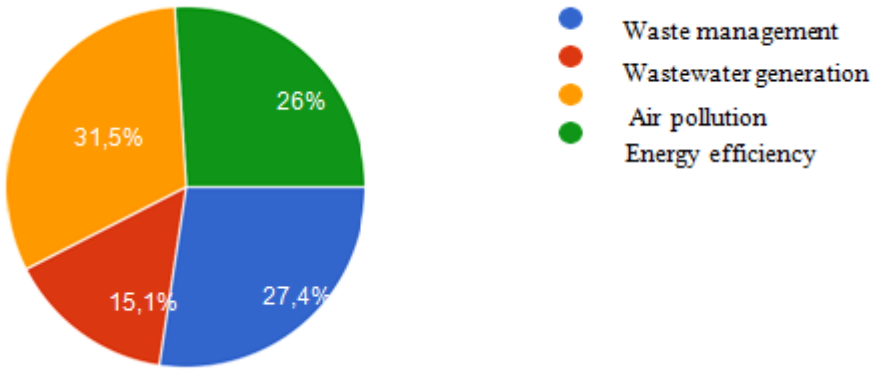
Question 7. Which subjects do you think are the most relevant to include in a master's program in Environmental Engineering? (Select up to four)

73 answer



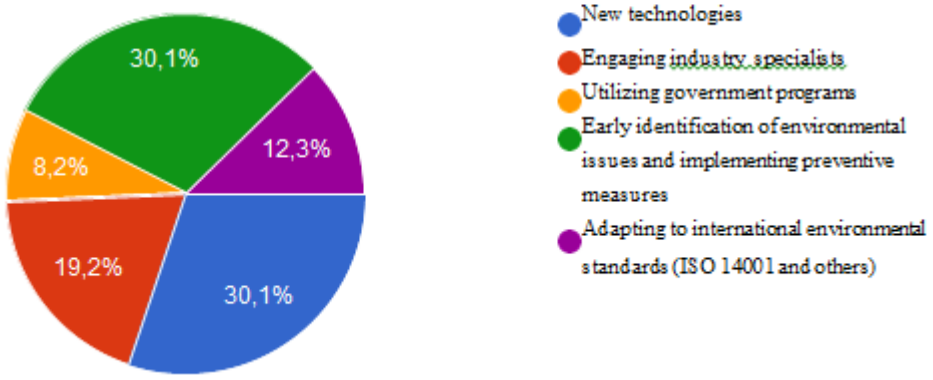
Question 8. What is the most urgent environmental problem for your company?

73 answer



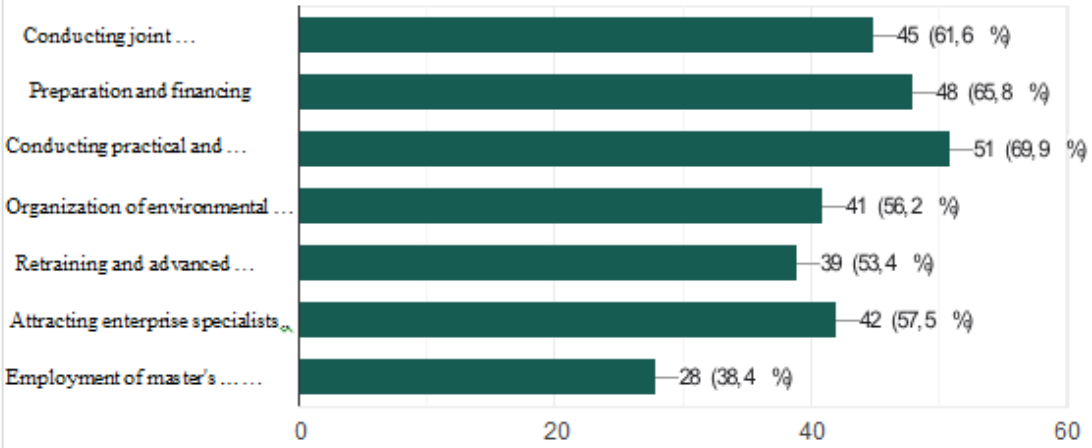
Question 9. What solutions do you consider necessary to address existing environmental problems in your company?

73 answer



Question 10. What integration programs between production and education in environmental protection do you consider necessary? (Choose up to four)

73 answer



Appendix 7.3. SWOT in Tabular Form

Strengths	Weaknesses
• Legislative awareness: 72.7% of participants are familiar with environmental laws. • Sustainable development: the government is promoting a green economy. • Focus on education: education in the field is considered crucial. • Government support: sustainable agriculture and water policies. • High social interest: 54% want to study, 43.5% desire to contribute to environmental causes. • Opportunities for higher education and new academic disciplines. • Participation in international cooperation and projects. • Environmental requirements in industry are increasing. • High demand for practical training.	• Weak connection between industry and education. •Educational programs do not adequately reflect practical experience and applied knowledge. •Limited job opportunities and incentives. • Environmental safety standards are not fully adhered to. •Limited financial resources, insufficient grants and scholarships. •Lack of funding for research activities and innovations. •Incomplete compliance with environmental safety standards at industrial enterprises. •Shortage of experienced personnel.
Opportunities	**Threats**
• Joint programs with the European Union. • Asian Development Bank and other donors. • Green economy, conversion of waste into energy. • Job opportunities are increasing. • Integration of industry and education, and practical training. • Demand for studying the environmental impact of production.	• Sluggishness of ecological measures. • Hazardous industries such as chemical, oil and gas, and energy. • Non-compliance with environmental standards. • Climate change, desertification, biological hazards. • Limited job opportunities and incentives. • Slow implementation of environmentally safe technologies harms industrial ecology.
Specificity	
•The environmental impact is intensifying with industrial development. •Failure to comply with standards is causing problems with air, water, and waste. •Chemical, oil and gas, and energy sectors are the main hazardous industries. •The Aral Sea crisis is an international environmental problem. •Master's degree education should be structured based on real environmental issues.	

7.4. Participating Institutions and Organizations

7.4.1. Participating Higher Education Institutions

1. Kimyo International University in Tashkent
2. Jizzakh Polytechnic Institute
3. Central Asian University for Environmental and Climate Studies
4. Andijan State Technical Institute
5. Fergana Polytechnic Institute

6. Karshi State Technical University
7. Namangan State Technical University
8. Samarkand State University of Architecture and Construction
9. Termez State University of Engineering and Agrotechnologies
10. Tashkent University of Architecture and Construction
11. Tashkent State Transport University
12. Bukhara State Technical University
13. National Research University “Tashkent Institute of Irrigation and Agricultural Mechanization Engineers”
14. Andijan Institute of Agriculture and Agrotechnologies
15. Karakalpak State University
16. Fergana State University
17. University of Geological Sciences
18. Gulistan State University
19. Namangan State University
20. Urgench State University
21. International Institute of Food Technology and Engineering
22. Samarkand State University of Veterinary Medicine, Animal Husbandry and Biotechnology
23. Tashkent Branch of Samarkand State University of Veterinary Medicine, Animal Husbandry and Biotechnology
24. Tashkent State Technical University
25. Karakalpakstan Institute of Agriculture and Agrotechnologies
26. Tashkent Institute of Textile and Light Industry
27. National University of Uzbekistan
28. Yangiyer Branch of Tashkent Institute of Chemical Technology
29. Bukhara State University
30. Tashkent Institute of Chemical Technology
31. Tashkent Medical Academy
32. Termez State University
33. Samarkand State University

7.4.2. Participating Enterprises and Organizations

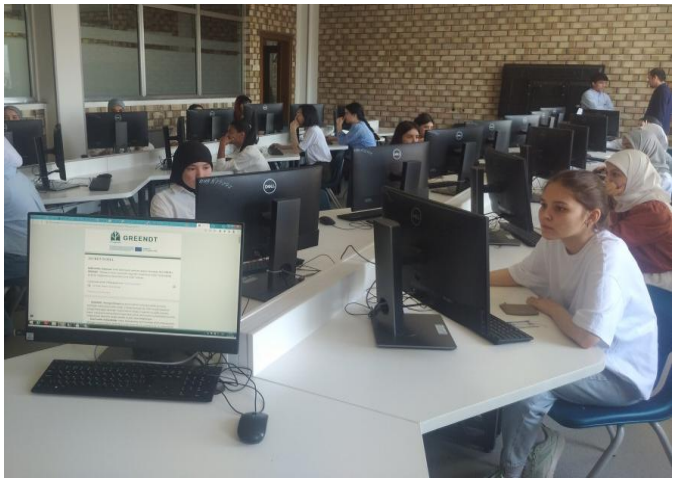
1. Ministry of Ecology, Environmental Protection and Climate Change of the Republic of Uzbekistan
2. Directorate of “Jizzax” Free Economic Zone
3. Jizzakh Regional Department of Ecology, Environmental Protection and Climate Change
4. “Roison Home White Goods” JV
5. “Master Building Products” JV
6. “Jizzax-Toshtepa Tekstil” LLC
7. “Minyuan Silu Industry” JVC
8. “Master Screw Systems” JV
9. “Sofitel” LLC JV
10. “Global Optical Communication Uzbekistan” LLC JV
11. “Raw Materials Cellulose” LLC
12. “Iruskon” LLC
13. “ Jizzax akkumliyator zavodi ” JSC
14. IP LLC “PETROMARUZ-UZBEKISTAN GRANITE-MINING” JV
15. “Uz Saemyung Co” JSC
16. Andijan Regional Department of Ecology, Environmental Protection and Climate Change
17. “UzAuto Motors” JSC
18. “Navoiy kon metallurgiya kombinati” JSC – Northern Mining Administration

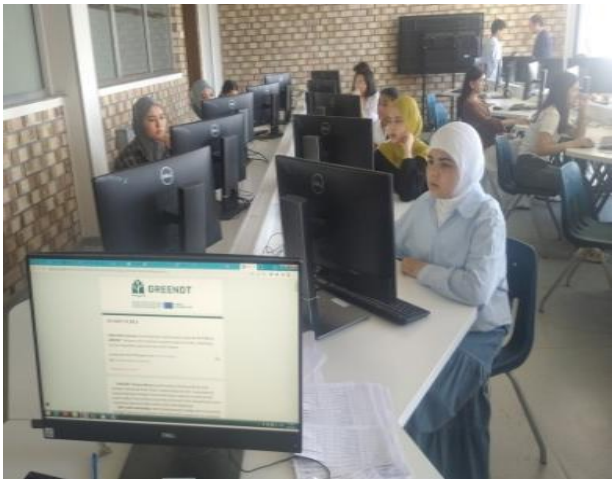
19. “Uz-Koram Co” LLC, Andijan City
20. “ Ferrum dekor qurilish ” LLC
21. Andijan Regional State Housing Cadastre Institution
22. Department of Landscaping of Buloqboshi District
23. Employment Department of Pakhtaobod District
24. “Uz DONG YANG CO” JV LLC
25. “ Andijon mehanika zavodi ” JSC
26. “Andijan Regional Electricity Networks” JSC
27. “Khantex Group” LLC
28. “Water Life Mineral” LLC
29. “UzAuto Motors Powertrain” JSC
30. “O‘zAvto-INZI” LLC
31. Tashkent Metallurgical Plant
32. “Enter Engineering” LLC
33. “Inno-Technopark” LLC
34. “Solar Nature” LLC
35. “Uzlogistic” LLC JV
36. Narpay Textile Factory
37. Samarkand Carpet Factory
38. “ Andijon suv ta’minoti ” LLC

7.4. Photographs

Jizzakh Polytechnic Institute

Kimyo International university in Tashkent





Fergana State Technical University

Andijan State Technical Institute