



unesco

Analysis of war damage to the Ukrainian science sector and its consequences



Published in 2024 by the United Nations Educational, Scientific and Cultural Organization,
7, place de Fontenoy, 75352 Paris 07 SP, France

© UNESCO 2024

ISBN 978-92-3-100662-3



This publication is available in Open Access under the Attribution-ShareAlike 3.0 IGO (CC-BY-SA 3.0 IGO) license (<http://creativecommons.org/licenses/by-sa/3.0/igo/>). By using the content of this publication, the users accept to be bound by the terms of use of the UNESCO Open Access Repository (<https://www.unesco.org/en/open-access/cc-sa>).

The designations employed and the presentation of material throughout this publication do not imply the expression of any opinion whatsoever on the part of UNESCO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The ideas and opinions expressed in this publication are those of the authors; they are not necessarily those of UNESCO and do not commit the Organization.

References to damage throughout this publication should be understood to refer to reported damage.

Cover photo: Usikov Institute of Radiophysics and Electronics in Kharkiv © Kunsht Science at Risk project/
Valentyn Kuzan

Graphic design: Claudia Tortello

Cover design: Claudia Tortello

Illustrations: Kunsht Science at Risk project/Valentyn Kuzan and (graphics) Junior Academy of Sciences of Ukraine

SHORT SUMMARY

Analysis of war damage to the Ukrainian science sector and its consequences

The conditions for conducting scientific and experimental work in Ukraine have significantly deteriorated since the Russian invasion of February 2022.

As a result of the bombing of Ukrainian cities over the past two years, many scientists in the public sector have been forced to change both their city of residence and their place of work. By January 2024, 12% of Ukrainian scientists and university teachers had been forced to emigrate or relocate internally. About 30% of all Ukrainian scientists have been forced to work remotely. Another 1,518 scientists have volunteered for combat duty.

The cost of restoring Ukraine's public research infrastructure has been estimated at US\$ 1.2637 billion. This figure covers both scientific equipment (US\$ 46 million) and buildings. Some 1,443 buildings belonging to 177 public scientific institutions have been damaged or destroyed since February 2022. Not all buildings can be assessed, however, as many are located in territories temporarily occupied by the Russian Federation.

The war has also eroded state budgets allocated to scientific institutions. In parallel, the number of contracts concluded with domestic and foreign business partners has fallen sharply, further diminishing the income of scientific institutions. Opportunities for joint research and technical projects have been curbed by the migration of scientists. These factors have led to a drop in scientific productivity at both national and international levels.

The present study has been commissioned from the Junior Academy of Sciences of Ukraine by UNESCO. The study is intended to inform UNESCO's strategy for supporting a recovery plan for Ukraine's science sector.

12%

Share of Ukrainian scientists obliged to emigrate or relocate since February 2022



unesco

"Since wars begin in the minds of men and women, it is in the minds of men and women that the defences of peace must be constructed"

Impact of war on Ukrainian science since February 2022



1,443

buildings belonging to 177 research institutes and universities damaged or destroyed



643

pieces of research equipment damaged beyond repair



US\$ 1.26 billion

needed to restore public research infrastructure, including US\$ 980.5 million for universities, responsible for 52% of public research



12%

of Ukrainian scientists and university teachers forced to emigrate (6.3%) or internally displaced (5.5%)



30%

of Ukrainian scientists forced to work remotely



1,518

scientists have volunteered for combat duty



53

countries are hosting displaced scientists from the National Academy of Sciences



48%

drop in budget of National Academy of Sciences since 2021: from US\$ 238.6 million to US\$ 124.8 million



39%

drop since 2021 in average monthly salary at National Academy of Sciences, responsible for 48% of public research: from US\$ 454.20 to US\$ 274.90



7%

fewer research articles published by National Academy of Sciences in international journals in 2023 than in 2021

Analysis of war damage to the Ukrainian science sector and its consequences

Acknowledgments

UNESCO wishes to thank the Junior Academy of Sciences of Ukraine for compiling and analysing the information and data contained in the present report and for authoring this study.

This assessment of damage to the Ukrainian science sector was commissioned in 2023 by UNESCO's Section for Basic Sciences, Research, Innovation and Engineering as part of the Organization's ongoing efforts to monitor damage to Ukraine, as reported in paragraph 16 of document 217 EX/4.I.H, entitled Report on UNESCO's Actions and Emergency Assistance Programme for Ukraine. At its 217th session in October 2023, the Executive Board of UNESCO requested 'the Director-General to actively monitor the situation in Ukraine within its internationally recognized borders in order to ensure direct UNESCO participation in the implementation of relevant actions within the mandate of the Organization' (paragraph 38).

The present assessment has been prepared by a team headed by Professor Stanislav Dovgyi, President of the Junior Academy of Sciences of Ukraine, and comprised of Oleksandr Stryzhak, Ivan Ryabchyi, Vitalii Prykhodniuk, Viacheslav Gorborukov and Maksym Nadutenko. The Junior Academy of Sciences of Ukraine also provided analytical materials and graphics for this assessment. The following team from the Ministry of Education and Science of Ukraine also contributed to the report: Dmytro Kurbatov, Oleg Taranov and Zoya Petrenko. A third team made up of Viacheslav Bohdanov, Oleksandr Osins'kyi and Tetiana Harbuz from the National Academy of Sciences of Ukraine made an additional contribution.

This study has been edited by Susan Schneegans, Communication Officer for Natural Sciences at UNESCO.

All tables and figures in the present document have been provided by the Junior Academy of Sciences of Ukraine.



Hryhorii Skovoroda Literary Memorial Museum in Skovorodnyivka
© Kunsht Science at Risk project/ Valentyn Kuzan

Contents

| | |
|--|----|
| 1. Introduction | 10 |
| 1.1 Scope and methodology..... | 10 |
| 1.2 Overview..... | 10 |
| 2. National Academy of Sciences | 14 |
| 2.1 Damage to real estate..... | 14 |
| 2.2 Damage to scientific equipment and other movable property..... | 15 |
| 2.3 Impact on scientific personnel..... | 17 |
| 2.4 Evolution in financial support..... | 19 |
| 2.5 Evolution in publishing activity..... | 19 |
| 3. Sectoral academies | 20 |
| 3.1 Damage to real estate..... | 20 |
| 3.2 Damage to scientific equipment and other movable property..... | 21 |
| 3.3 Impact on scientific personnel..... | 21 |
| 4. University sector | 22 |
| 4.1 Damage to real estate..... | 22 |
| 4.2 Damage to scientific equipment and other movable property..... | 22 |
| 4.3 Impact on academic personnel..... | 24 |
| 5. Ministries with research institutions | 27 |
| 5.1 Damage to real estate..... | 27 |
| 5.2 Damage to scientific equipment and other movable property..... | 27 |
| 5.3 Impact on ministry personnel..... | 27 |
| 6. Main Challenges Faced by Ukrainian Science Sector | 29 |
| Appendices..... | 31 |

1. Introduction

1.1 Scope and methodology

The present report describes the impact on science in Ukraine of the invasion by the Russian Federation on 24 February 2022, with some reference also to territories temporarily occupied by the Russian Federation since March–April 2014. The report analyses the impact of the war on scientific personnel employed in the public sector, as well as damage to the research infrastructure of the scientific and educational institutions of the National Academy of Sciences of Ukraine, which conduct 48% of research and development (R&D) in the public sector (see **Appendix A**); this category extends to the sectoral Academies of Agrarian Sciences; Medical Sciences; Arts; Legal Sciences; and Educational Sciences.

The report also covers the university sector, which falls under the Ministry of Education and Science, as well as scientific institutions attached to seven other ministries, namely the Ministries of Agrarian Policy and Food; Environmental Protection and Natural Resources; Finance; Internal Affairs; Culture and Information Policy; Health; and Justice (see **Appendix B**).

The report analyses the impact on both real estate and movable property, which includes scientific and experimental equipment, materials for conducting experiments, office equipment and vehicles. The report also analyses changes to the staffing of Ukrainian scientific institutions.

Lexical and semantic methods, conceptualisation and transdisciplinary integration were used to analyse information, in order to assess changes in the infrastructure

of the scientific sector. Data structuring and classification were implemented using big data, system analysis, ontological engineering and hierarchical clustering methods.

In undertaking this study, the Junior Academy of Sciences (JAS) first identified categories that invariably characterise the public research sector and the provision of resources to research institutions and universities. This initial information was then collected from all research institutions and universities. At a third stage, an automated workplace was created to enable experts to conduct a systematic analysis of both the information already received from research institutions and universities, as well as incoming information. JAS proposes maintaining this online information platform, which would function within the framework of Ukraine–UNESCO cooperation. The aim of this online platform would be to provide regularly updated, objective information about damage to the real estate of scientific, research and educational institutions and to scientific equipment and other movable property, as well as on the consequences of the war for academic, research and educational personnel.

Detailed information is already being regularly updated on this online platform. The platform may be consulted for a full description of damaged and destroyed property, as well as changes to staffing:

Go to: <https://polyhedron.ulif.org.ua/en/destroyed-property/>

Login: unesco

Password: B6#2JS5A9viY

1.2 Overview

The Russian Federation has temporarily occupied the Autonomous Republic of Crimea (Ukraine) and the Donbas grouping the Luhansk and Donetsk regions since early 2014. It launched a full-scale invasion of Ukraine on 24 February 2022 which has sparked an ongoing war.

The conditions for conducting scientific and experimental work in Ukraine have significantly deteriorated since the Russian invasion of February 2022. As a result of the

bombing of Ukrainian cities, many scientists have been forced to change both their city of residence and their place of work. However, internal displacement is not the only cause of the steep drop observed in the number of scientific personnel in Ukraine. Other contributing factors are emigration, occupation by a foreign force, the consequences of scientific workers joining the ranks of the Armed Forces of Ukraine and the death of scientific workers in combat operations and bombings.

Ukraine's public science sector comprises about 450 research institutes and 140 universities. From February 2022 to January 2024, a total of 1,443 buildings belonging to 177 institutions were damaged or destroyed. There are also reported losses among the engineering infrastructure of research institutes: 188 structures have been damaged or destroyed, including laboratory complexes and experimental sites. **Figure 1** shows the extent of damage to Ukraine's entire public research infrastructure as of January 2024.

It is the real estate of universities that has suffered the biggest losses. Restoring these assets alone will cost at least US\$ 980.5 million (see **Table 1**). This amount excludes damaged and destroyed scientific equipment in some universities, the replacement of which will cost at least US\$ 16.5 million.

The real estate of the National Academy of Sciences has also suffered significant damage. According to preliminary estimates, more than US\$ 43 million is needed to restore it.

The cost of restoring the real estate of research institutes affiliated with sectoral academies of science and ministries amounts to more than US\$ 191.8 million.

Owing to the damage and destruction incurred by buildings, essential research equipment has been completely destroyed or rendered inoperable. Today, more than 750 units of scientific and technological equipment used in a wide range of research activities have been damaged or destroyed. In February 2022, the market value of such equipment was more than US\$ 46 million.

Table 1: Value of damaged and destroyed buildings in Ukraine by type of institution

| Type of institution | Residual value (US\$ millions) | Market value (US\$ millions) | Estimated restoration costs (US\$ millions) |
|--------------------------------|--------------------------------|------------------------------|---|
| National Academy of Sciences | – | – | 42.5 |
| Sectoral academies of sciences | 46.7 | 42.5 | 48.8 |
| Ministries | 103.5 | 22.5 | 143 |
| Universities | 637.6 | 664.4 | 980.5 |

The cost of restoring Ukraine's public research infrastructure has been estimated at US\$ 1.2637 billion (see **Figure 1**). Besides real estate, more than 750 items of scientific equipment had been damaged by January 2024 (see **Figure 2**). More than 643 items of these have been damaged beyond repair and will need to be replaced. In addition, there is a need to purchase another 630 pieces of equipment to support research in Ukraine.

The war has shrunk the pool of scientists in Ukraine (see **Figure 3**). In February 2022, the public research sector employed 88,629 researchers and academic and teaching personnel. Since then, 10,429 Ukrainian researchers and professors from 524 academic and departmental research institutes and universities (12% of total) have been forced to emigrate or relocate within Ukraine: 5,542 (6,3%) have emigrated and 4, 887 (5,5%) have been displaced (see **Figures 4** and **5**). About 30% of all Ukrainian scientists have been forced to work remotely.

Some 1,518 scientists have volunteered for combat duty. Some scientists and university teachers have been killed while defending Ukraine in the line of duty or as a consequence of the hostilities (see **Figure 6**).

Since 24 February 2022, some 74 women holding a PhD or equivalent degree (excluding those in business and economics) have emigrated. More than half are now living in the following countries: Germany (22), Poland (10) and France (7). The other women are also primarily now based in Europe: Czechia (6), Sweden (5), Finland, Switzerland and the United Kingdom (3 each), the USA, Austria, Canada, the Netherlands and Luxembourg (2 each), Spain, Slovakia, Denmark, Brazil and Japan (1 each). The cities which have lost the most female PhD-holders to emigration over the past two years are Kyiv, Kharkiv and Odesa.

The war has eroded research expenditure both in real terms (adjusted for inflation) and as a share of GDP, according to the UNESCO Institute for Statistics. Ukraine devoted 0.38% of GDP to research and development (R&D) in 2021 but only 0.33% of GDP in 2022 (see **Appendix C**). This corresponds to a drop in gross domestic research expenditure (in constant 2017 prices) from PPP\$ 2,019.5 million to PPP\$ 1,242.1 million. It should be noted, however, that Ukraine's research intensity had already receded from 0.73% of GDP in 2013 to 0.40% of GDP by 2020.

Figure 1: Real estate of scientific institutions reportedly damaged and destroyed as of January 2024

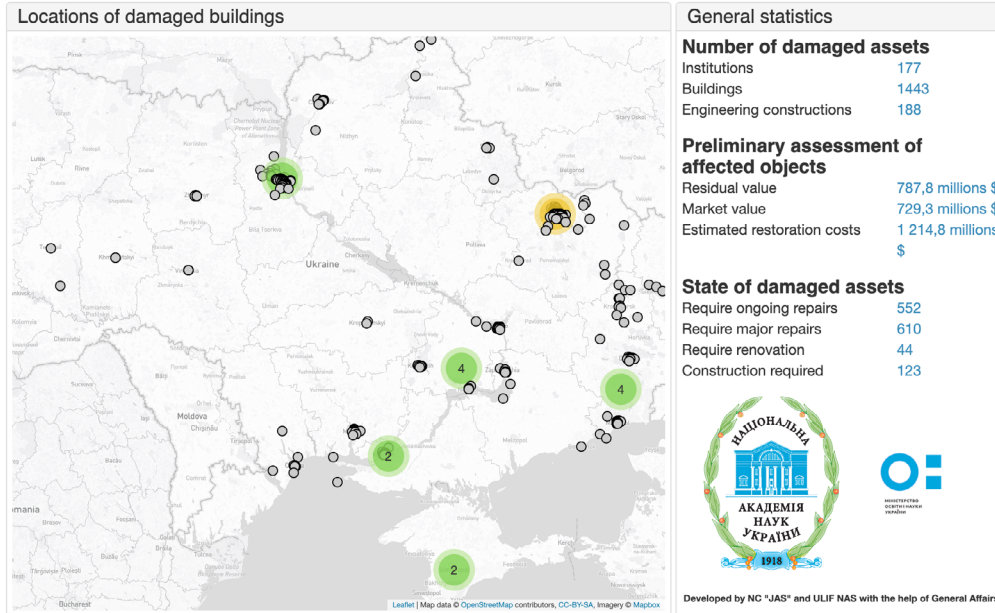


Figure 2: Damaged and destroyed scientific equipment as of January 2024

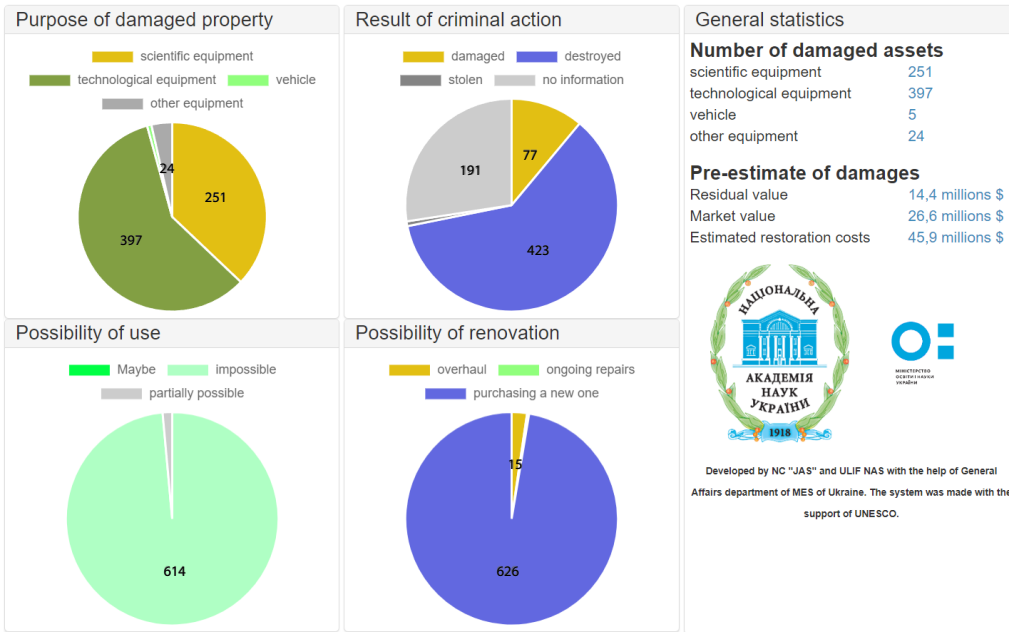


Figure 3: Drop in number of Ukrainian researchers employed by universities and research institutes as of January 2024

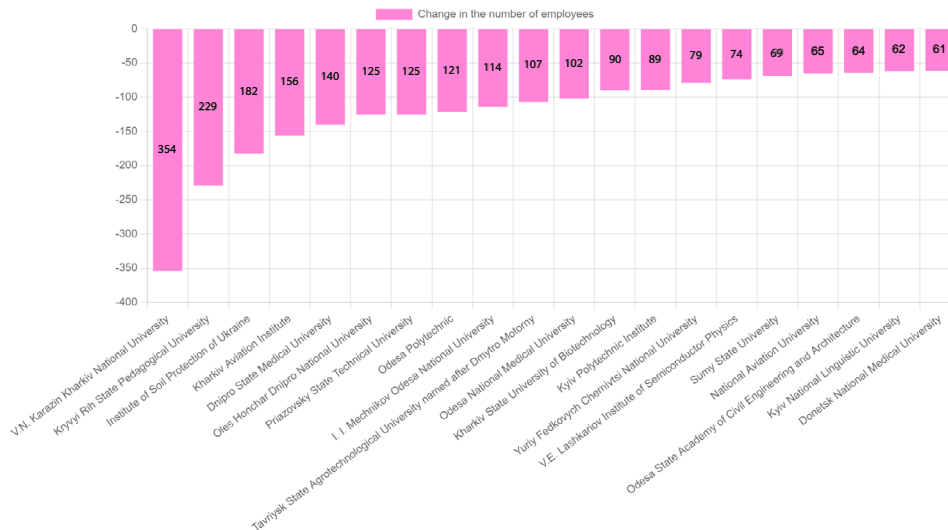


Figure 4: Number of Ukrainian scientists and educators living abroad by host country as of January 2024

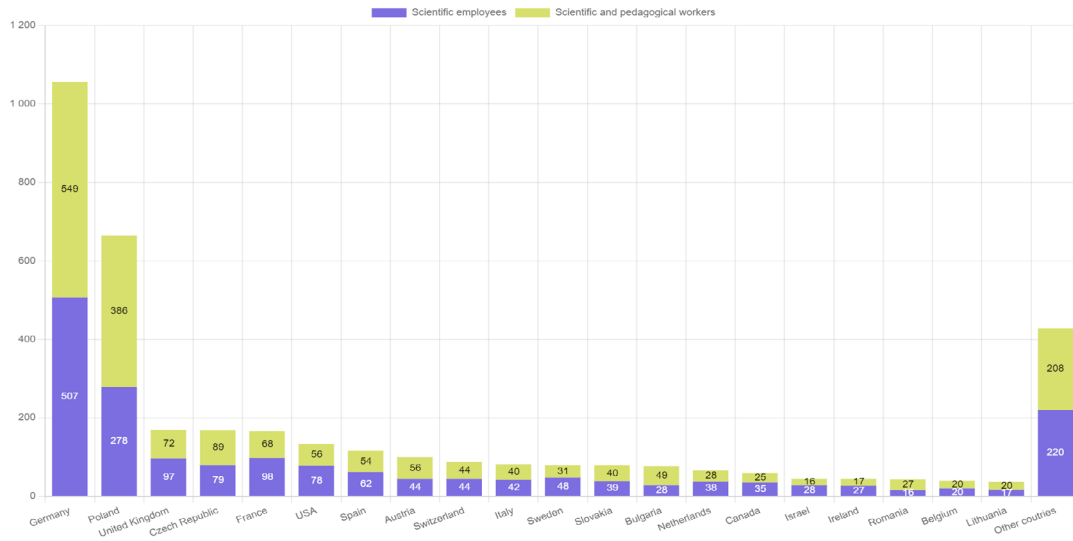


Figure 5: Location of Ukrainian researchers as of January 2024

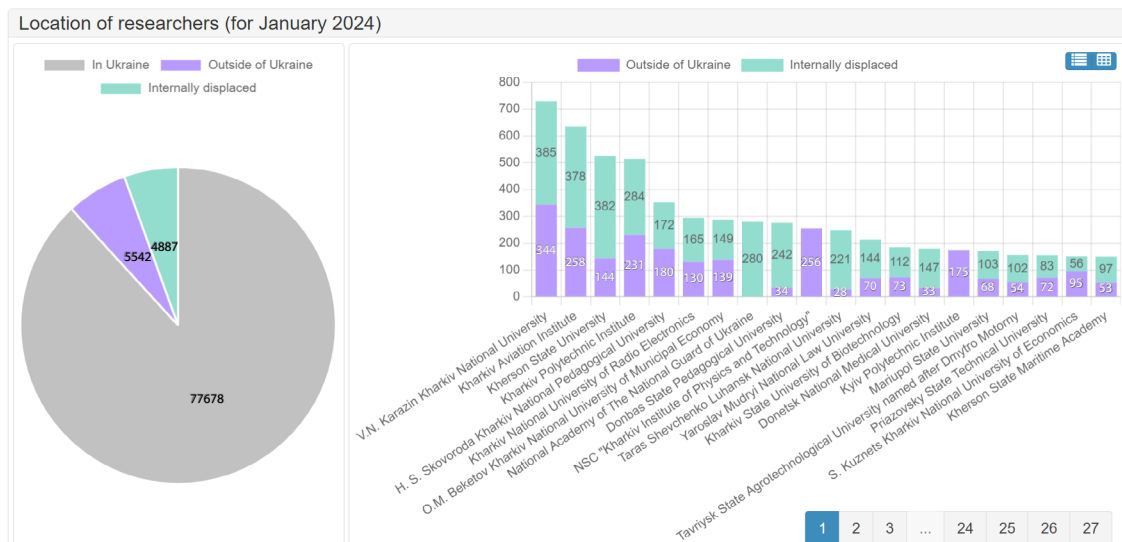
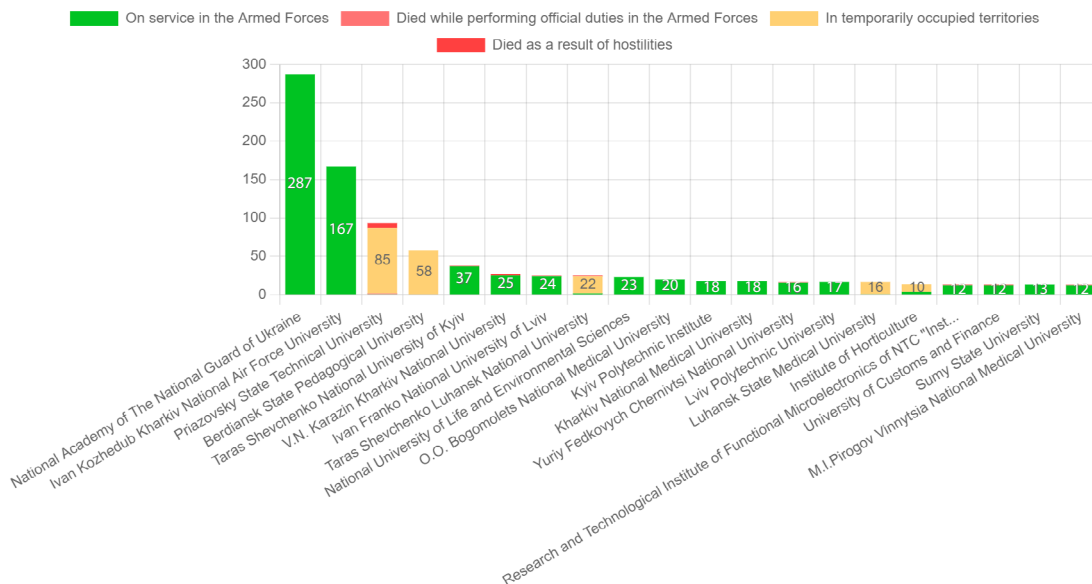


Figure 6: Loss of employees of Ukrainian science sector to war effort, hostilities and occupation as of January 2024



2. National Academy of Sciences of Ukraine

2.1 Damage to real estate

The National Academy of Sciences of Ukraine (hereafter abbreviated to the National Academy of Sciences) is linked to research infrastructure via its research institutes and other scientific institutions, which include observatories, botanical gardens, arboretums, nature reserves, libraries, museums and scientific and technical complexes. (See **Appendix A** for a breakdown of the National Academy of Sciences by sectoral cluster). In all, there are 160 scientific institutions and 36 organizations with an experimental production base within the National Academy of Sciences.

As of the beginning of January 2024, the real estate of the National Academy of Sciences has suffered significant damage to 55 of its scientific institutions and 10 of its enterprises. Of this real estate, 311 buildings have been severely damaged, 19 of which are engineering structures in the university sector (see **Figure 7**). The initial estimated cost of restoration is US\$ 42.5 million, as determined by the damage assessment reports received (see **Figure 7**). Many other reports are still under preparation. **Table 2** lists those institutions attached to the National Academy of Sciences which have sustained the greatest damage. **Table 3** shows the cost of destroyed buildings and those having suffered the greatest damage. It is those institutes located in Kharkiv that have suffered the most property damage.

Special commissions have been established which are in the process of inventorying the extent of damage to scientific institutes of the National Academy of Sciences. It is estimated that up to US\$10 million will be needed to conduct the survey alone. However, a complete survey of the extent of damage to property under the umbrella of the National Academy of Sciences is being hindered by the fact that some institutes are situated in the war zone, including several in occupied territory. This includes institutes located on the territory of Zaporizhzhia, Kherson, in the Luhansk and Donetsk regions and in the Autonomous Republic of Crimea (Ukraine). For example, the research teams of the Institute of Pulse Processes and Technologies in Mykolaiv, the Kherson Hydrobiological Station, and the Zaporizhzhia Scientific and Engineering Center for Plasma Technologies of the E.O. Paton Institute of Electric Welding, which conduct research in the field of nanotechnology, ecology and plasma processes, are situated in the combat zone and under constant shelling. **Figure 8** shows the most

damaged institutions of the National Academy of Sciences over 2014–2023.

A total of 18 scientific institutes from the regions of Zaporizhzhia, Kherson, Luhansk and Donetsk and the Autonomous Republic of Crimea have had to be temporarily relocated. Some of these institutes were previously studying the ecology and biodiversity of Luhansk, Donetsk and Crimea and the impact of technological processes on the natural environment. The activities of these institutes, which no longer have access to local biodiversity and the wider ecosystem, are essential for ensuring the sustainable development of the entire European region.

Table 2 : Institutions of National Academy of Sciences having sustained greatest reported damage as of January 2024

| Institution | Number of damaged and destroyed buildings |
|---|---|
| Kharkiv Institute of Physics and Technologies | 61 |
| Institute of Single Crystals | 41 |
| A.Podgorny Institute of Mechanical Engineering Problems | 16 |
| Institute for Nuclear Research | 12 |
| Subbotin Institute of Geophysics | 29 |

Table 3 : Conservative estimates of renovation costs for institutions of National Academy of Sciences as of January 2024

| Institution | Estimated renovation cost (US\$ millions) |
|---|---|
| Kharkiv Institute of Physics and Technologies | 16.9 |
| Institute of Single Crystals | 7.0 |
| Institute of pulsing processes and technologies | 4.4 |
| Institute of Nuclear Research | 2.4 |
| V. Bakul Institute for Superhard materials | 2.4 |

2.2 Damage to scientific equipment and other movable property

A prerequisite for conducting scientific research is the availability of scientific equipment. Arbitrary theoretical conclusions require experimental confirmation. The conditions for carrying out scientific and experimental work have significantly deteriorated in the National Academy of Sciences' sectoral clusters of Physical and Technical Sciences, Chemical and Technological Sciences and Biological Sciences as a consequence of the bombardments. The Institute for Safety Problems of Nuclear Power Plants needs to upgrade scientific equipment with a market value of US\$ 18.5 million (see **Figure 9**). The Kharkiv Institute of Physics and Technology has lost much of its scientific equipment installed in buildings that have been destroyed. Institutions that are part of the Institute of Single Crystals have lost 21 experimental complexes; the cost of renovating these assets has been estimated at US\$7 million (see **Table 3**).

Of particular note is the Chernobyl district where the laboratories of the Institute for Safety Problems of Nuclear Power Plants are located. This territory was occupied in March 2022. All the scientific equipment that used to provide full-scale monitoring of the state of the Ukrainian nuclear industry, including the Zaporizhzhia nuclear power plant – the largest in Europe with six reactors – has been stolen or destroyed by the Russians since their occupation of the Chernobyl plant in March 2022. For instance, the institute has lost a unique radiological laboratory which had been established thanks to Western aid to control radiation levels at the plant. The loss of the institute's scientific equipment could endanger the nuclear safety and health of more than two billion inhabitants of Europe, North Africa, the Middle East and Central Asia.



Figure 7: Location of damaged and destroyed property of the National Academy of Sciences as of January 2024



Figure 8: Cost of damage to institutes of the National Academy of Sciences of Ukraine caused over 2014–2023

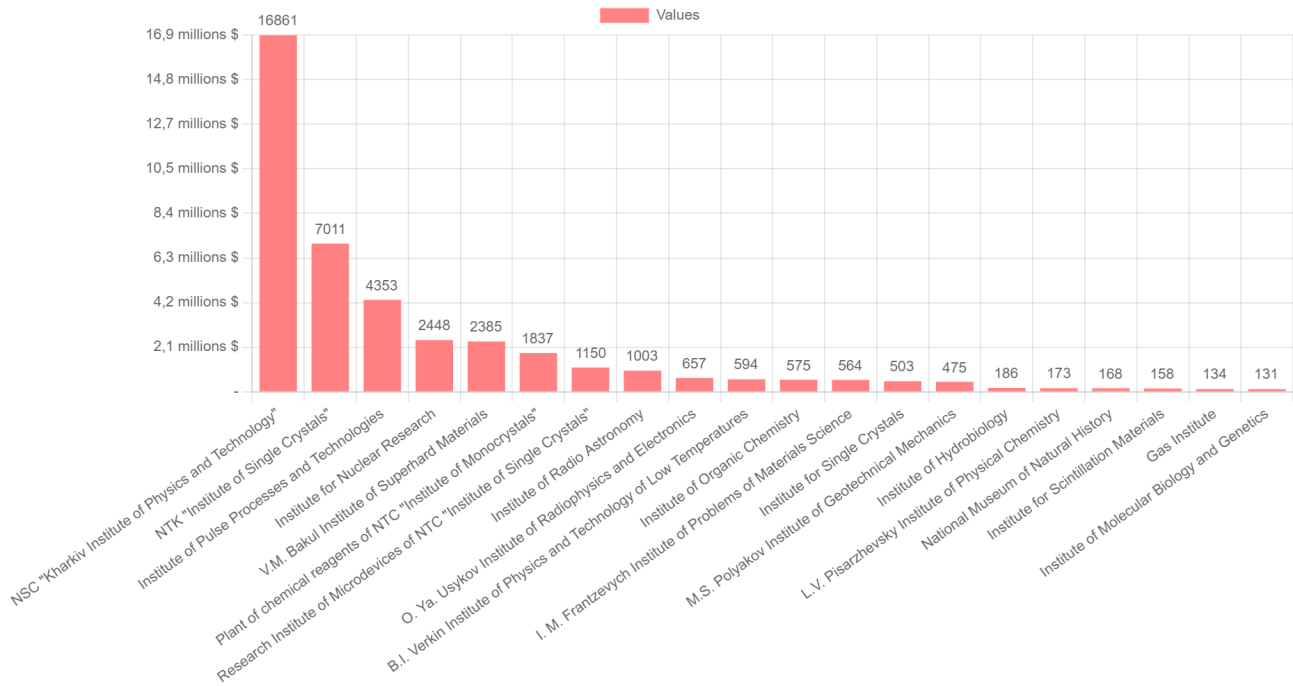
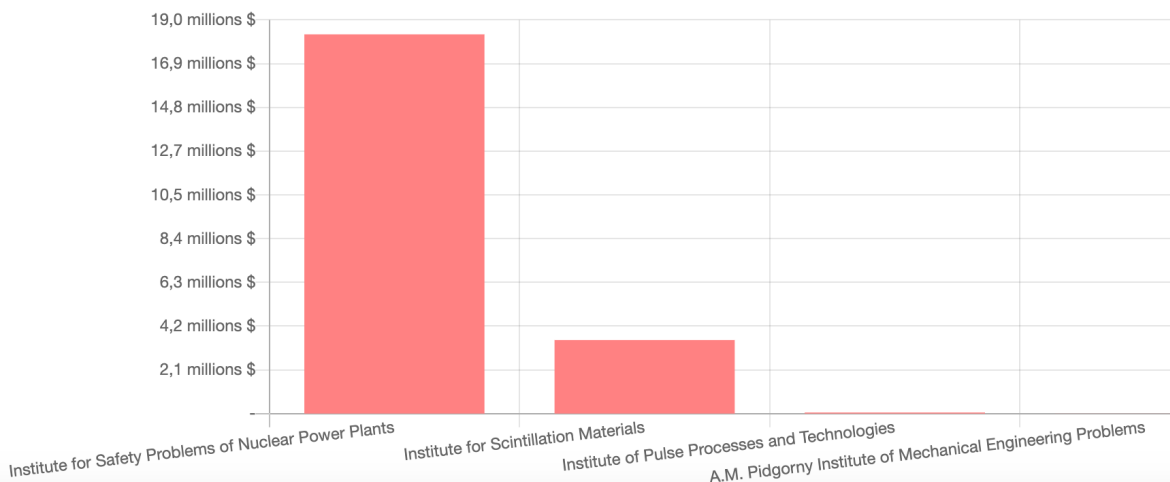


Figure 9: Examples of research institutes having lost most of their scientific equipment as of January 2024
Market value in US\$





V. Bakul Institute for Superhard Materials
© Kunsht Science at Risk project/ Valentyn Kuzan

2.3 Impact on scientific personnel

At the beginning of 2022, the National Academy of Sciences counted 26,167 employees, including 13,883 researchers, among whom there were 2,422 doctors of science and 6,487 candidates of science. By January 2024, these numbers had dropped slightly, with the National Academy of Sciences now counting 24,980 employees, including 13,444 researchers: 2,344 doctors of science and 6,359 candidates of science.

The drop from 13,883 to 13,444 researchers can be explained by the fact that 439 resigned from the National Academy of Sciences or were killed over this two-year period. Eleven of the 208 researchers who joined the Armed Forces of Ukraine have been killed. Another five scientists have died in bombardments of Kyiv, Kharkiv, Sumy and Dnipro.

Although 11% of the Academy's scientific researchers have left Ukraine over the same two-year period, they have retained their employee status. This corresponds to 1,475 out of 13,883 employees. These employees of the Academy are now dispersed across 53 countries. The majority have settled in Germany (406), Poland (220), the United Kingdom (87) and France (81) [see **Figure 10**].

Some 715 researchers (5.3%) are on unpaid leave and another 4% are working remotely. A further 514 (3.8%) have been internally displaced, 1.9% have accepted an internship and 1.7% have taken a leave of absence to launch their own business project. A small number of employees (141) have

been forced to accept part-time work and a drop in pay to 67% of a full working wage.

The scientific discipline most affected by these trends is physics. Some 706 physicists (5% of scientific researchers employed by the Academy) had left Ukraine by January 2024: this includes 292 (2% of the total) from the Department of Nuclear Physics and 235 (1.8%) from the Department of Physics and Astronomy.

Some 256 employees of the Kharkiv Institute of Physics and Technology have had to move abroad following the bombing of the city of Kharkiv; they represent 35% of the scientists who used to work for the institute (see **Figure 11**). In addition, the employment contract has been temporarily suspended for 218 scientists employed by the Kharkiv Institute of Physics and Technology.

The V.E. Lashkariov Institute of Semiconductor Physics has lost 74 staff to emigration and the International Scientific and Educational Centre for Information Technologies and Systems has lost 18 (see **Figure 12**).

The humanities have been least affected by these trends. Just 27 literary scholars (0.2% of scientific researchers) from the Department of Literature, Language and Art Studies have been affected by these trends, a similar level to the Department of Mechanics (30 people, or 0.2%) and institutions under the Presidium of the National Academy of Sciences (29 people, or 0.2%).

Figure 10: Country of residence of displaced employees of the National Academy of Sciences as of January 2024

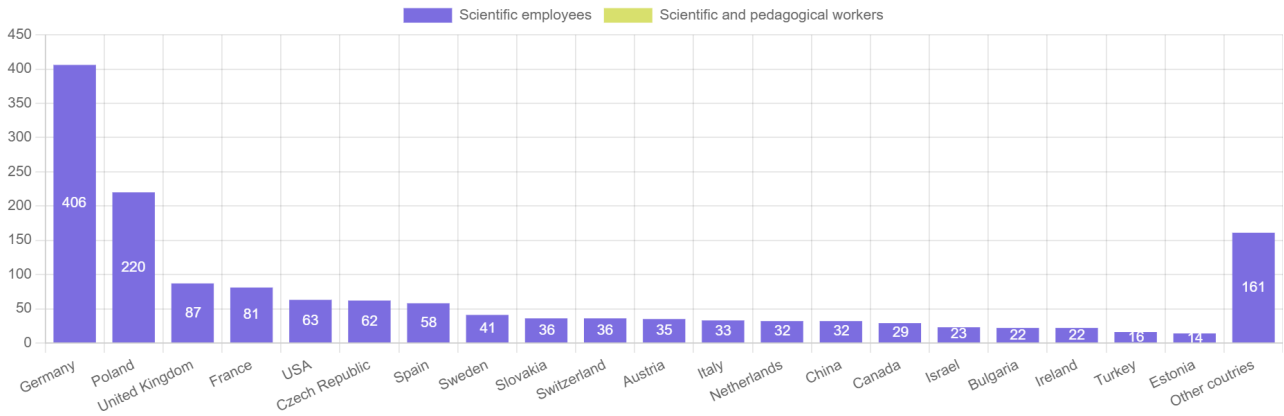


Figure 11: Employee migration from institutions of the National Academy of Sciences as of January 2024
In head counts

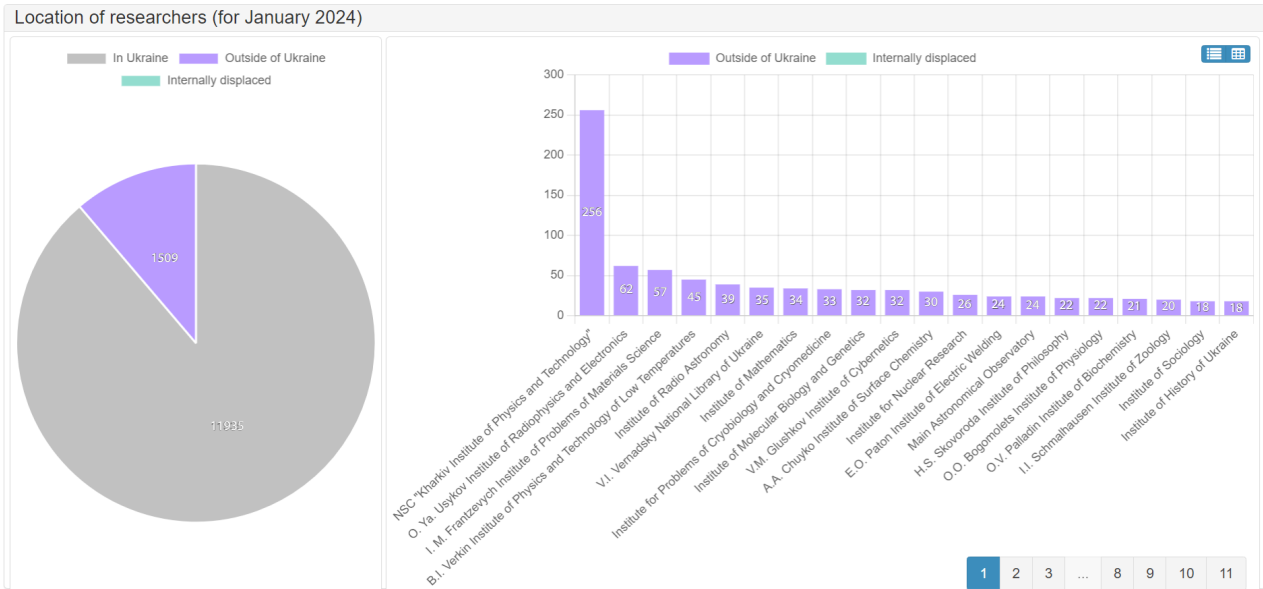
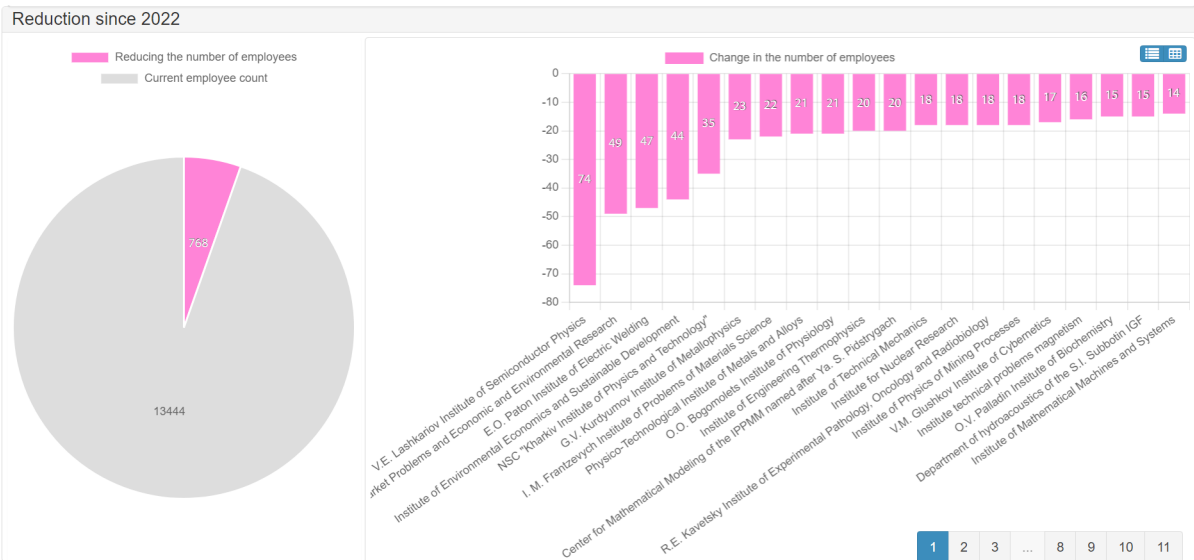


Figure 12: Decrease in number of scientific researchers at National Academy of Sciences as of January 2024
In head counts



2.4. Evolution in financial support

Ukraine's state budget has seen a dramatic decrease in funding as a consequence of the Russian invasion in February 2022. The entire budget plan of the National Academy of Sciences has almost halved in two years: from US\$ 238.6 million in 2021 to US\$ 184.8 million in 2022 and US\$ 124.8 million in 2023.

This has eroded the average monthly salary of employees from US\$ 454.2 (2021) to US\$ 371.5 (2022) then US\$ 274.9 (2023). In other words, salaries dropped by US\$ 82.7 in 2022 then by US\$ 179.3 in 2023, compared to their level in 2021. The average monthly salary of the Academy's employees was already lower before the war than in the country's economic and industrial sectors.

Another manifestation of the prolonged underfunding of the National Academy of Sciences since February 2022 is the amount of time that scientists are spending on unpaid leave. The average occupational level at the Academy has dropped to 10.2 months and the average coefficient of working time to 0.85.

In light of the National Academy of Sciences' current funding situation, steps have been taken to ensure that its institutions can operate during wartime, including by:

- reducing the funding approved at the beginning of the year for the estimated capital expenditure of the Academy's institutions, rendering the purchase of research instruments and equipment impossible and making it necessary to terminate the programme for the Provision of Housing for the National Academy of Sciences' Researchers;
- terminating funding for a number of ongoing targeted research programmes and projects; and by
- reducing expenditure earmarked to support research infrastructure.

The main challenge for the sustainable development of Ukraine's scientific infrastructure will be to reformat its strategic collaboration with science systems worldwide, on the one hand, and to adapt domestic business processes, on the other.

2.5 Evolution in publishing activity

One negative consequence of the Russian invasion has been a decrease in publishing activity by scholars attached to the National Academy of Sciences. There has been a drop in scientific collaboration with member states of the European Union, members of the Euro-Atlantic Partnership and the democratic and technologically advanced countries of the African and Asian regions. This has hampered Ukraine's European and global integration.

In 2021, scientists in Ukraine published 73 monographs abroad, as well as 5,299 research articles in foreign professional and indexed journals. In parallel, they published 355 monographs in Ukraine and 10,177 research articles in domestic periodicals.

In 2022, however, the number dropped to 41 monographs and 5,013 research articles published abroad and 223 monographs and 8,720 research papers published in

domestic journals. This translates into a drop of 43% and 6%, respectively, for the number of monographs and research articles published abroad in 2022 and into a drop of 17% for monographs and 16% for the number of articles published in Ukrainian scientific journals (see **Table 4**). These negative trends were primarily caused by significant cutbacks to the funding of institutions attached to the National Academy of Sciences.

In 2023, the situation stabilized at 2022 levels. Some 49 monographs were published abroad, a drop of 33% over 2021 but a slight increase over 2022 (see **Table 4**). The number of scientific articles published abroad pursued its decline but only by a modest 1.7% in 2022. On the domestic front, the number of monographs rose slightly in 2023 over the previous year, as did the number of scientific articles published by Ukrainian journals.

Table 4: Volume of publishing by institutions of National Academy of Sciences of Ukraine, 2021–2023

| Type of Publication | 2021 | | 2022 | | 2023 | | Change, 2021–2022 | | Change, 2021–2023 | |
|---------------------|----------|---------------|----------|---------------|----------|---------------|-------------------|----------|-------------------|----------|
| | Domestic | International | Domestic | International | Domestic | International | International | Domestic | International | Domestic |
| Monograph | 355 | 73 | 223 | 41 | 229 | 49 | -44% | -37% | -33% | -36% |
| Research article | 10,177 | 5,299 | 8,720 | 5,013 | 8,835 | 4,928 | -6% | -14% | -7% | -13% |



Okhlyrka Municipal Local History Museum
© Kunsht Science at Risk project/ Valentyn Kuzan

3. Sectoral academies

3.1 Damage to real estate

Some 22 institutions, 141 buildings and 33 engineering constructions of the sectoral academies had been damaged and destroyed as of January 2024. The cost of renovating them has been estimated at US\$ 49 million (see **Table 1**). Twenty-four will require reconstruction. Another 40 require ongoing repairs and 10 renovation. See **Figures 13** and **14** for the sectoral academies most affected.

The cost of damage to the Institute of Mechanics and Automation in Agro-industrial Production under the National Academy of Agrarian Sciences is estimated at US\$ 26.5 million. For the V. T. Zaitsev Institute of General and Emergency Surgery under the National Academy of Medical Sciences, the damage has been estimated at US\$ 7.5 million. It is followed by the Institute of Neurology, Psychiatry and Narcology (US\$ 4.1 million) and the V. Y. Danilevsky Institute of Endocrine Pathology Problems (US\$ 3.3 million), the Institute of Experimental and Clinical Veterinary Medicine (US\$ 1.5 million).

Damage to the buildings of the Bila Tserkva Institute of Continuing Professional Education of the University of Educational Management, which falls under the National Academy of Pedagogical Sciences, has been estimated at US\$ 1.3 million. This institution was transferred to the city of Bila Tserkva in the Kyiv region in 2014 after the Russian occupation of the Donbas.

The 12 research institutes of the National Academy of Agrarian Sciences have been most affected, as all are under occupation. They are the following:

- Genichesk Research Station of the State Institution of the Institute of Grain Crops;
- Roziv Research Station of the State Institution of the Institute of Grain Crops;
- State Institution Research Farm “Brylivske” of Sarnenska Research Station of the Institute of Water Problems and Amelioration;
- State Institution Research Farm “Velyki Klyny” of Sarnenska Research Station of the Institute of Water Problems and Amelioration;
- State Institution Research Farm “Kahovske” of the Institute of Irrigated Agriculture;
- State Institution Research Farm “Pioneer” of the Institute of Climate-Oriented Agriculture;
- State Institution Research Farm “Kopany” of the Institute of Irrigated Agriculture;
- State Institution Research Farm “Novokakhovske” of the Rice Institute;
- Melitopol M. F. Sydorenko Research Station of Horticulture of the Institute of Horticulture;
- State Institution Research Farm “Melitopolske” of Melitopol M. F. Sydorenko Research Station of Horticulture of the Institute of Horticulture;
- State Institution Research Farm “Renaissance” of Donetsk State Agricultural Research Station; and the
- State Institution Research Farm “Yakymivske” of the Experimental Station of Essential Oil and Rare Agricultural Crops.

3.2 Damage to scientific equipment and other movable property

The research institutes of sectoral academies have lost practically none of their scientific and technical equipment, with the exception of the Institute of Dermatology and Venereology attached to the National Academy of Medical Sciences. Located in the Kharkiv region, the institute has lost research equipment worth US\$ 161,500.

The National Academy of Agrarian Sciences should be included in this category but, as it is situated in temporarily occupied territory, it is currently impossible to determine the extent of damage, although this is expected to be in the tens of millions of US dollars.

3.3 Impact on scientific personnel

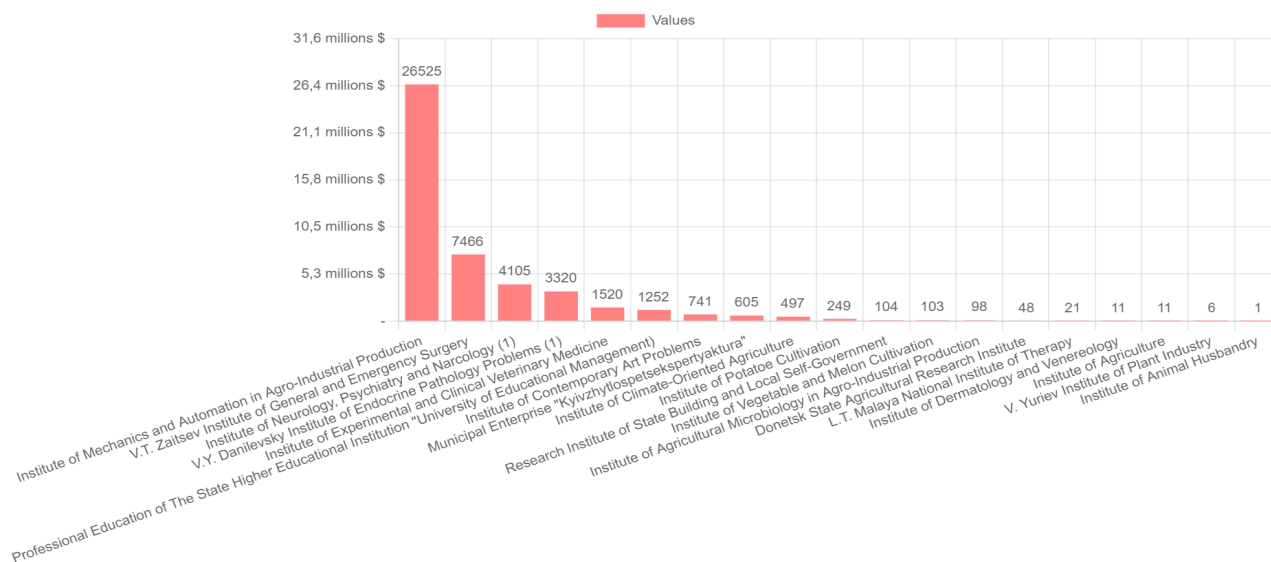
In early 2022, 6,856 scientists were employed by research institutes attached to the sectoral academies of science. These institutes have since lost more than one-quarter (27.9%) of their researchers. By January 2024, 1,060 (15.5%) were working remotely, 365 (5.1%) had resigned,

276 (4.1%) were living abroad and 134 (2.0%) had been internally displaced. Of the 75 scientists (1.1%) who have joined the ranks of the Armed Forces of Ukraine, four have since died in combat.

Figure 13: Damaged buildings of sectoral academies as of January 2024



Figure 14: Most damaged institutes of sectoral academies as of January 2024
Residual value in US\$





Admiral Makarov Mykolaiv National University of Shipbuilding
© Kunsht Science at Risk project/Valentyn Kuzan

4. University sector

4.1. Damage to real estate

The university sector conducts 52% of publicly funded research. About 140 universities are subordinated to the Ministry of Education and Science. Of these, about 40 are grouped in the cities of Kyiv, Kharkiv and Odesa. About 20 universities are under temporary occupation in the Donetsk, Luhansk and Crimean regions, as well as in part of the temporarily occupied districts of Zaporizhzhia and in the Kherson region.

As of January 2024, the buildings of 65 universities attached to the National Academy of Sciences had

been damaged, including research laboratories. Of the 703 severely damaged buildings, 131 are engineering structures used for scientific purposes. **Figure 15** shows the location of universities, some of which are situated in the combat zone or under occupation, as well as the damage to these. The residual value – or salvage value – of damaged university buildings amounts to more than US\$ 638 million. It is estimated that at least US\$ 981 million will be needed to restore them. **Figure 16** shows the most affected universities.

4.2 Damage to scientific equipment and other movable property

The war has caused widespread damage to the research equipment of Ukrainian universities, with 618 pieces of equipment having been disabled, damaged or destroyed (see **Figure 17**).

The State Technical University of Priazovsk has suffered the greatest damage. It is now located in temporarily occupied territory. The value of its damaged and destroyed equipment has been estimated at more than US\$ 1 million. Other universities that have incurred significant damage to equipment include Taras Shevchenko National University of Luhansk (US\$ 890,200), the State University of Mariupol (US\$ 657,000) and V. N. Karazin National University of Kharkiv (US\$ 482,500). See **Figure 18**.

It is the universities in the Kharkiv region that have suffered the most damage. The cost of damage to Yaroslav Mudryi National Law University amounts to US\$ 116.5 million and damage to the O. M. Beketov National University of Urban Economy has been calculated at US\$ 104.1 million. Taras Shevchenko National University of Kyiv was damaged by cruise missiles, causing damage of US\$ 96.3 million.

The total cost of damage to the scientific equipment of Ukrainian universities comes to more than US\$14.3 million but it would cost an estimated US\$16.5 million to replace it. These are preliminary estimates that do not take into account the impact on some unique research.

Figure 15: Location of damaged and destroyed universities as of January 2024



Figure 16: Cost of damage to university buildings as of January 2024
Residual value in US\$

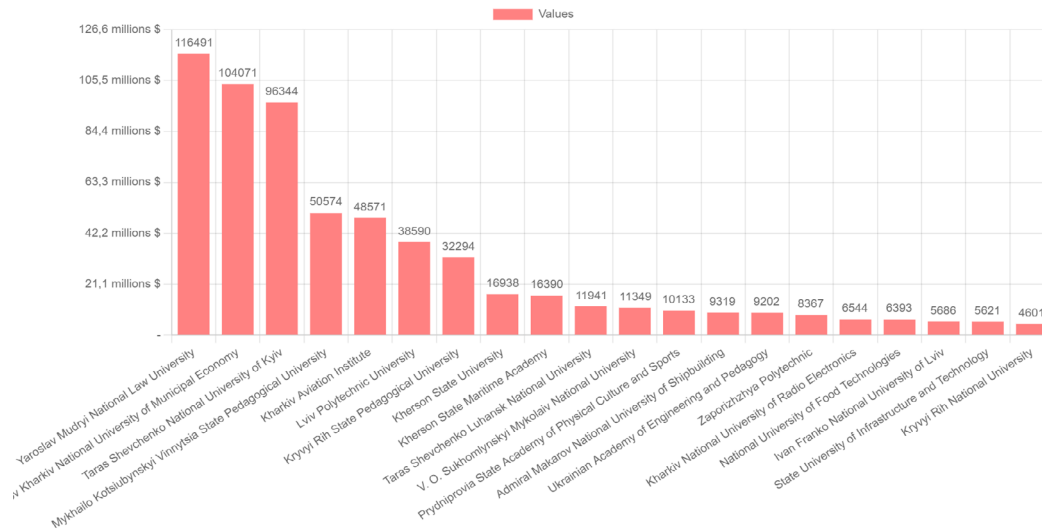


Figure 17: Damaged and destroyed equipment of Ukrainian universities as of January 2024

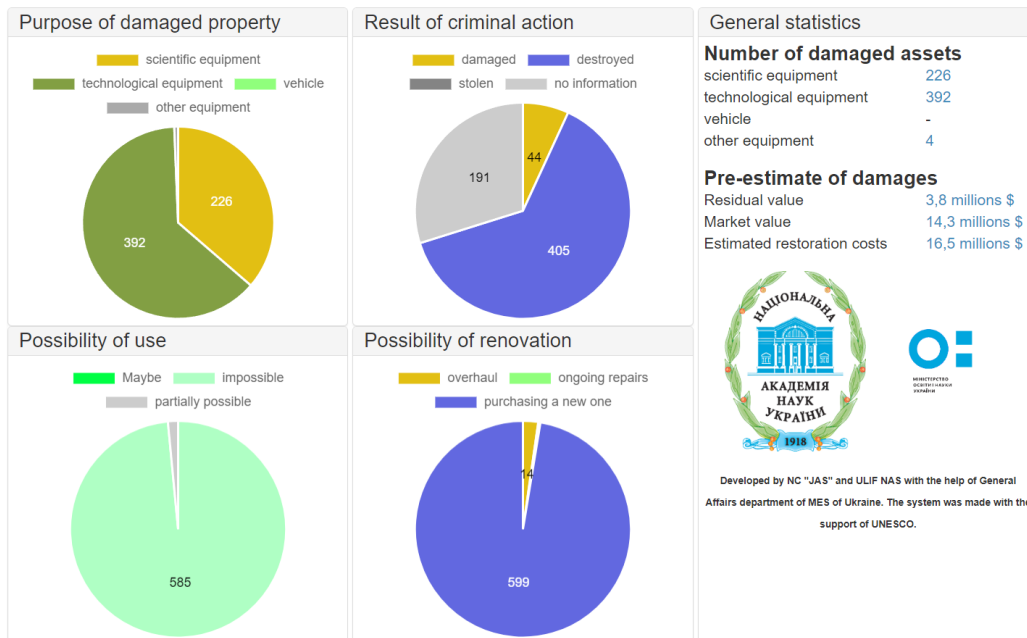
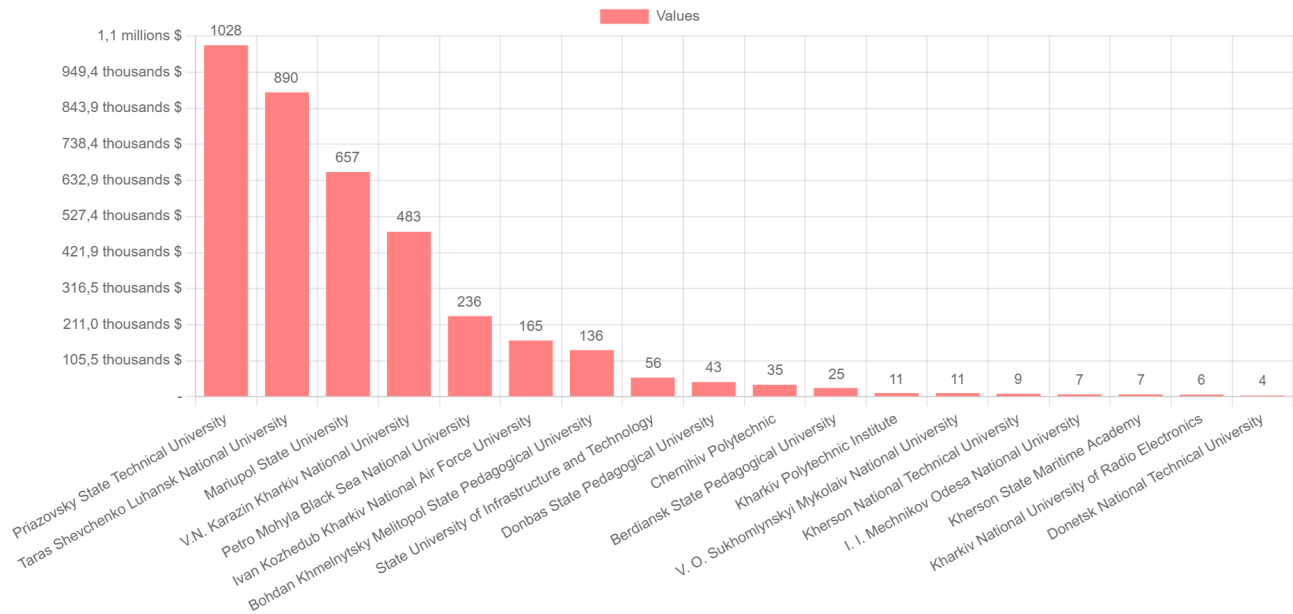


Figure 18: Ukrainian universities with the most damaged scientific equipment as of January 2024
Residual value in US\$



4.3. Impact on academic personnel

Before the war, the academic staff of Ukrainian universities numbered 54,630, including researchers, professors, associate professors and lecturers. As of January 2024, 7,375 researchers, professors, associate professors and lecturers have either been internally displaced or emigrated, representing 13.5% of all academic staff. Of these, 3,949 scientists have been forced to change their place of residence within Ukraine to escape from bombardments and another 3,426 have moved to other countries in Europe or to North America (see **Figures 19** and **20**).

It is the V.N. Karazin National University of Kharkiv which has lost the most academic staff: 385 have been internally displaced and another 344 have left Ukraine. The university is followed by the Aviation Institute of Kharkiv (378 staff displaced within Ukraine and 258 emigrants), the State University of Kherson (382 within Ukraine and 144 emigrants) and the Polytechnic Institute of Kharkiv (284 within Ukraine

and 231 emigrants). At ten universities, the number of internally displaced or emigrant staff exceeds 200.

According to data from the Ministry of Science and Education for 102 universities out of 140, these institutions employed 44,040 researchers in 2023. Of these, 25,300 (57.4%) were women. This means that women dominate staffing tables at these universities, since gender parity is considered to fall within the range of 45–55% of researchers.

According to the UNESCO Institute for Statistics, women made up 46.4% of researchers (in head counts) in the Ukrainian public research sector as a whole in 2022. This ratio has remained relatively stable over the past decade, although it has increased by two percentage points since 2019 (from 44.3%), including by one percentage point since the start of the war. In 2020, women made up 45.4% of Ukrainian researchers and, in 2022, 46.1% (see **Appendix C**). These figures exclude the temporarily occupied territories.

Figure 19: Countries of residence of academic staff having emigrated from Ukraine, as of January 2024

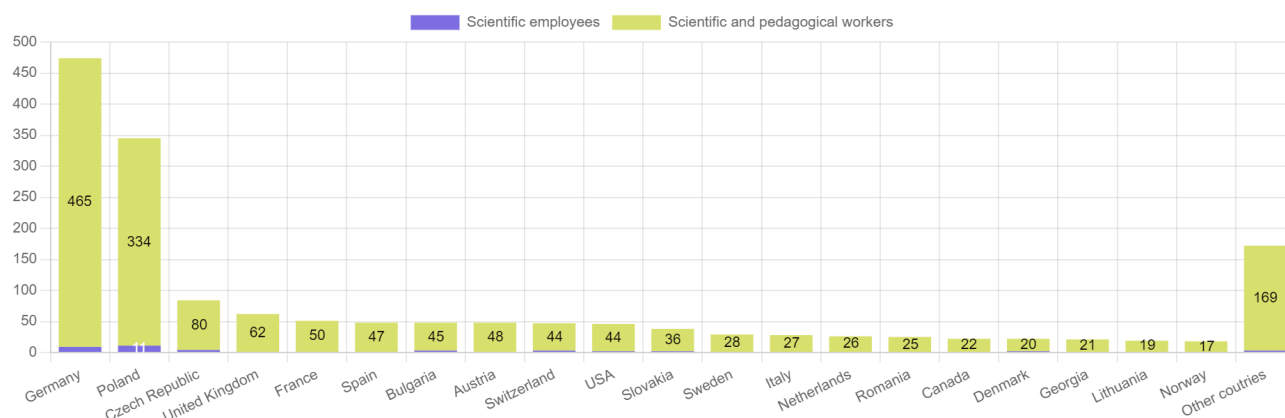
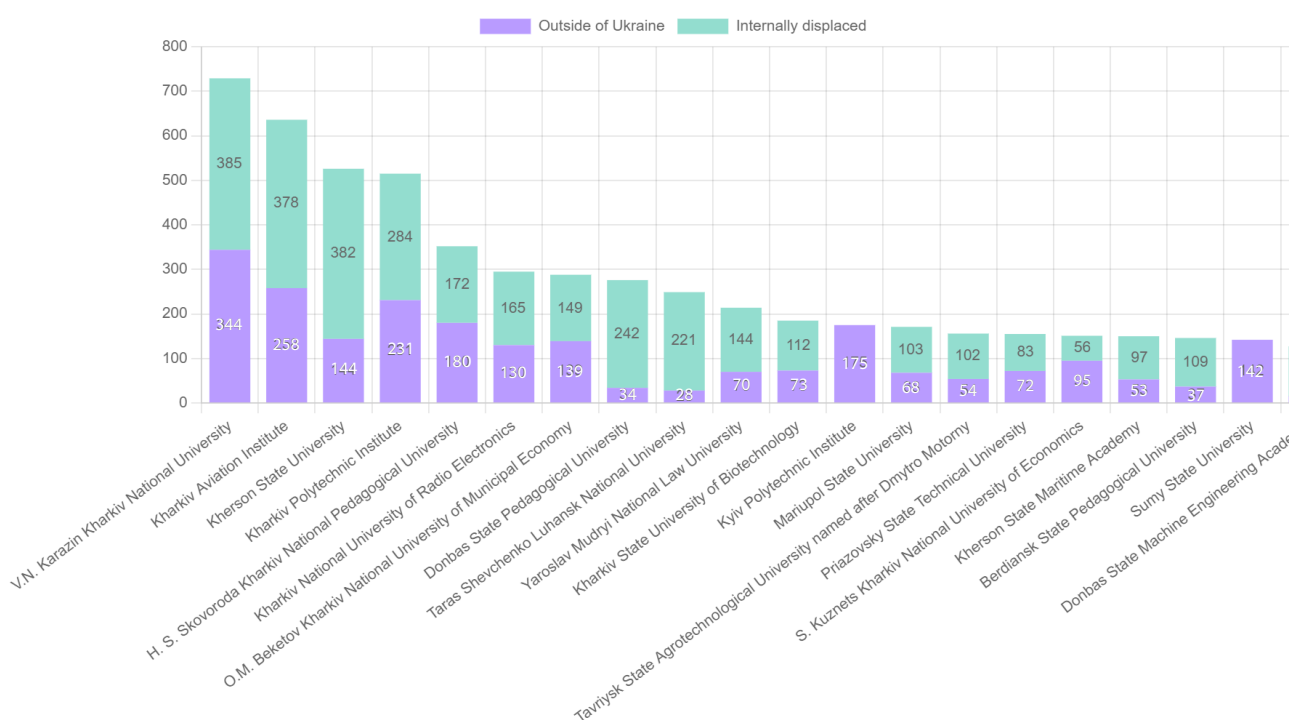


Figure 20: Location of academic staff as of January 2024



The displacement of university staff has affected the organization of work. Some 21,857 academic researchers are working remotely, equivalent to 40% of all university research and teaching staff (see **Figure 21**). In all, more than 500 scientists from 16 universities are working remotely. Most are located in the Kharkiv, Kyiv, Sumy, Dnipro, Odesa and Zaporizhzhia regions, which are most affected by bombardments.

This situation has driven the following universities to move many of their academics to teleworking: Aviation Institute of Kharkiv (1,722 scientists), Polytechnic Institute of Kharkiv (1,286), National Aviation University of Kyiv (1,162), Mykhailo Drahomanov Ukrainian State University (935), Yaroslav Mudryi National Law University (922) State University of Sumy (784).

Some 30 scientists from academia who had volunteered to defend Ukraine have been killed in the line of duty. A further 926 scientists from 101 universities are currently fighting in the Armed Forces of Ukraine (see **Figure 22**), 187 (20.2%) of them in occupied territory. For instance, 167 scientists from

the Ivan Kozhedub National Air Force University of Kharkiv have joined the Armed Forces of Ukraine, along with 37 from Taras Shevchenko National University of Kyiv, 25 from the V.N. Karazin National University of Kharkiv and 24 from Ivan Franko National University of Lviv.

Figure 21: Number of academics on an adjusted work regime as of January 2024

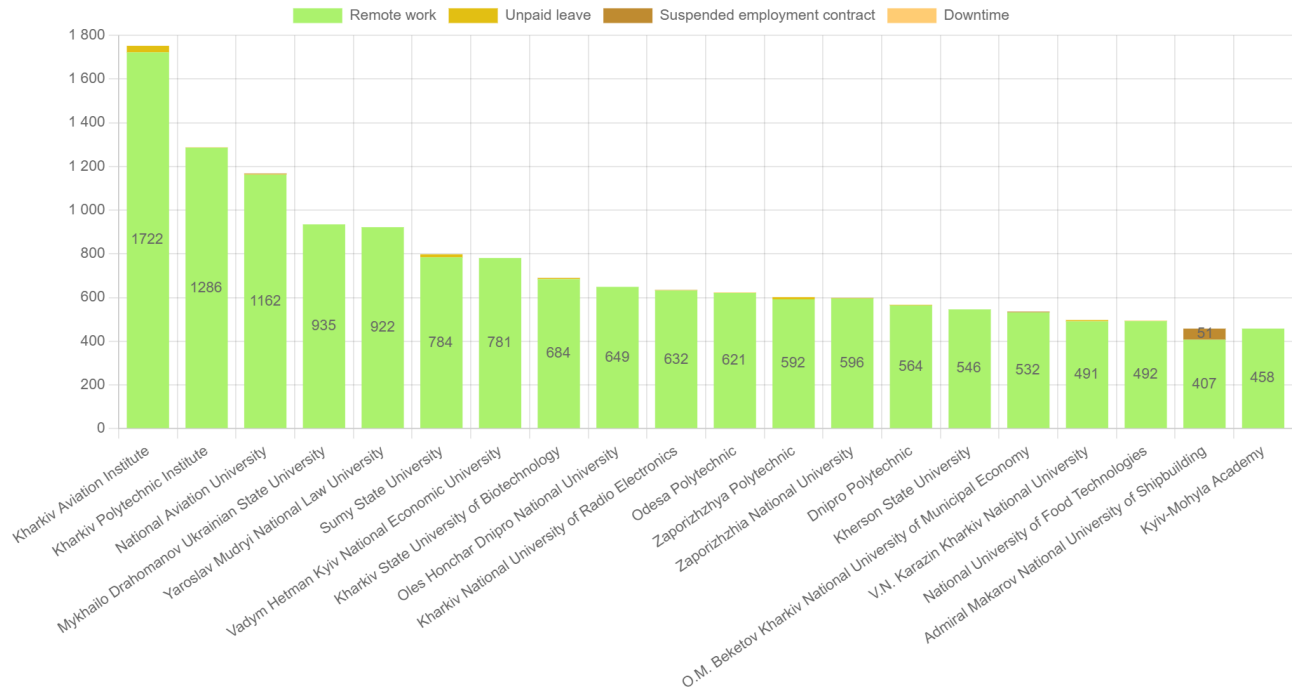
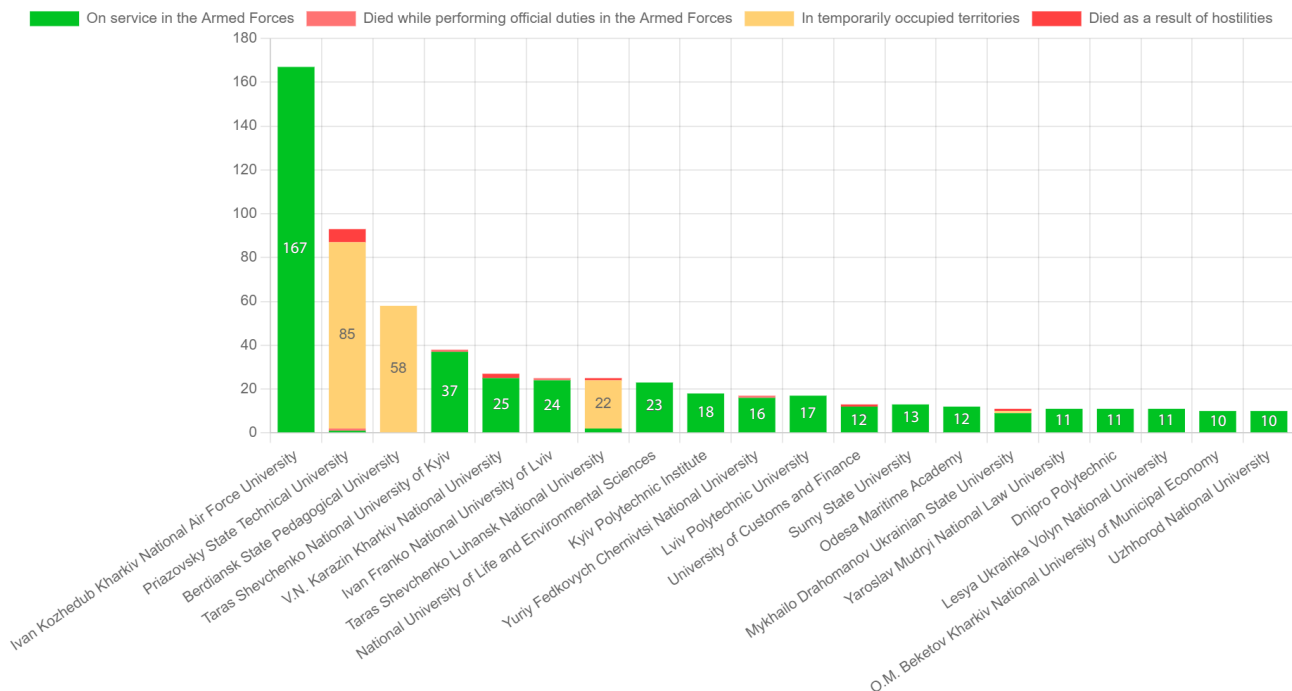


Figure 22: Loss of academics to the war effort, hostilities and occupation as of January 2024



5. Ministries with research institutions

5.1 Damage to real estate

The location of the property of the seven ministries with research institutes is presented in **Figure 23**. (For the list of these seven ministries, see **Appendix B**.) As can be seen from **Figure 24**, 35 institutions, 288 buildings and 5 engineering constructions have been damaged and destroyed since 2022. The cost of rebuilding has been estimated at more than US\$ 143 million. Some 33 buildings will need to be entirely reconstructed, 143 buildings require repairs and, for 82 of them, major repairs. A further seven require renovation.

The most damaged institutes (see **Figure 25**) are Kharkiv National Medical University (US\$ 55.7 million worth of

damage), State Tax University (US\$ 15.2 million); the National Academy of the National Guard (US\$ 10.9 million), National University of Civil Defense (US\$ 5.7 million), Kyiv Institute of the National Guard (US\$ 5.7 million), Donetsk State University of Internal Affairs (US\$ 5 million) and the Ukrainian Research Institute of Ecological Problems (US\$ 3 million).

It should be noted that damage to research institutes of the following ministries has been estimated at more than US\$ 143 million: the Ministry of Health; Ministry of Internal Affairs; and the Ministry of Environmental Protection and Natural Resources.

5.2. Damage to scientific equipment and other movable property

The Ministry of Environmental Protection and Natural Resources, represented by the Ukrainian Scientific Centre of Marine Ecology, has suffered the greatest losses in terms of scientific and technical equipment. It has lost the Boris Alexandrov, a research vessel which was used for state environmental monitoring of marine waters, at a cost of US\$ 10.4 million.

Preliminary estimates of the cost of renewing the scientific equipment of the ministries' research institutes are: Ministry of Environmental Protection and Natural Resources (US\$ 10.9 million), Ministry of Agriculture (US\$ 1 million), and Ministry of Internal Affairs (US\$ 148,700).

5.3. Impact on ministry personnel

The seven ministries employ 13,102 scientists. Of these, 1,586 (12.1%) are working remotely, 812 (6.2%) are internally displaced and 329 (2.6%) are living abroad. Of the 525 scientists who have joined the ranks of the Armed Forces of Ukraine,

11 have since died in combat. Another 811 scientists (5.9%) have resigned from research institutes attached to the seven ministries. This means that, in all, the seven ministries have lost three in ten (31%) of their scientists since February 2022.

Figure 23: Damaged buildings of research institutions attached to ministries as of January 2024

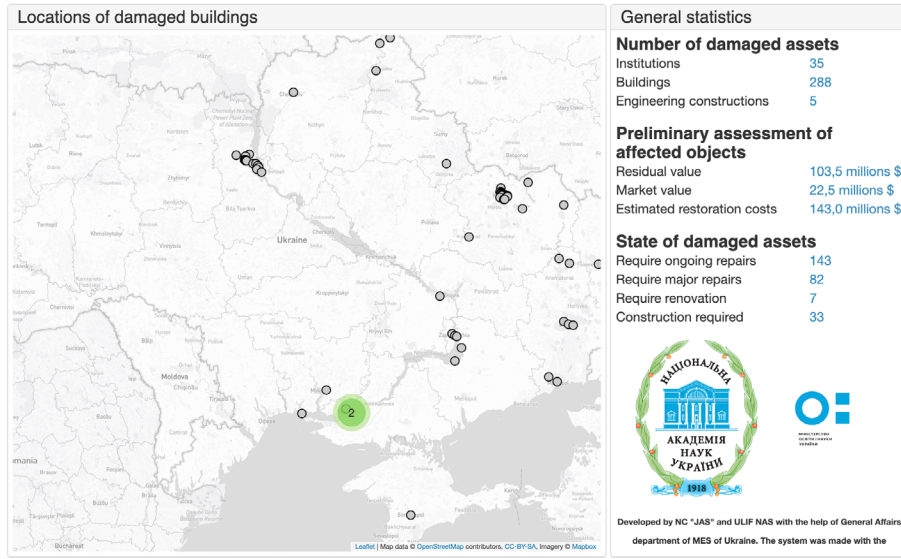


Figure 24: Most damaged insitutions attached to ministries as of January 2024

Residual value in US\$

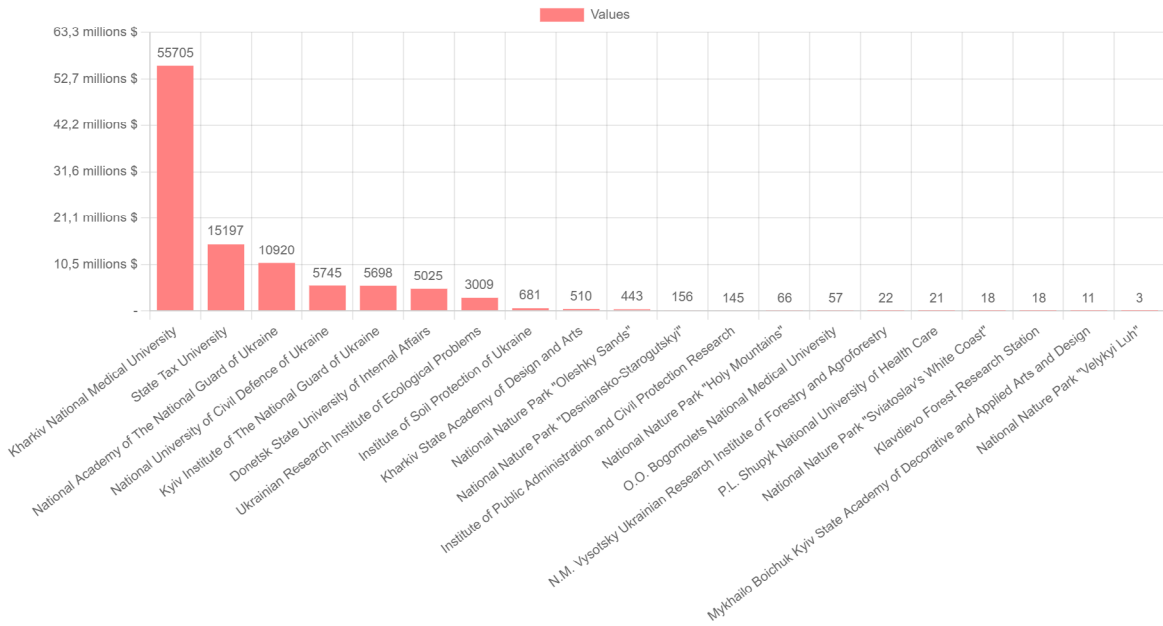
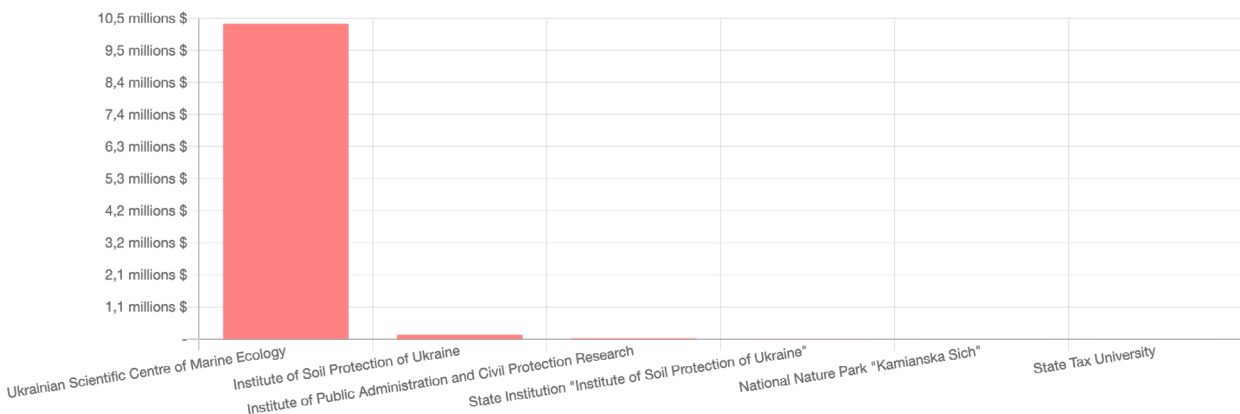


Figure 25: Most damaged scientific insitutions attached to ministries as of January 2024

Residual value in US\$



6. Main Challenges Faced by Ukrainian Science Sector

The main challenge faced by the Ukrainian science sector is the unfavourable working environment for research and academic pursuits induced by the war. Property and scientific equipment have been damaged or destroyed, with looting of scientific equipment posing an additional problem. The number of scientists and engineers is dropping as a consequence of internal displacement and emigration.

Financial support for the scientific institutions of the National Academy of Sciences of Ukraine has dropped, as has the number of scientific publications. Scientific publishing used to be one of the platforms for establishing linkages both between the different sectors of the Ukrainian economy and with the science systems of other countries.

Scientific collaboration has declined, despite being so important for the integration of Ukraine's technological and socio-humanitarian development processes with relevant structures and processes in countries of the European Union, with members of the Euro-Atlantic Partnership and with the democratic and technologically advanced countries of the African and Asian regions.

These processes can be identified and substantiated through the effective transfer of knowledge characterizing and describing them in scientific and technological narratives. This is one of the basic conditions for the implementation of essential steps in ensuring sustainable

development processes in Ukraine towards European and global integration.

To some extent, the migration of scientific staff has dampened collective interactions that used to take place through joint research and technical projects. This highlights another challenge related to the efficiency of the knowledge transfer accumulated in Ukraine's scientific infrastructure.

The aforementioned factors have affected the implementation of technological solutions based on scientific and technical products that ensure the development of a country's economy. In particular, the volume of internal contracts concluded with domestic departmental and business structures has fallen by US\$ 10,429,818, compared to 2021 (from US\$ 22,059,157 in 2021 to US\$ 11,629,339 in 2022), a 1.9-fold reduction.

A similar trend has been observed for international contracts. Compared to 2021, the total volume of contracts with foreign business structures decreased by US\$ 1,891,600 in 2022 (from US\$ 5,072,190 to US\$ 3,180,590), a 1.6-fold reduction.

Therefore, the main mega-challenge for the sustainable development of Ukraine's scientific infrastructure in the context of the Russian invasion will be to reformat its strategic communication with scientific systems worldwide and internal business processes.

Appendix A

BREAKDOWN OF NATIONAL ACADEMY OF SCIENCES OF UKRAINE BY SECTORAL CLUSTER

The scientific institutions of the National Academy of Sciences of Ukraine are broken down into 14 departments grouped in three sectoral clusters (see **Table A1**). The sectoral academies comprise five national academies, to which are attached 116 research institutions (see **Table A2**).

Table A1: Sectoral clusters of National Academy of Sciences of Ukraine

| | |
|--|--|
| Sectoral Cluster of Physical and Technical Sciences | Department of Mathematics |
| | Department of Informatics |
| | Department of Mechanics |
| | Department of Physics and Astronomy |
| | Department of Earth Sciences |
| | Department of Physical and Technical Problems of Materials Science |
| | Department of Physical and Technical Problems of Energetics |
| Sectoral Cluster of Chemical, Technological and Biological Sciences | Department of Nuclear Physics and Energetics |
| | Department of Chemistry |
| | Department of Biochemistry, Physiology and Molecular Biology |
| Sectoral Cluster of Social Sciences | Department of General Biology |
| | Department of Economics |
| | Department of History, Philosophy and Law |
| | Department of Literature, Language and Art History |

Table A2: Research institutions attached to Ukrainian sectoral academies

| Sectoral academy | Number of research institutions |
|--|--|
| National Academy of Agrarian Sciences | 52 |
| National Academy of Medical Sciences | 36 |
| National Academy of Art Studies | 5 |
| National Academy of Legal Sciences | 8 |
| National Academy of Pedagogical Sciences | 15 |

Appendix B

MINISTRIES OF UKRAINE WITH RESEARCH INSTITUTIONS

Seven ministries have a total of 128 research institutions attached to them (see **Table B1**). These institutions are spread throughout the territory of Ukraine to reflect their focus on researching various ecological processes in different parts of the country.

Table B1: Research institutions attached to seven Ukrainian ministries

| Ministry | Number of research institutions |
|--|---------------------------------|
| Ministry of Agrarian and Industrial Complex | 8 |
| Ministry of Environmental Protection and Natural Resources | 62 |
| Ministry of Finance | 1 |
| Ministry of Internal Affairs | 15 |
| Ministry of Culture and Information Policy | 15 |
| Ministry of Health | 25 |
| Ministry of Justice | 2 |

Appendix C

RESEARCH EXPENDITURE AND RESEARCHERS IN UKRAINE, 2011–2021

The UNESCO institute for Statistics has compiled statistics on trends in research expenditure (see **Table C1**) and researchers (see **Table C2**) in Ukraine over the period from 2011 to 2022 using data provided by the State Statistics Service of Ukraine. From 2014 onwards, the totals below exclude data from the temporarily occupied Autonomous Republic of Crimea (Ukraine) and the Donbas grouping the Luhansk and Donetsk regions. The 2022 data for the proportion of female researchers in Ukraine are provisional.

Table C1: Trends in research expenditure in Ukraine, 2011–2022

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| GERD as a percentage of GDP | 0.71 | 0.72 | 0.73 | 0.65 | 0.61 | 0.48 | 0.45 | 0.47 | 0.43 | 0.40 | 0.38 | 0.33 |
| GERD in local currency (millions) | 9 591.3 | 10 558.5 | 11 161.1 | 10 320.3 | 12 224.9 | 11 530.7 | 13 379.3 | 16 773.7 | 17 254.6 | 17 022.5 | 20 544.1 | 16 972.7 |
| GERD in current PPP\$ (millions) | 3 004.5 | 3 202.1 | 3 704.9 | 3 004.5 | 2 677.2 | 2 299.6 | 2 261.4 | 2 515.9 | 2 433.8 | 2 205.3 | 2 228.4 | 1 466.6 |
| GERD in PPP\$ and constant prices - 2017 (millions) | 4 202.4 | 4 284.1 | 4 341.6 | 3 463.7 | 2 954.3 | 2 379.7 | 2 261.4 | 2 456.9 | 2 334.8 | 2 088.4 | 2 019.5 | 1 242.1 |

Source: UNESCO Institute for Statistics database, February 2024

Table C2: Trends in researchers in Ukraine, 2011–2022

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Researchers per million inhabitants (FTE) | 1 259 | 1 231 | 1 160 | 1 021 | 1 006 | 1 037 | 994 | 988 | 881 | 846 | 753 | 581 |
| Researchers per million inhabitants (HC) | 1 544 | 1 510 | 1 447 | 1 297 | 1 259 | 1 495 | 1 400 | 1 365 | 1 218 | 1 232 | 1 044 | 871 |
| Researchers (FTE) - Total | 57 387 | 55 955 | 52 626 | 46 191 | 43 016 | 44 177 | 42 164 | 41 713 | 36 969 | 35 316 | 31 181 | 23 812 |
| Researchers (HC) - Total | 70 378 | 68 599 | 65 641 | 58 695 | 53 835 | 63 694 | 59 392 | 57 630 | 51 121 | 51 427 | 43 229 | 35 702 |
| Researchers (HC) - % female | 45.5 | 45.8 | 45.8 | 45.8 | 46.3 | 45.0 | 44.7 | 44.7 | 44.3 | 45.4 | 46.1 | 46.4 |
| Researchers (FTE) - % female | ... | ... | ... | ... | ... | 43.9 | 43.3 | 43.6 | 43.3 | 45.1 | 45.0 | 45.9 |

Source: UNESCO Institute for Statistics database, February 2024

Abbreviations/Notes

| | |
|--------------|---|
| GERD | Gross domestic expenditure on research and experimental development |
| GDP | Gross Domestic Product |
| PPP\$ | Purchasing Power Parity dollars |
| FTE | Full-time equivalents |
| HC | Head counts |
| ... | Data unavailable |

