The Contribution of Military Research and Development (R&D) to the Development of the Regional Economy

Sorin TOPOR
National Institute for Research and Development in Informatics - ICI Bucharest
sorin.topor@ici.ro

Abstract: The existence and maintenance of military-industrial structures and scientific research and development (R&D) capabilities for military products and technologies are of great importance for ensuring the national security of any state and its international status. The capacity of R&D institutions and departments to invent or innovate military technologies, combined with military industrial capabilities and without external aid, gives a state an extraordinary power in the complex context of international relations.
On the background of the situations that characterize hybrid warfare and the balance of power changes in which humanity finds itself, strategies based exclusively on a national military force are obsolete because no state is able to achieve exclusive hegemony in any area of national security. This does not mean that the right to collective self-defense, determined by a political-military alliance, only entails security benefits and a compensation for deficiencies in the military field. Without any concern in the field of R&D of military technologies specific to the peculiarities of the national security and defense culture, no one can do to a possible aggressor who uses hybrid tactics, especially in cyberspace.
This study aims to demonstrate that the development and promotion of advanced, emerging and disruptive technologies by civil and commercial educational entities can contribute significantly to strengthening national security and supporting defence, against the background of regional and national economic development.
Keywords: Military R&D, Economic Development, Urban Development, Innovative Technologies, Strategy.

INTRODUCTION

Mainly, the current war power of countries is represented by modern military forces that are equipped and trained to use high-tech equipment and have the ability to apply high-tech equipment properly. The lessons learned from the current warfare amply demonstrate that the provision of high-tech military equipment and the comprehensive exploitation of military capabilities based on disruptive and emerging technologies are fundamental factors for achieving victory.

https://doi.org/10.54851/v6i2y202408

These modern military capabilities include the results of quality scientific research and extensive programs of technological development, which strengthens the position and status of the respective country, reflected in the following stages:

- Determining and establishing the technical requirements of equipment and combat systems as well as the tactical norms regarding the employment of the armed forces. Prototypes and advanced models can reform the quality and quantity of armed structures and, at the same time (Laird, 2024), can be subjects of international interest regarding the production, sale and equipping of allied forces;
- The production of quality components, systems and ammunition, thanks to high technologies and increased production capacities, can turn into a strategic direction of development (Deitz & Freyman, 2024), not only for the military industry but also for the economic support of countries;
- Maintaining independence. Undoubtedly, the national military power cannot match the country's economic power. However, the overall magnitude of the power factor cannot be compared with that of major states like USA, Japan, China, Russia and others. Achieving leadership in a subfield of military research, development, or production can generate strong support for economic, local and regional security, a mutually reinforcing and complementary model with civilian technologies and equipment that can support development technology and promote national independence. It is ideal that through scientific research and development the national industry can make proprietary combat systems. This effort can be supported by very few countries that have solid foundations, strong capabilities, and sufficient funds allocated for this purpose. It is noted that even the most powerful states cannot be totally independent in research, development and acquisition of high-performance technologies and equipment. However,talent can be identified, attracted and to identify key solutions for adapting advanced technologies to meet future risks and threats.
- Selecting some research directions and maintaining them as strategic development directions. From the point of view of research and development of military technologies and sciences, there are international leaders in fundamental subfields such as strategy, electronics, electromagnetic technologies, space technologies, 5G/6G communications, autonomous systems, quantum computing and quantum sensors, artificial intelligence (AI) etc. Maintaining a direction of development of advanced technologies based on national resources, even if the subsequent equipment is purchased for the complementary activity from external partners, can determine the occupation of a dominant position in a sub-domain of the world market (Hote et al., 2023). This position will form and strengthen diplomatic and technological relations not only for military systems but for related civilian ones.

The speech of NATO Secretary General Jens Stoltenberg at the meeting of NATO foreign ministers in Riga (Stoltenberg, 2021), held under the auspices of „NATO's outlook towards 2030 and beyond, outlines the framework and establishes the need for a reform of NATO's strategic concept based on patterns new geopolitical realities. From afar, it is noted that NATO forces must be prepared for the unexpected, and focused on responding to multiple challenges or threats, even if they are visible or disguised. The same trend must be supported within the European Union (EU). In this context, the challenges of cyberspace technologies and terrorism remain threats with values far superior to those specific to the armed response that can be given by a single state. The model of NATO's armed capabilities to reinvent and reorient itself according to the situation must be found in the security system of each state of the alliance.

CRITICAL ANALYSIS OF RELATIONSHIPS BETWEEN MILITARY TECHNOLOGIES AND CIVILIAN, EDUCATIONAL AND ECONOMIC UNITS

As emerging, disruptive and critical technologies became centres of global competition, management and governance required normative transformations, especially for the regulation of disputes, a fact that required the adoption of laws and legal clarifications within international bodies and institutions. Thus, the Organization for Economic Co-operation and Development (OECD), the UN and UNESCO, NATO, and groups such as the G7, G20, Quad and others have all prepared norms based on a responsible interpretation. In parallel, companies and pioneers in technical fields have adopted work principles, policies and standards that inform the work of product development and sales teams. It is observed that, simultaneously with the technological experiments, new applications, based on AI, are introduced on the market for data communications, mergers, control of compliance with ethical norms, current rules and standards. Diplomacy and technology or techdiplomacy is at the basis of the formation of the framework in which technical standards are established about what should mean the responsible use and governance of new technologies about the ways of its implementation, monitoring and verification. Dialogue and collaboration are the most important factors in identifying sustainable solutions for a safe and sustainable economy.

For example, in the field of telecommunications and AI, the Australian Strategic Policy Institute (ASPI) has published a report that shows that the most significant contributors to the scientific development of the field come from academia and civil society R&D. Based on the analysis of scientific publications, it is estimated that the biggest contributors come from the EU and Great Britain, followed by those from China. However,the first areas of development are grouped in China, Germany, Egypt, India, Great Britain and the USA (Hogeveen et al., 2024).

The EU's approach to this direction aims to stimulate research and the development of industrial capabilities against the background of ensuring the security and fundamental rights of people. Specifically, EU countries aim to establish favorable conditions for the development of human-centred technologies aimed at protecting citizens, safe, reliable and sustainable technologies by stimulating talent and education. The main factors are environmental sustainability/low-emission technologies and digitization/adaptation to Industry 4.0. Thus, the European Commission, with the support of expert groups, committees and regional standardization groups, develops strategies and policies to regulate research and technological development, as well as to train the next generation of academic experts. At the same time, it stimulates the formation of multilateral cooperations with non-EU commercial and technological structures anywhere in the world. In 2023, for example, the joint development of the voluntary AI Code of Conduct with the USA was initiated and digital partnerships were concluded with Japan, Singapore and the Republic of Korea.

Highly qualified staff in science and technology in the EU work in countries where the employment rate of tertiary graduates is very high in the bussines enterprise sector (56%), in higher education (32%) and less in the government sector (10.1%) (Eurostat, 2023). In 2023, despite economic uncertainties, EU companies that invested heavily in R&D for advanced technologies surpassed those in the US and China (Nindl et al., 2023).

Technologies such as the Internet of Things, industrial data, advanced manufacturing, robotics, 3D printing, blockchain technologies and artificial intelligence offer several opportunities that will enable the transition to a greener economy and a sustainable, fair and prosperous industry, essential conditions in the modernization of the base industrial through research and innovation. Industrial research and innovation are supported under Cluster 4, „Industry, Digital and Space" in the Horizon Europe program (European Commission, 2024).

In the current geopolitical context, many projects aim to develop new technological solutions that improve the performance and efficiency of defense systems. Thus, collaboration between the defence industry and other technological sectors is encouraged for the transfer of knowledge and the application of new technologies in the defence context (Eliasson, 2017). In addition, the international and interdisciplinary collaboration allows partners to combine their resources and expertise in common directions for the development of advanced solutions, in the improvement of production, logistics and resource management processes, as well as for the integration of digital technologies in the defence industry. The development of space capabilities, for example, are essential for defence applications in Earth observation missions, satellite navigation and space communications, all of which are critical capabilities for both modern military operations and territorial surveillance for other services.

In a global analysis of R&D, the opening of the EU policy for research and innovation has allowed maintaining the leading position in the field. The 2021 UNESCO Scientific Report showed the progress of the share of scientific co-authorship for 2019 as 41.1% for the EU, 41.3% for the US, 23% for China, and 23.5% for other areas of the world (Figure 1).

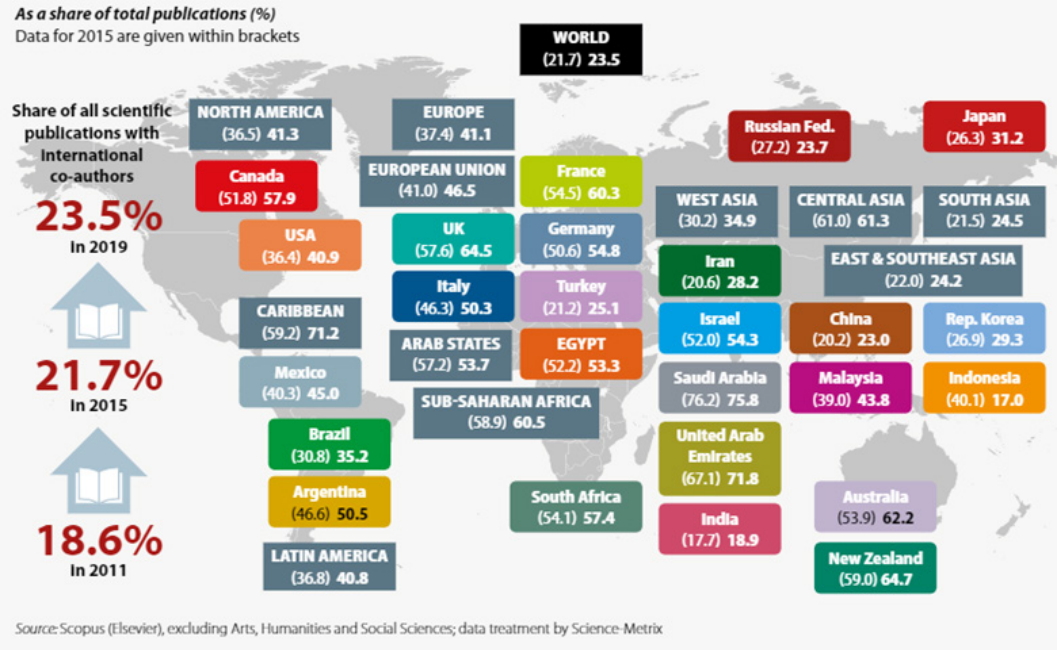

Figure 1. *International scientific co-autorship, by region and selected country, 2015 and 2019 (UNESCO, 2021a, p.57)*

Globally, the share of researchers grew three times faster (13.7%) than the global population (4.6%). In the EU, the share of growth in the number of researchers (11.5%) is double the rate of population growth (5.2%) (UNESCO, 2021b, p.72). Around 9.8% of EU scientific publications are among the top 10% of the most cited publications worldwide. The highest scores are seen in the Netherlands, Switzerland, the United Kingdom and Denmark, where at least 13% of scientific publications are among the top 10% of the most cited publications worldwide (European Commission, 2022a, p.9).

For the EU, the average R&D intensity in the public sector is 0.78%, with the highest implementation scores (1.00%) being observed in Denmark, Norway and Germany (European Commission, 2022b, p.13).

China is recognized as very advanced in researching key military technologies that the US and its main allies cannot catch up with. China's goals are based on the idea of ensuring that international initiatives reflect its domestic policy, regulations and standards. Chinese authors contributed 10% of the studies, promoting the idea of leading in 19 out of 23 key areas, with implications for establishing superiority in AI and global high-tech manufacturing. It is worth noting that Chinese authors, even if there are suspicions of unethical academic practices by multiple citations of other Chinese researchers in order to increase the country's authorization (Lariviere et al., 2018), are well regarded, some of them being invited to hold academic courses in the USA, Australia or the UK.

At the country level, the strategy of promoting Chinese positions and interests is applied through international agreements in organizations such as the UN, BRICS and global ODS (Operational Data Stores). For example, at the Belt and Road Forum for International Cooperation (2023) China's Global Initiative on Artificial Intelligence Governance was presented, at the UN Convention on Certain Conventional Weapons (2022) it presented a position paper, and at the summit REAIM (2023), China endorsed a call for the responsible use of AI in the military domain. (Government of the Netherlands, 2023).

The US continues to remain a dynamic centre for generating innovative ideas and a pole of attraction for scientific researchers through appropriate policies and allocation of funds that encourage and support innovation. In 2023, according to the sixth edition of the US Innovation Scorecard, the main direction for research and development was to attract funds and investments, combined with the government and private sector. As secondary directions followed research in the fields of communications, drones, and other entrepreneurial and business activities for SMEs (Consumer Technology Association, 2023), it being known that the USA still holds the leading position in high-impact research in autonomous systems, quantum computing and quantum sensors, in some areas of AI and cyber security.

In the field of global R&D, it is observed that there is a high degree of compatibility despite the different degrees of design and implementation within each country. As a particularity of these developments, countries located in regions with geopolitical instability invest more in research and development of military capabilities, depending on the specifics of the country's strategic culture, the implementation of new technologies for military purposes being different for physical, traditional, cyber or hybrid weapons.

Analyzing the Ukraine conflict engagement, it is appreciated that the levels of ambition and the scale of military objectives must be carefully designed; any irrational effort can destabilize the consumption of resources, commercial markets and even the approach to military operations. In this sense, It is considered extremely important to know and understand the Triple Helix model of university-industry-government relations, proposed by Etzkowitz & Leydesdorff (Leydesdorff, 2012), in 2000 and applied in a multitude of fields.

The model underpins a transdisciplinary system and can be simplified in innovative contexts without affecting the integrity of the underlying processes. However, such restructuring can weaken existing boundaries at the level of traditional institutions, as any military system has, especially in complex systems of innovation. This approach encourages science-based performance. But it can also cause uncomfortable aspects for institutions that operate with a hierarchical structure based on operational rather than scientific performance rules. In these situations, the dialogue is purely formal and does not produce a synergy of the three environments.

The Triple Helix model applied to a geographical-administrative region assumes the existence of the following elements:

- metropolitan area of the city;
- an innovation system based on knowledge within the limits of the geographical region determined, mainly by the relations of

the communication system (road, railway, telecommunications system etc.);
- a system of relations with partners external to the region, structured on strategic fields and technological, logistical, military, economic-financial subfields etc.

In fact, any NATO military base is organized in this direction. Outside the military unit itself, a large urban area is developed with all its facilities (Pawelczyk, 2018). This, in addition to ensuring the social comfort of the military, ensures regional economic development through a variety of infrastructures, services and other social and economic aspects. Among these, there can be listed: the development of physical infrastructures (transport, utilities, housing), social infrastructure (educational, health, social services), economic facilities (commercial spaces, industrial units and services, jobs), elements of urban planning (land management plans, sustainable development plans, green spaces etc.), environmental and public health elements, citizen safety and security elements, cultural and recreational entities, civic engagement and governance/administration programs and initiatives public.

In this way, an attractive and sustainable living environment is created for all residents, implicitly also for soldiers and their families.

DISCUSSIONS AND OBSERVATIONS

Analyzing all these strategic aspects, it is estimated that the presence of a military base will contribute essentially to the achievement of a sustainable regional economic development under two aspects as:

1. The development of an architecture based on the functional requirements of the military base with effects in the development of critical administrative-territorial infrastructures (information, mobility, logistics etc.), but also of other economic relationships that derive from the systematic consumption of resources;
2. Development of social infrastructure (supporting education, urban health facilities, social services) and supporting local economic infrastructure (commercial spaces, services, jobs etc.). This approach is considered a social innovation hub for a wide range of fields, through divergent solutions and good practices developed in civil-military relations.

In general, military innovation is an attractive strategy for developing defense capabilities. This is based on the strategy that, in the situation of insufficient own military resources, the only option to discourage a possible aggressor is creativity in the use of technology and new war methods, especially in countries with a well-educated population and with more aggressive neighbours (to see the model of hybrid warfare against Ukraine). The particularities of hybrid warfare favor military innovation as an integrated technological capability, resulting from the combination of military resources with technologies of interest and new conceptual ideas for its use.

However, the military, in general, does not have sufficient funds allocated to the field of research and technological development of specific equipment. In this context, overlayed on the Triple Helix model, any urban entity can develop a series of relations with a military base, in sub-domains and in strategic directions, such as: economic, social and cultural relations, infrastructural relations, security and defense relations, political relations administrative, research and development relations, etc.

It is believed that the central role will be played by educational and R&D units that will develop joint research and development projects benefiting from mutual resources and expertise to develop innovative technologies and solutions. In addition, inter-institutional collaborations can facilitate the transfer of technology and knowledge from the military sector to civilian applications contributing to the urban's technological progress.

Military specialists can be co-opted in flexible and adaptive educational programs for the training and instruction of students (practice programs, transfer of know-how, demonstration activities etc.).

Moreover, over time, the interaction between military personnel, their families and the local community will form a regional security culture by:

- Increasing respect for authority, discipline and patriotism in the community;
- The development of cultural diversity through the exchange of traditions, customs and other ways of life, with visible influences in the situation where soldiers from other countries are present;
- Investments in infrastructure and education due to the needs of the military and their families;
- Social interactions in the context of organizing activities and social events, with significant impact on the understanding of military culture etc.

Under a global approach, R&D of military sciences, not being able to keep up with technological developments in the sciences, in materials, in communication and communications, in information, autonomy etc., the specific activity of the military service will stimulate consumption, the indirect investments of the various economic subfields being elements of great synergy for regional development.

In a fair way, they are the result of how the people adapts through the implementation and use of new technologies, which ensure the progress of the whole society. However, these developments also create new security and defense vulnerabilities. Even if militaries represent challenges and requires for new security and defence solutions, they can also be considered opportunities for innovation in the aspect of optimizing decisions in the exploitation of technologies and in preparing for the adoption of proactive defense solutions.

Such an approach should not be seen as a militarization of a region but as a form of preparing the territory for defense. In the conditions of hybrid warfare and cyber attacks, the most numerous victims will be civilians, even if the damage will not be predominantly physical. Currently, one can observe a series of positions of the leaders of some political parties who, as a rule, based on prejudices and misinterpretations, criticize any initiative to modernize the military system. However, the lack of a strategic security culture, even as an explanatory model, only erodes the ability to innovate in any field of science.

It can be said that innovation processes would be better stimulated by using an actor that tests and exploits new technologies or that generates operational requirements that determine a pace of progress in innovation processes. It is almost universally accepted that the military actor most rapidly exploits military innovation in the exercises it systematically conducts in the specific training and preparation programs of the armed forces. Under these perspectives, as a feedback relationship from military R&D to civil society, the technological transfer center being ensured by the presence of the military base, regional development will be supported in the following directions:

- Military R&D projects attract significant investment from the government and, sometimes, from the private sector to build and maintain research infrastructure, production facilities and for job creation;
- Regional infrastructure development projects through the implementation of new technologies such as high-speed internet, advanced navigation systems, renewable energy technologies etc.;
- Collaborative projects and technological transfer of solutions validated in military applications that can be adapted for civilian use, such as OT security, communications, medicine, energy etc.;
- Developing education by offering advanced educational programs for professional and specialized training in fields such as engineering, technology and applied sciences;
- Regional security and emergency resources in the event of natural disasters or public health crises;
- Regional reputation, branding and technology tourism, known as attractive for military facilities and related events that can attract visitors interested in technology and innovation.

CONCLUSIONS

The approach used in this study contributes to the understanding of the role of the military base presence and how it develops not only innovation in the field of military science but also how regional development can be stimulated, influencing in multiple aspects the general well-being and competitiveness of the region.

It is appreciated that, in the future, more multidisciplinary studies are needed to develop knowledge in this field. However, this study highlights the need for an in-depth exploration of the decision-making processes for using advanced technologies and adapting military capabilities to meet the new challenges of hybrid and cyber warfare. Among these, it is worth noting the encouragement of the promotion of military innovation not only for the development of the military system but also for the establishment of new types of relationships and multidisciplinary knowledge, thus contributing to the identification of the directions of evolution of war technologies and the realization of a communication strategy regarding the results of the evaluation of the use advanced technologies in various scenarios.

REFERENCE LIST

Consumer Technology Association (2023) 2023 CTA U.S. *Innovation Scoorecard*. https://cdn.cta.tech/cta/media/media/advocacy/scorecard/us-pdfs/2023-cta-us-innovation-scorecard-white-paper.pdf [Accessed 8th July 2024]

Deitz, S. & Freyman, C. (2024) The State of U.S. Science and Engineering 2024. *National Science Foundation | National Science Board, Science &Engineering Indicators*. https://ncses.nsf.gov/pubs/nsb20243/discovery-u-s-and-global-r-d [Accessed 4th July 2024].

Eliasson, G. (2017) Visible Costs and Invisible Benefits: Military Procurement as Innovation Policy. Economics of Science, Technlogy and Innovation series. *Springer*, p. 20.

European Commission (2024) Industrial research ad innovation. Strategies and policies supported. *Research and innovation*.https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation_en [Accessed 8th July 2024].

European Commission, Directorate-General for Research and Innovation (2022 a) *European Innovation Scoreboard 2022, Annex B Performance per indicator.* https://research-and-innovation.ec.europa.eu/system/files/2022-09/ec_rtd_eis-2022-annex-b.pdf [Accessed 8th July 2024].

European Commission, Directorate-General for Research and Innovation (2022 b) *European Innovation Scoreboard 2022, Annex B Performance per indicator.* https://research-and-innovation.ec.europa.eu/system/files/2022-09/ec_rtd_eis-2022-annex-b.pdf [Accessed 8th July 2024].

Eurostat Statistics Explained (2023) *R&D personnel.* https://ec.europa.eu/eurostat/statistics-explained/index.php?title=R%26D_personnel#Researchers [Accessed 5th July 2024].

Government of the Netherlands (2023) *REAIM 2023 Call to Action.* https://www.government.nl/documents/publications/2023/02/16/reaim-2023-call-to-action [Accessed 4th July 2024].

Hogeveen, B., Basu, A., Suri, I. & Grewal, B. (2024) Negotiating technical standards for artificial intelligence, A techdiplomacy playboook for policy-makers and technologists in the Indo-Pacific. *ASPI, Centre for Internet & Society.* https://ad-aspi.s3.ap-southeast-2.amazonaws.com/2024-06/Negotiating%20technical%20standards%20for%20artificial%20intelligence.pdf?VersionId=ZD2cI1xXbCO9a3imgfyGd7og_08Z2Nu [Accessed 4th July 2024].

Hote, K., Somers, M. & Theodorakopoulos, A. (2023) Technology and Jobs: A systematic literature review. *Technological Forecasting & Social Change.* 194, 122750. doi:10.1016/j.techfore.2023.122750

Laird, R. (2024) *The New Revolution in Military Affairs and Force Structure Change: The Perspective of LtGen Heckl.* https://sldinfo.com/2024/08/the-new-revolution-in-military-affairs-and-force-structure-change-the-perspective-of-ltgen-heckl/ [Accessed 6th July 2024].

Lariviere V., Gong K. & Sugimoto C.R. (2018). Citations stregth begins at home, The increasing production of papers Lariviere, V., Gong, K. & Sugimoto, C.R. (2018) Citations strength begins at home. The increasing production of papers and a propensity to cite compatriots makes China likely to win the referencing race. *Nature*. https://www.nature.com/articles/d41586-018-07695-1 [Accessed 4th July 2024].

Leydesdorff, L. (2012) The Triple Helix of Universit-Industry-Government Relation. *SSRN Electronic Journa*l. doi:10.2139/ssrn.1996760.

Pawelczyl, M. (2018) Contemporary challenges in military logistics support. *Security and Defence Quarterly,* 20(3), 85-98. doi:10.5604/01.3001.0012.4597.

Nindl, E., Confraria, H., Rentocchini, F., Napolitano, L., Georgakaki, A., Ince, E., Fako, P., Hernandez- Guevara, H., Gavigan, J., Tubke, A., Pinero-Mira, P., Rueda-Cantuche, J., Banacloche-Sanchez, S., de Prato, G. & Calza, E. (2023) The 2023 EU Industrial R&D Investment Scoreboard. *JRC Publications Repository.* doi:10.2760/73822, JRC135576.https://iri.jrc.ec.europa.eu/scoreboard/2023-eu-industrial-rd-investment-scoreboard [Accessed 4th July 2024].

Stoltenberg, J. (2021) *Speech by NATO Secretary General Jens Stoltenberg at the event: NATO's outlook towards 2030 and beyond.* https://www.nato.int/cps/en/natohq/opinions_189089.htm [Accessed 4th July 2024].

UNESCO (2021a) UNESCO Science Report: The Race Against Time for Smarter Development. *UNESCO Open Access Repositor.* https://unesdoc.unesco.org/in/documentViewer.xhtml?v=2.1.196&id=p::usmarcdef_0000377433&file=/in/rest/annotationSVC/DownloadWatermarkedAttachment/attach_import_9910a29f-a9af-4cf7-90b6-1547ab382c63%3F_%3D377433eng.pdf&updateUrl=updateUrl5241&ark=/ark:/48223/pf0000377433/PDF/377433eng.pdf.multi&fullScreen=true&locale=en#%5B%7B%22num%22%3A229%2C%22gen%22%3A0%7D%2C%7B%22name%22%3A%22XYZ%22%7D%2C-1%2C842%2C0%5D [Accessed 8th July 2024].

UNESCO (2021b) UNESCO Science Report: The Race Against Time for Smarter Development. *UNESCO Open Access Repository*. https://unesdoc.unesco.org/in/documentViewer.xhtml?v=2.1.196&id=p::usmarcdef_0000377433&file=/in/rest/annotationSVC/DownloadWatermarkedAttachment/attach_import_9910a29f-a9af-4cf7-90b6-1547ab382c63%3F_%3D377433eng.pdf&updateUrl=updateUrl5241&ark=/ark:/48223/pf0000377433/PDF/377433eng.pdf.multi&fullScreen=true&locale=en#%5B%7B%22num%22%3A229%2C%22gen%22%3A0%7D%2C%7B%22name%22%3A%22XYZ%22%7D%2C-1%2C842%2C0%5D [Accessed 8th July 2024].



This is an open access article distributed under the terms and conditions of the Creative Commons Attribution-NonCommercial 4.0 International License.