



Research Article

Back to Classics: Developing an Existential Security Scenario Framework for Global Non-Anthropogenic Catastrophes

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Abstract: International security and defense institutions have acknowledged the urgent need to incorporate existential environmental scenarios and global environmental threats into the spectrum of international security scenario analysis. There are valuable contributions to assessing environmental security risks, for instance, by combining existential risk with security policy to develop a framework of existential security, as well as a vast array of applications of scenario techniques to environmental issues. Yet, there is still a lack of scientific, methodological, and theoretical foundations, as well as coherent theoretical frameworks. Diverse techniques with unclear processes limit many studies, preventing the advancement of further research on existential scenarios. This applies to the spectrum of plausible existential environmental catastrophes, particularly those that are non-anthropogenic, uncertain, and complex, and potentially affect the entire planet. This study suggests that the absence of a narrowly structured research area results in a lack of adequate theoretical foundations. Such a structured research area would help unlock current theoretical stagnation and enable the development of a foundational theoretical framework to evaluate the basis of related inquiries. Through a novel evidence synthesis-based mapping analysis, this study contributes to a framework for existential security scenarios related to non-anthropogenic global planetary catastrophes of complex and uncertain nature.

Keywords: existential security scenario, environmental security, uncertainty, complex scenarios, planetary catastrophe, survivability, planetary defense.

Introduction

Scholarship has highlighted that we are beginning to witness the effects of an anthropogenic period,¹ where the impact of humanity is affecting natural development on a global scale by crossing three of the nine “Planetary Boundaries” that humanity must protect to operate safely.² However, currently emerging environmental scientific efforts and the security policy domain have been expanding their focus from anthropogenic (man-made disasters) to a non-anthropogenic spectrum (non-man-made disaster events). Here, the emphasis lies on non-anthropogenic environmental disasters, such as high-magnitude tsunamis and earthquakes, mega-volcanic eruptions,³ and outer-space objects impacting Earth.⁴ The deep uncertainty and highly complex nature of a non-anthropogenic global catastrophic scenario, which differs from anthropogenic disasters, and the existential security threat of potentially severe effects, could lead to planetary catastrophe, even threatening the collapse of nations.

Non-anthropogenic catastrophes and their effects have already been addressed in studies on existential risk and global catastrophes,⁵ in conjunction with diverse environmental security and planetary disciplinary spheres. In this context, recent studies on the environmental spectrum have extended their focus, highlighting the importance of the outer-space environment.⁶ At the same time, natural hazards on a planetary scale have been increasing considerably at both global and stratospheric levels. Therefore, recent studies have also identified the need for a new classification of disaster severity, ranging from 0 to 10, with 10 representing worldwide devastation.⁷

Consequently, the transition of the environmental spectrum from Earth’s surface to the stratosphere, and further into outer space, has led a recent study to

¹ Colin N. Waters et al., “The Anthropocene Is Functionally and Stratigraphically Distinct from the Holocene,” *Science* 351, no. 6269 (2016), aad2622, <https://doi.org/10.1126/science.aad2622>.

² Johan Rockström et al., “Planetary Boundaries: Exploring the Safe Operating Space for Humanity,” *Ecology and Society* 14, no. 2 (2009), 32, www.ecologyandsociety.org/vol14/iss2/art32/.

³ Lara Mani, Doug Erwin, and Lindley Johnson, “Natural Global Catastrophic Risks,” in *The Era of Global Risk: An Introduction to Existential Risk Studies*, ed. SJ Beard et al. (Open Blik Publishers, 2023), 123-146, <https://doi.org/10.11647/OBP.0336.06>.

⁴ Jean-Marc Salotti, “Humanity Extinction by Asteroid Impact,” *Futures* 138 (2022), 102933, <https://doi.org/10.1016/j.futures.2022.102933>.

⁵ Adrian Currie and Seán Ó hÉigeartaigh, “Working Together to Face Humanity’s Greatest Threats: Introduction to the Future of Research on Catastrophic and Existential Risk,” *Futures* 102 (2018): 1-5, <https://doi.org/10.1016/j.futures.2018.07.003>.

⁶ Rada Popova and Volker Schaus, “The Legal Framework for Space Debris Remediation as a Tool for Sustainability in Outer Space,” *Aerospace* 5, no. 2 (2018), 55, <https://doi.org/10.3390/aerospace5020055>.

⁷ H. Jithamala Caldera and S.C. Wirasinghe, “A Universal Severity Classification for Natural Disasters,” *Natural Hazards* 111, no. 3 (2022): 1533-1573, <https://doi.org/10.1007/s11069-021-05106-9>.

propose a new approach for environmental research: “Earth-space sustainability,” described as a “new frontier for sustainability, requiring the expansion of conceptual and analytical tools.”⁸ Hence, the need for this expansion to include outer space has become highly relevant due to the plausibility of future global natural planetary catastrophic scenarios – particularly disasters triggered by near-earth objects impacting Earth.⁹ Despite the low probability but clear plausibility of such global catastrophic events,¹⁰ current studies have estimated a probability of 2.2×10^{-12} for an asteroid impact within the next hundred years, with a “very short warning time.”¹¹

In this context, even if a non-anthropogenic global catastrophic scenario may not trigger a direct existential security threat, it could generate a globally uncertain and complex situation of cascading environmental and societal catastrophes. This could create a global security risk leading even to collapse, as recent studies have rightly pointed out: “The systemic nature of risk is important to consider for other extreme natural hazards such as stellar explosions, coronal mass ejections and the reversal of the Earth’s magnetic field, amongst others. All of these risks may not pose a direct threat of human extinction as we currently understand, but the risks they pose to the systems and infrastructures that sustain our societies could constitute a global catastrophic risk, even push us towards collapse.”¹²

Therefore, foreknowledge of uncertain and complex non-anthropogenic planetary catastrophic scenarios due to extreme natural hazards—such as asteroid impacts, mega-volcanoes, and their cascading effects on the planet and society—is extremely important.¹³ It is vital for formulating assertive security policies, given the uncertainty of human consequences such events may trigger.¹⁴ Such knowledge is also necessary for developing courses of action for preparedness, strategic plans for uncertainty,¹⁵ and effective decision-making mecha-

⁸ Xiao-Shan Yap and Bernhard Truffer, “Contouring ‘Earth-Space Sustainability’,” *Environmental Innovation and Societal Transitions* 44 (2022): 185-193, <https://doi.org/10.1016/j.eist.2022.06.004>.

⁹ Nikola Schmidt, *Planetary Defense: Global Collaboration for Defending Earth from Asteroids and Comets* (Cham, Switzerland: Springer, 2018).

¹⁰ Nahum Melamed and Avishai Melamed, “The Terrestrial Example: Natural Disasters as Model for Planetary Defense Planning,” *Journal of Space Safety Engineering* 7, no. 1 (2020): 67-77, <https://doi.org/10.1016/j.jsse.2020.02.003>.

¹¹ Salotti, “Humanity Extinction by Asteroid Impact.”

¹² Mani, Erwin, and Johnson, “Natural Global Catastrophic Risks.”

¹³ Timothy Titus et al., “A Review of Common Natural Disasters as Analogs for Asteroid Impact Effects and Cascading Hazards,” *Natural Hazards* 116, no. 2 (2023): 1355-1402, <https://doi.org/10.1007/s11069-022-05722-z>.

¹⁴ Seth D. Baum, “Assessing Natural Global Catastrophic Risks,” *Natural Hazards* 115, no. 3 (2023): 2699-2719, <https://doi.org/10.1007/s11069-022-05660-w>.

¹⁵ Tim Haarhaus and Andreas Liening, “Building Dynamic Capabilities to Cope with Environmental Uncertainty: The Role of Strategic Foresight,” *Technological Forecasting*

nisms to confront global catastrophic scenarios.¹⁶ In this context, anticipatory knowledge through a novel integral framework for existential security scenarios can provide the necessary insights to deeply understand and operationalize uncertain non-anthropogenic global scenarios, thereby enabling security responses to potential complex catastrophic events.

Current Challenges

International security and defense institutions have acknowledged the urgent need to incorporate existential environmental scenarios and global environmental threats into the spectrum of international security scenario analysis. Valuable contributions exist to assess environmental security risks – for instance, combining existential risk¹⁷ with security policy to develop a framework of existential security,¹⁸ as well as a vast array of applications of scenario-planning techniques to environmental issues. Yet, there is still a lack of theoretical frameworks for scenarios,¹⁹ and diverse techniques with unclear processes limit many studies.²⁰ This prevents the advancement of further research on existential scenarios, especially regarding the spectrum of plausible existential environmental catastrophes,²¹ particularly non-anthropogenic, uncertain, and complex planetary catastrophes.²² Efforts in this area are still in their infancy, and the absence of an existing framework for existential security scenarios that integrates these efforts remains unexplored.

These critical gaps have led to a weak foundation in science, theory, methodology, and practice. As a result, stagnation has prevented the development of an integral and applicable framework for existential security scenarios, hindering the urgent need to incorporate existential scenarios into the emerging field of

and *Social Change* 155 (2020): 120033, <https://doi.org/10.1016/j.techfore.2020.120033>.

¹⁶ Melamed and Melamed, “Natural Disasters as Model for Planetary Defense Planning.”

¹⁷ Nick Bostrom, “Existential Risks: Analyzing Human Extinction Scenarios and Related Hazards,” *Journal of Evolution and Technology* 9 (2002), <https://nickbostrom.com/existential/risks.pdf>.

¹⁸ Nathan Alexander Sears, “Existential Security: Towards a Security Framework for the Survival of Humanity,” *Global Policy* 11, no. 2 (2020): 255-266, <https://doi.org/10.1111/1758-5899.12800>.

¹⁹ Christopher Münch and Heiko A. von der Gracht, “A Bibliometric Review of Scientific Theory in Futures and Foresight: A Commentary on Fergnani and Chermack 2021,” *Futures & Foresight Science* 3, no. 3–4 (2021): e88, <https://doi.org/10.1002/ffo2.88>.

²⁰ Kathya Cordova-Pozo, and Etiënne A.J.A. Rouwette, “Types of Scenario Planning and Their Effectiveness: A Review of Reviews,” *Futures* 149 (May 2023): 103153, <https://doi.org/10.1016/j.futures.2023.103153>.

²¹ Caldera and Wirasinghe, “A Universal Severity Classification for Natural Disasters.”

²² Tisha Hupkes and Anders Hedman, “Shifting Towards Non-Anthropocentrism: In Dialogue with Speculative Design Futures,” *Futures* 140 (2022): 102950, <https://doi.org/10.1016/j.futures.2022.102950>.

existential security. Existential security has been informally addressed for decades in the security and defense domains since the beginning of the Cold war. Moreover, there have been valuable attempts to formally frame existential security within an anthropogenic catastrophes framework based on a political science approach.²³ Yet, these critical and significant gaps remain, preventing the full development of an applicable, suitable, and integral framework of existential security scenarios that can be embedded into security paradigms.

This study suggests that the current scientific, theoretical, methodological, and practical stagnation is due to the lack of a narrowly structured research area. Future scholarship requires a focused research area to overcome theoretical stagnation and to establish a foundational theoretical framework for evaluating the basis of these inquiries. Through a novel evidence synthesis-based mapping analysis, this study provides a foundational, theoretically structured research area that leads to a framework for existential security scenarios related to complex, uncertain, and non-anthropogenic global planetary catastrophes.

Method of Analysis

There is a variety of existential approaches related to non-anthropogenic risk and threats, such as Long-term Future Studies,²⁴ based on long-term trajectories of human civilization, ethics, and existential risk, and Anthropic Reasoning,²⁵ which aims to assess existential risks based on humanity's own observations of itself and the universe. Additionally, Ethical Existential Risk²⁶ seeks to judge the consequentialist ethics and moral imperative of securing and protecting humanity's long-term potential, while the Catastrophic Harm Precautionary Principle²⁷ centres on cautionary behavior in the face of potential catastrophic consequences.

This research is based on Existential Risk and Global Catastrophic Risk approaches.²⁸ The authors selected Existential Risk because it addresses both anthropogenic and non-anthropogenic catastrophic events that could lead to humanity's extinction or cause a drastic reduction in humanity's potential. Furthermore, Global Catastrophic Risk was chosen as it also focuses on risks that could

²³ Caldera and Wirasinghe, "A Universal Severity Classification for Natural Disasters."

²⁴ Nicholas Beckstead, *On the Overwhelming Importance of Shaping the Far Future*, PhD Dissertation (New Brunswick, New Jersey: State University of New Jersey, 2013), <https://doi.org/10.7282/T35M649T>.

²⁵ Bostrom, "Existential Risks: Analyzing Human Extinction Scenarios and Related Hazards."

²⁶ Toby Ord, *The Precipice: Existential Risk and the Future of Humanity* (New York: Hachette Books, 2020).

²⁷ Cass R. Sunstein, "The Catastrophic Harm Precautionary Principle," *Issues in Legal Scholarship* 6, no. 3 (2007), <https://doi.org/10.2202/1539-8323.1091>.

²⁸ Seth D. Baum, "Global Catastrophic Risks Edited by Nick Bostrom & Milan Cirković," *Risk Analysis* 29, no. 1 (2009): 155-156, <https://doi.org/10.1111/j.1539-6924.2008.01162.x>.

trigger global catastrophes, such as natural hazards, which could subsequently lead to human extinction or societal collapse.

While Human Security²⁹ and Securitization³⁰ approaches offer rich theoretical tools to assess and operationalize global non-anthropogenic environmental disasters, the framing of this study builds on Environmental Security and Security Cosmopolitanism. Environmental Security³¹ focuses on how natural hazards can trigger societal and nation-state conflicts in local and regional settings, leading to security instability in national and global spheres as part of a complex, non-linear system. Consequently, the authors of this study endorse the conceptualization of an interconnected view of global security³² in response to planetary threats to humanity as a whole, aiming for an international security that extends beyond the nation-state, to encompass the security of humanity globally, in line with Security Cosmopolitanism.³³ The latter emphasizes that nation-states should pursue not only state objectives and interests, but also the well-being of humanity beyond national boundaries, making it suitable for the development of an Existential Security Scenarios framework.

This study employed a novel theoretical evidence synthesis-based mapping analysis using a modified evidence synthesis, as mapping analyses are “primarily concerned with structuring the research area.”³⁴ To enhance the viability and validity, the authors designed a novel evidence synthesis-based methodology that includes a critical appraisal in its protocol by applying a Tabula Rasa approach. Through Tabula Rasa, the researchers critically evaluated, based on selection criteria, the most suitable and relevant paradigms and theoretical approaches for structuring the research area into a theoretical framework.

Additionally, to enhance analytical power and deliver a concise representation of the interconnections and relationships among theoretical approaches in uncovering the structured research area, this study employed Symbolic Equation due to its powerful capability for formulating and representing conceptualizations. Symbolical Equation has its roots in mathematical science; however, it has been applied across diverse disciplines such as biology, information technology,

²⁹ United Nations Development Programme, *Human Development Report 1994: New Dimensions of Human Security* (New York: Oxford University Press, 1994), <https://hdr.undp.org/content/human-development-report-1994>.

³⁰ Barry Buzan, Ole Wæver, and Jaap de Wilde, *Security: A New Framework for Analysis* (Boulder, CO: Lynne Rienner Publishers, 1998).

³¹ Thomas F. Homer-Dixon, “On the Threshold: Environmental Changes as Causes of Acute Conflict,” *International Security* 16, no. 2 (Fall 1991): 76-116, <https://muse.jhu.edu/article/447281>.

³² Richard Beardsworth, *Cosmopolitanism and International Relations Theory* (Cambridge: Polity Press, 2011).

³³ Gillian Brock and Harry Brighouse, eds., *The Political Philosophy of Cosmopolitanism* (Cambridge: Cambridge University Press, 2005).

³⁴ Kai Petersen, Sairam Vakkalanka, and Ludwik Kuzniarz, “Guidelines for Conducting Systematic Mapping Studies in Software Engineering: An Update,” *Information and Software Technology* 64 (2015): 1-18, <https://doi.org/10.1016/j.infsof.2015.03.007>.

and humanities-related fields—including psychology, linguistics, and sociology—due to its precise and concise ability to construct representations of novel conceptual frameworks across diverse disciplinary areas.

Furthermore, the authors approached this study through transdisciplinary lenses, drawing on their areas of expertise: global environmental studies and international security studies.

Novel Evidence Synthesis-Based Analysis

The authors conducted a relevant theoretical scrutiny using a novel evidence synthesis-based mapping analysis approach designed for this study. Through an assertive and exploratory overview of the existing corpus of theoretical literature, they assessed the most relevant theories suitable for this research. The aim was to uncover the constellation of the most relevant linked theoretical approaches, provide a more narrowly structured research area, and deliver a theoretical framework for non-anthropogenic planetary catastrophic scenario analysis. Using the novel evidence synthesis-based mapping analysis, the researchers delved into existing theoretical approaches. (1) They explored and identified five theoretical approach areas as follows: Scenarios, Complexity, Uncertainty, Future, and Knowledge. (2) They then proceeded with the analytical process to detect the most relevant and suitable approaches from this pool, and (3) critically appraised and identified the most relevant theoretical approaches by applying Tabula Rasa and Symbolic Equation formulation. (4) Consequently, the study uncovered the structured research area for Existential Security Scenarios.

$$K = f \left(\sum_{i=1}^n I_i \right)$$

where:

- K – New knowledge
- f – Transformation process (*Tabula Rasa*)
- I_i – Individual idea components
- n – Total number of components

The formulation delivers, in a simple and concise representation, that new knowledge is a function of conceptualizations. Herein, (1) conceptualizations (i -th idea components) are the encapsulated ideas in theories, paradigms, or approaches, and (2) the transformation function (f , *Tabula Rasa*) is the process that generates new knowledge from the conceptualizations (i -th idea components).

Consequently, the equation reads as:

The new knowledge K (theoretical approach) is the result of applying a transformation function f (Tabula Rasa) to the summation of idea components I_1

to I_n (theoretical approach), where new knowledge K is generated by the transformation function f (Tabula Rasa).

where: $K = f(\sum_{i=1}^n I_i)$, with K (new knowledge) being the result of the transformation function f (Tabula Rasa) applied to the summation of n concepts.

Furthermore, Tabula Rasa's transformation function f (the process of conceptualizations into new knowledge) allowed for a critical assessment of the correlation, suitability, and relevance of each theory, approach, and paradigm derived from the results of the analysis, based on the research inquiries from a "blank slate." The Symbolic Equation approach, on the other hand, was chosen for its unique capacity to provide a concise representation of the process and the relationships among key concepts from multiple theories, in order to build a precise conceptual formulation. This novel integration of Tabula Rasa and Symbolic Equation enhances viability and validity, providing a powerful explanatory framework for the objective of this research. In the subsequent sections, the authors present the results of the most suitable approaches of complexity, uncertainty, future, and knowledge for the existential security scenarios framework.

Results of the Study

Suitable Knowledge Approaches for Existential Security Scenarios

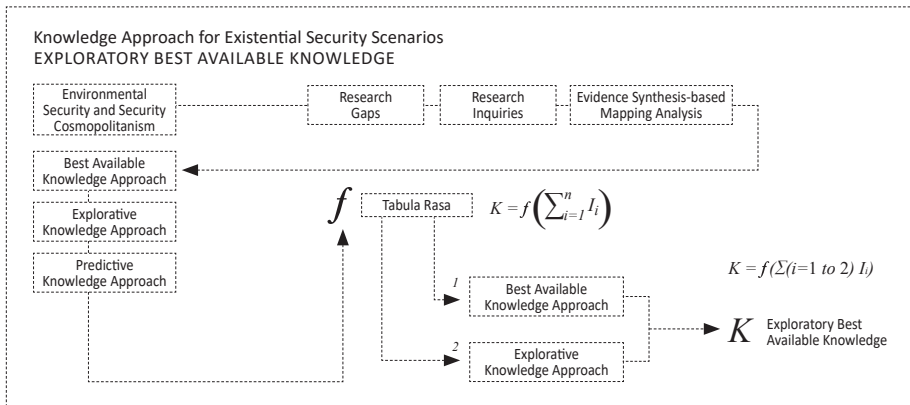


Figure 1: Process and Results: Suitable Knowledge Approaches for Existential Security Scenarios.

Among the most relevant approaches to knowledge, *Tabula Rasa* identified the following. Firstly, *Predictive Knowledge*, which is mainly concerned with the predictability of future events based on knowledge acquisition and representation, relies on analyzing component relationships using data from existing information, trends, and patterns. It can be applied in algorithmic equations and in

the development of statistical models to achieve predictability, and it is a powerful approach for anticipating systems that embody linearity. However, in non-linear complex systems—such as nation-states, social structures, and international conflicts, among other human phenomena—Predictive Knowledge is limited and ineffective for examining non-linear complexity, as it relies on stationary statistical properties.³⁵ This renders the approach unsuitable for operationalizing existential security scenarios.

The second relevant approach identified in the analysis was *Best Available Knowledge*. It relies on analyzing, evaluating, and synthesizing the most up-to-date information, and is suitable for examining non-linear systems in biology³⁶ as well as in human behavior,³⁷ as it emphasizes the factor of *temporality* in knowledge. Furthermore, it seeks to measure knowledge in relation to temporal factors by continuously exploring and identifying the most current sources of information that can be transformed into knowledge and utilized in decision-making processes involving future inquiries.

The third relevant approach identified in the analysis was *Explorative (or Exploratory) Knowledge*, which is often linked to exploratory approaches in scenario studies as an alternative to normative approaches.³⁸ Explorative knowledge focuses on investigating notions about the future, whereby knowledge is not consolidated.³⁹ Its main characteristic is the ability to explore inquiries about the future without prejudgments, desired outcomes, or reliance on trends. This approach is often employed in Delphi studies, which utilize groups of experts in relevant fields of knowledge, as they can provide diverse perspectives and inquiries about plausible futures that can be used to explore possible answers regarding multiple futures.

The capabilities of Explorative Knowledge to assess multiple unknown futures make it suitable for application in Existential Security Scenarios. The same applies to the Best Available Knowledge approach, as it provides assertive and dynamic analytical power to evaluate the magnitude of both anthropogenic and

³⁵ Demetris Koutsoyiannis and Alberto Montanari, “Negligent Killing of Scientific Concepts: The Stationarity Case,” *Hydrological Sciences Journal* 60, no.7–8 (2015): 1174–1183, <https://doi.org/10.1080/02626667.2014.959959>.

³⁶ Tomas Willebrand and Scott Newey, “Reaching and Implementing the Best Available Knowledge in Wildlife Biology,” *Wildlife Biology*, no. 2 (March 2025): e01307, <https://doi.org/10.1002/wlb3.01307>.

³⁷ Elinor Ostrom, “A General Framework for Analyzing Sustainability of Social-Ecological Systems,” *Science* 325, no. 5939 (2009): 419–422, <https://doi.org/10.1126/science.1172133>.

³⁸ Roberto Poli, “A Note on the Classification of Future-Related Methods,” *European Journal of Futures Research* 6, no. 1 (2018), 15, <https://doi.org/10.1186/s40309-018-0145-9>.

³⁹ Steve Banks, Warren E. Walker, and Jan H. Kwakkel, “Explorative Modeling and Analysis,” in *Encyclopedia of Operations Research and Management Science*, ed. Saul I. Gass and Michael C. Fu (Boston, MA: Springer, 2013), 532–537, https://doi.org/10.1007/978-1-4419-1153-7_314.

non-anthropogenic environmental catastrophic scenarios. This is because these scenarios are not static elements, but transform, move, change, and evolve within complex systems.

Result: Explorative Best Available Knowledge

Formulation:

$$K = f(\sum_{i=1}^n I_i)$$

f: critical screening and rigorous assessment of:

1. correlation
2. suitability, and
3. relevance to research inquiries

Process:

$$K = f(\sum_{i=1}^2 I_i)$$

Transformation function *f* (*tabula rasa*) by the summation of:

1. Best Available Knowledge
2. Explorative Knowledge

Results:

K: (Explorative Best Available Knowledge) for Existential Security Scenarios

Suitable Scenario Approaches for Existential Security Scenarios

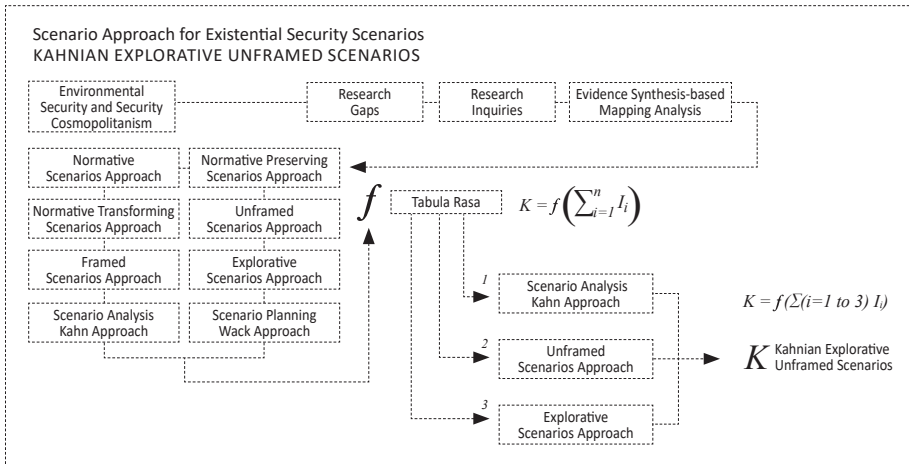


Figure 2: Process and Results: Suitable Scenario Approaches for Existential Security Scenarios.

Among the approaches to scenario building, Tabula Rasa distinguished six relevant types as follows. Firstly, the *Normative Scenario*, which consists of a series of coordinated actions designed to depict an achievable future outcome with

particular characteristics and conditions.⁴⁰ It attempts to design a goal-oriented vision of the future and aims to achieve it while remaining within the boundaries of the possible.

The second approach is the *Explorative Scenario*. It seeks to analyze, detect, and identify multiple plausible futures,⁴¹ centering efforts on uncovering a wide range of potential factors, while giving primary importance to the uncertainty that arises from the multiplicity of possible outcomes, rather than focusing on a predefined one. This approach has proven to be well-suited to encapsulate uncertainty⁴² due to the breadth of unknown outcomes. Furthermore, the main advantage of the Explorative Scenario approach lies in its scope: it considers multiple outcomes and focuses on a range of different aspects and factors that could lead to several plausible futures, thereby enhancing scenario discovery for existential security scenarios.

The third and fourth approaches are mutually related: *Preserving and Transforming scenarios*. Following the scenario typology presented by Börjeson and others, normative scenario approaches embody two types, distinguished by how the system structure is treated: (1) *Normative Preserving Scenarios*, and (2) *Normative Transforming Scenarios*. According to this typology, “Preserving scenarios respond to the question: How can the target be reached, by adjustments to current situation? Transforming scenarios respond to the question: How can the target be reached when the prevailing structure blocks necessary changes?”⁴³ In this context, both Preserving and Transforming scenarios set a desirable future to achieve. However, the gravitational force lies in the structure of the system. These approaches rely on achieving a desired future and do not have the capacity to provide analytical explanatory outcomes for existential security scenarios, which by their nature are uncertain, complex, and situated in the realm of unknown unknowns.

The fifth and sixth approaches identified were *Unframed and Framed scenarios*. The Unframed Scenario is based on explorative approaches that aim to understand all potential factors in multiple future scenarios, thereby providing a comprehensive understanding of complex possibilities for potential future outcomes.⁴⁴ It sets the maximal condition for multiple interpretations and perspec-

⁴⁰ Andrew M. Parker, Sinduja V. Srinivasan, Robert J. Lempert, and Sandra H. Berry, “Evaluating Simulation-Derived Scenarios for Effective Decision Support,” *Technological Forecasting and Social Change* 91 (2015): 64-77, <https://doi.org/10.1016/j.techfore.2014.01.010>.

⁴¹ Uri Avin, Robert Goodspeed, and Lily Murnen, “From Explorative Scenarios to Plans: Bridging the Gap,” *Planning Theory & Practice* 23, no. 4 (2022): 637-646, <https://doi.org/10.1080/14649357.2022.2119008>.

⁴² Marc J. Metzger et al., “How Personal Judgment Influences Scenario Development: An Example for Future Rural Development in Europe,” *Ecology and Society* 15, no. 2 (2010), art. 5, <http://www.ecologyandsociety.org/vol15/iss2/art5/>.

⁴³ Lena Börjeson et al., “Scenario Types and Techniques: Towards a User’s Guide,” *Futures* 38, no. 7 (2006): 723-739, <https://doi.org/10.1016/j.futures.2005.12.002>.

⁴⁴ Börjeson et al., “Scenario Types and Techniques: Towards a User’s Guide.”

tives toward a potential future scenario without limiting the analysis by predetermined aspects or factors.

In contrast, a Framed Scenario focuses on a particular view or interpretation of a potential future scenario and on specific aspects of potential future outcomes, such as specific risks, threats, predetermined factors or uncertainties, and interpretations set by mental models.⁴⁵ Overall, a Framed Scenario provides strong guidelines for analyzing future scenarios; however, it limits the scope of potential futures that can be explored. On the other hand, an Unframed Scenario approach embodies the “ability to identify a wider range of multiple plausible futures,”⁴⁶ making it a suitable approach for existential security scenarios.

Finally, there are two main approaches to scenario analysis: *Classical Scenario Analysis*, developed by security and defense analyst Herman Kahn at the RAND Corporation, and *Scenario Planning*, developed by Shell Corporation business manager Pierre Wack (influenced by Kahn’s earlier work). The two paradigms differ importantly and critically in their foundational conceptualizations and objectives compared to how this study appraised the dimensions and nature of scenarios. On the one hand, from the international studies spectrum, Kahn defined scenario analysis as: “A set of hypothetical events set in the future constructed to clarify a possible chain of causal events as well as their decision points.”⁴⁷ In the context of global affairs, this primarily referred to nuclear existential threats and the future of humanity.

On the other hand, from the perspective of businesses and organizations, Wack described scenario planning as follows: scenario analysis requires that managers first understand the forces driving their business systems rather than relying solely on forecasts or alternatives.⁴⁸ In this context, Kahn’s approach directly addresses global existential catastrophes, reflecting the classical scenario analysis paradigm of “unknown unknowns,” “what if,” and “thinking the unthinkable,” grounded in systems theory.⁴⁹ Classical Scenario Analysis, as originally conceptualized by Kahn⁵⁰ in the field of strategic and international studies, situ-

⁴⁵ Robert J. Lempert, Steven W. Popper, and Steven C. Bankes, *Shaping the Next One Hundred Years: New Methods for Quantitative, Long-Term Policy Analysis* (Santa Monica, CA: RAND Corporation, 2003), https://www.rand.org/pubs/monograph_reports/MR1626.html.

⁴⁶ H.R. Maier et al., “An Uncertain Future, Deep Uncertainty, Scenarios, Robustness and Adaptation: How Do They Fit Together?” *Environmental Modelling & Software* 81 (2016): 154-164, <https://doi.org/10.1016/j.envsoft.2016.03.014>.

⁴⁷ Herman Kahn and Anthony Wiener, *The Year 2000: A Framework for Speculation on the Next Thirty-Three Years* (New York: Macmillan New York, 1967).

⁴⁸ Pierre Wack, “Scenarios: Shooting the Rapids,” *Harvard Business Review* 63, no. 6 (1985): 139-150.

⁴⁹ Herman Kahn and Anthony J. Wiener, “The Next Thirty-Three Years: A Framework for Speculation,” *Daedalus* 96, no. 3 (Summer 1967): 705-732, <https://www.jstor.org/stable/20027066>.

⁵⁰ Jeremy Stapleton, “Exploring Scenario Planning (XSP): Navigating an Uncertain Future,” *Manual* (Cambridge, MA: Lincoln Institute of Land Policy, 2020): 6-13,

ates scenario analysis within the context of existential risks (e.g., nuclear catastrophe) and actors (nation-states and humanity). Thus, it is best suited for existential security scenarios and global threats.

Result: Kahnian Explorative Unframed Scenario

Formulation:

$$K = f(\sum_{i=1}^n I_i)$$

f: critical screening and rigorous assessment of:

1. correlation
2. suitability, and
3. relevance to research inquiries

Process:

$$K = f(\sum_{i=1}^3 I_i)$$

Transformation function *f* (*tabula rasa*) by the integration of:

1. Kahn Scenario Approach
2. Explorative Scenario
3. Unframed Scenario

Results:

K: (Kahnian Explorative Unframed Scenario) for Existential Security Scenarios

Suitable Future Approaches for Existential Security Scenarios

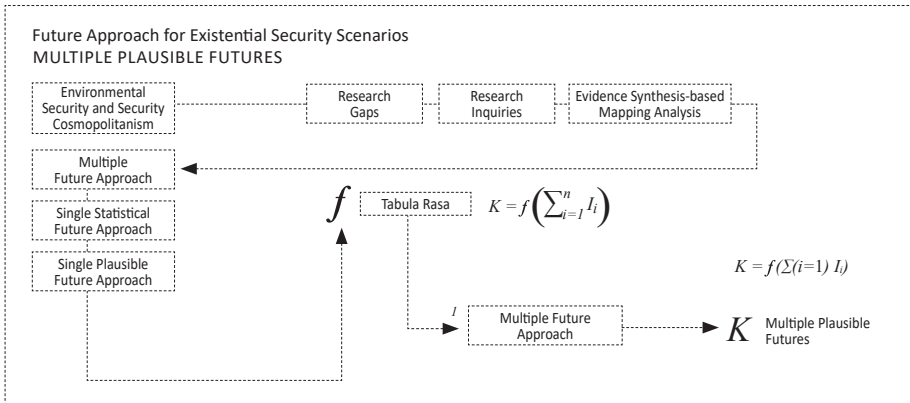


Figure 3: Process and Results: Suitable Future Approaches for Existential Security Scenarios.

Tabula Rasa analysis detected three relevant future approaches in the literature. Firstly, *Single Plausible Future*, which shares the same lineaments of normative and framed scenario approaches. Specifically, it refers to the exploration of a single particular potential scenario based on the best available knowledge or a determined future,⁵¹ and it relies on present and past knowledge, data, and trends.⁵² However, the approach lacks exploratory power in detecting uncertainties, as it focuses on projecting a single plausible scenario while overlooking factors that could potentially lead to different outcomes. This renders the approach unable to address the inquiry of existential security scenarios of non-anthropogenic disasters due to the complexity that multiple distinctive futures embody.

The second relevant approach identified in the analysis is *Single Statistical Future*, which lies in the domain of quantitative analysis, specifically statistical models and probability distributions. It attempts to quantify a single future and predict the statistical uncertainty for that probable future⁵³ based on data and trends. In contrast to the Single Plausible Future, it can provide notions of uncertainty. However, it does not withstand robust analysis when applied to complex systems, as is needed for existential security scenarios. Moreover, it arguably lacks the capability to foresee potential complex dynamics and configurations within systems outside mathematics and physics – domains not governed by universal laws. Due to these limitations, the analysis in this study discarded both approaches.

The results identified *Multiple Plausible Futures* as the most suitable future approach for designing existential security scenarios, as it provides an exhaustive analysis of the most relevant potential outcomes in a complex system. This approach addresses the analytical weakness of a Single Future Approach, in which probabilistic and statistical models cannot adequately answer inquiries about potential future scenarios.⁵⁴ In addition, it offers a rich content analysis of the uncertainties and complexities of multiple future existential security scenarios, particularly in socially complex systems such as disaster events involving global conflicts, disruptions, emergencies, and instability. It involves gathering and analyzing distinct assumptions and arguments of plausibility in non-linear contexts, making it the most suitable approach for examining the complexity and uncertainty of the international system.

⁵¹ Warren Walker and Marjolijn Haasnoot, "White Paper: Uncertainty Analysis and Decision-Making under Uncertainty with the Deltamodel," Deltares, February 16, 2011, https://publications.deltares.nl/1204151_014b.pdf.

⁵² Joseph Voros, "Integral Futures: An Approach to Futures Inquiry," *Futures* 40, no. 2 (2008): 190-201, <https://doi.org/10.1016/j.futures.2007.11.010>.

⁵³ Walker and Haasnoot, "Uncertainty Analysis and Decision-Making under Uncertainty with the Deltamodel."

⁵⁴ Steve Bankes, "Exploratory Modeling for Policy Analysis," *Operations Research* 41, no. 3 (1993): 435-449, <https://doi.org/10.1287/opre.41.3.435>.

Result: Multiple Plausible Futures

Formulation:

$$K = f(\Sigma(i = 1 \text{ to } n) I_i)$$

f: critical screening and rigorous assessment of:

1. correlation
2. suitability, and
3. relevance to research inquiries

Process:

$$K = f(\Sigma(i = 1) I_i)$$

Transformation function *f* (*tabula rasa*) by the selection of:

1. Multiple Plausible Futures

Results:

K: (Multiple Plausible Futures) for Existential Security Scenarios

Suitable Complexity Approaches for Existential Security Scenarios

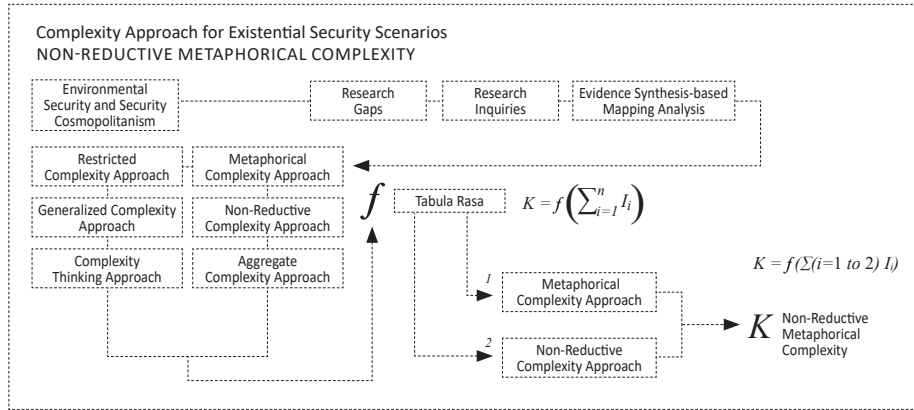


Figure 4: Process and Results: Suitable Complexity Approaches for Existential Security Scenarios.

The study identified five relevant complexity approaches as follows. Firstly, *Restricted Complexity*, which focuses on exploring and understanding complex system phenomena based on classical scientific approaches and refers to the mathematical principle of reduction.⁵⁵ It argues that complex systems are predictable,

⁵⁵ Edgar Morin, "Restricted Complexity, General Complexity," in *Worldviews, Science and Us*, ed. Carlos Gershenson, Diederik Aerts, and Bruce Edmonds (World Scientific, 2007), 5-29, https://doi.org/10.1142/9789812707420_0002.

but predictability varies with the conditions of the system, as in the type of complexity that “emerges from rule-based interactions amongst simple elements.”⁵⁶ Restricted Complexity aims to reduce complexity—essentially de-complexifying the system⁵⁷—and postulates that all interactions within a system can be measured, which allows predictability. However, it does not account for the non-linear nature of existential security scenarios, such as non-anthropogenic global catastrophes.

The second approach, *Generalized Complexity*, accepts the reductionist notion of Restricted Complexity, but not to maximize simplification in order to understand the phenomenon.⁵⁸ Instead, it reduces complexity by excluding certain factors of the system. The approach is constructed on the foundations of linear connections among the components of a complex system, as well as on the assumption that by identifying and analyzing each component, the whole can be fully understood and predicted. This predictability is based on linearity and does not accommodate the non-linearity of social complex systems, such as cascading social effects after global catastrophes.

The third approach, *Non-Reductive Complexity*,⁵⁹ focuses on the interconnections of each component in a non-linear relationship. It emphasizes the relevance of the dynamic relationship among elements, while arguing that a complex system is characterized by its unpredictability. Additionally, Non-Reductive Complexity incorporates the factor of *emergence* as a disruptive phenomenon that differentiates complex systems from complicated systems and is, thus, appropriate for global catastrophic scenarios.

The fourth approach, *Complexity Thinking*, acknowledges the importance of the unexplainable characteristics in a system, as well as the incomplete knowledge of the interactions and components of a system. Raisio and Lundström provide a clear explanation of Complexity Thinking by pointing out that “complexity thinking focus is on what cannot be explained. Based on the idea that an exact understanding of reality is always incomplete, complexity thinking focuses on the limits of our knowledge.”⁶⁰ This recognition of the limitations of knowledge is an important factor in a complex system, since it eliminates weak predictability and centers on potential outcomes, while emphasizing patterns or trends. This is especially suitable for complex systems not governed by universal

⁵⁶ David Byrne and Gillian Callaghan, *Complexity Theory and the Social Sciences: The State of the Art* (Abingdon, UK: Routledge, 2022).

⁵⁷ Morin, “Restricted Complexity, General Complexity.”

⁵⁸ Morin, “Restricted Complexity, General Complexity.”

⁵⁹ Jeanette Lancaster, “The Complex Systems of Practice,” in *Practice, Learning and Change: Practice-Theory Perspectives on Professional Learning*, ed. Paul Hager, Alison Lee, and Ann Reich (Dordrecht: Springer Netherlands, 2012), 119-131, <https://doi.org/10.1007/978-94-007-4774-6>.

⁶⁰ Harri Raisio and Niklas Lundström, “Managing Chaos: Lessons from Movies on Chaos Theory,” *Administration & Society* 49, no. 2 (2014): 296-315, <https://doi.org/10.1177/0095399714541269>.

laws. However, since this approach aims to achieve predictability through linear algorithms, it does not hold analytical power for non-linear complex scenarios.

The fifth approach, *Metaphorical Complexity*, challenges the assumption of linearity in complex systems from classical sciences, and acknowledges that “rather than being viewed as a machine, the world is viewed metaphorically as an organic entity.”⁶¹ This approach focuses on complex systems that are not governed by universal laws (and the fact that without universal laws there is no predictability), such as human systems that involve social dynamics and interactions, which are inherently ambiguous, as well as non-linear effects, like global disruptions, wars, global disasters, and collapses in complex system phenomena. Additionally, it acknowledges the factor of emergence (e.g., natural hazards), since the interactions and dynamics of a complex system not governed by universal laws involve the emergence of new characteristics (e.g., cascading effects) in a scenario that cannot be predicted from the interactions of its individual components.

Suitable Uncertainty Approaches for Existential Security Scenarios

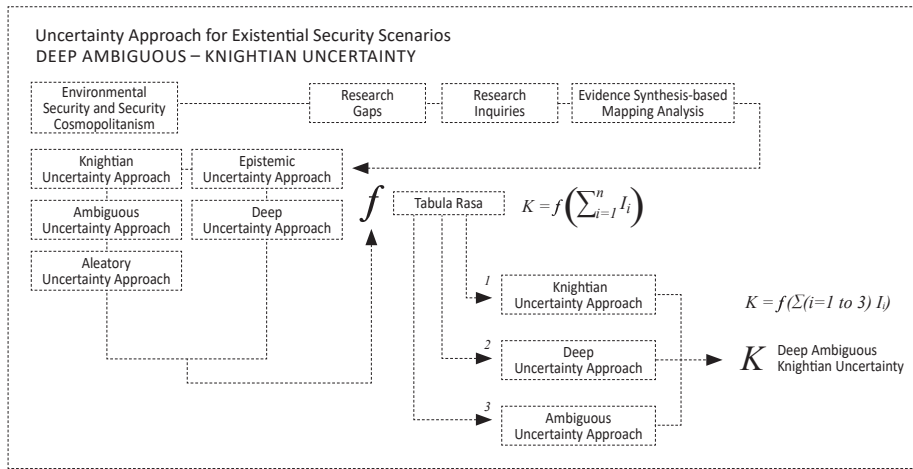


Figure 5: Process and Results: Suitable Scenario Uncertainty for Existential Security Scenarios.

Tabula Rasa identified five relevant approaches to uncertainty as follows. The first approach, *Knightian Uncertainty*,⁶² was developed in economics and addresses the unknown probabilities of outcomes. Knightian Uncertainty states that there are two major factors in probability outcomes: (1) known risks, whose

⁶¹ Raisio and Lundström, “Managing Chaos: Lessons from Movies on Chaos Theory.”

⁶² Frank H. Knight, *Risk, Uncertainty and Profit* (Houghton Mifflin, 1921).

outcomes can be measured probabilistically, and (2) unknown risks, whose outcomes cannot be measured, also called true uncertainty. Unknown risk refers to a lack of or limited knowledge that prevents the assessment of outcomes dominated by the unpredictability of potential future events. It arises when there is knowledge of a potential outcome, but not of the probabilities associated with that outcome.⁶³ In addition, it can be understood as the uncertainty produced by an abstract, preconditioned idea of what could potentially occur in a future event, without mechanisms to measure the probabilities of that event; hence, the future cannot be predicted. Furthermore, Knightian Uncertainty exists not only due to a lack of quantifiable knowledge, but also due to incomplete knowledge, limited knowledge, or ignorance. Moreover, according to Hallegatte, it may also arise from the existence of multiple possible futures without knowledge of their probabilities.⁶⁴

The second approach, *Epistemic Uncertainty*, like Knightian Uncertainty, emerges from a lack of knowledge about potential future outcomes. However, unlike Knightian Uncertainty, here, uncertainty also arises due to ambiguity. Epistemic Uncertainty links ambiguity to a series of multiple and distinct plausible explanatory causations for different futures, which prevent a clear identification of the causes of potential unknown outcomes, or, as pointed out in previous studies, to the existence of multiple frames for assessing the uncertain phenomenon.⁶⁵ In this context, ambiguity can also arise from the limitation or lack of scientific knowledge, as well as from insufficient information.⁶⁶ Overall, the main contribution of Epistemic Uncertainty to uncertainty studies is the inclusion of ambiguity as a major factor shaping uncertain futures, which is particularly suitable for analyzing non-anthropogenic global disasters.

The third approach, *VUCA Ambiguous Uncertainty* (Volatility, Uncertainty, Complexity, Ambiguity), focuses on strategic global unknowns, specifically existential threats characterized by high levels of ambiguity. It does not aim to predict future outcomes or rely on trends, but instead seeks to deliver an understanding of multiple potential uncertain and complex scenarios that are operationalized in dynamic and volatile global configurations with unpredictable outcomes.

⁶³ Yasuhiro Sakai, "J. M. Keynes on Probability Versus F. H. Knight on Uncertainty: Reflections on the Miracle Year of 1921," *Evolutionary and Institutional Economics Review* 13, no. 1 (2016): 1-21, <https://doi.org/10.1007/s40844-016-0039-0>.

⁶⁴ Stéphane Hallegatte et al., "Investment Decision Making Under Deep Uncertainty: Application to Climate Change," Policy Research Working Paper No. 6193 (World Bank, 2012), <https://hdl.handle.net/10986/12028>.

⁶⁵ Marcela Brugnach et al., "Toward a Relational Concept of Uncertainty: About Knowing Too Little, Knowing Too Differently, and Accepting Not to Know," *Ecology and Society* 13, no. 2 (2008), art. 30, <http://www.ecologyandsociety.org/vol13/iss2/art30/>.

⁶⁶ Jon C. Helton, Clifford W. Hansen, and Cedric J. Sallaberry, "Uncertainty and Sensitivity Analysis in Performance Assessment for the Proposed Repository for High-Level Radioactive Waste at Yucca Mountain, Nevada," *Procedia - Social and Behavioral Sciences* 2, no. 6 (2010): 7580-7582, <https://doi.org/10.1016/j.sbspro.2010.05.128>.

Result: Deep Ambiguous – Knightian Uncertainty

Formulation:

$$K = f(\Sigma(i = 1 \text{ to } n) I_i)$$

f: critical screening and rigorous assessment of:

1. correlation
2. suitability, and
3. relevance to research inquiries

Process:

$$K = f(\Sigma(i = 1 \text{ to } 3) I_i)$$

Transformation function *f* (*tabula rasa*) by the integration of:

1. Deep Uncertainty
2. Knightian Uncertainty
3. Ambiguous Uncertainty

Results:

K: (Deep, Ambiguous, Knightian Uncertainty) for Existential Security Scenarios

The fourth approach, *Aleatory Uncertainty*—also referred to as statistical uncertainty—relies on statistics and probability and arises from “randomness” or natural variability that cannot be mitigated or reduced, but can be represented with probabilistic methods. In a recent study on machine learning, Hüllermeier and Waegeman provided helpful insights: “epistemic uncertainty refers to the reducible part of the (total) uncertainty, whereas aleatoric uncertainty refers to the irreducible part.”⁶⁷ Aleatory Uncertainty is suitable for linear-based analysis in mathematical approaches to represent randomness quantitatively, but does not provide analytical instrumentation for uncertain futures in existential security scenarios based on the unknown, as it focuses on irreducible factors.

The fifth approach, *Deep Uncertainty*, arises when uncertain potential multiple futures are produced due to a lack of useful knowledge that can be operationalized probabilistically. The emphasis of Deep Uncertainty lies in the uncertainty of multiple plausible futures and the lack of knowledge about them. In this context, Hallegatte and colleagues suggested that Deep Uncertainty can also be produced by the presence of Knightian Uncertainty. Maier and others, citing Kwakkel and colleagues, pointed out that Deep Uncertainty is also present when analysts identify possibilities but cannot rank their likelihood.

These two approaches, in conjunction with VUCA Ambiguous Uncertainty, are most suitable for framing existential security scenarios for global non-anthropogenic catastrophes.

⁶⁷ Eyke Hüllermeier and Willem Waegeman, “Aleatoric and Epistemic Uncertainty in Machine Learning: An Introduction to Concepts and Methods,” *Machine Learning* 110 (2021): 457-506, <https://doi.org/10.1007/s10994-021-05946-3>.

Theoretical Approaches for Existential Security Scenarios

The study delivered a critical screening and rigorous assessment of (1) correlation, (2) suitability, and (3) relevance for the research inquiries, providing a concise analysis of the representation of interconnections and relationships among the theoretical approaches. It did so in order to (1) uncover the structured research area and (2) consequently build a novel theoretical framework using *Tabula Rasa*, integrated with *Symbolic Equation* in the analysis design, due to its powerful capability for the formulation and representation of conceptualizations. On the following pages, the results of the most relevant and suitable theoretical approaches for existential security scenarios are presented.

Table 1. Process and Results: Theoretical Approaches of the Study.

Formulation	Analysis	Results	Knowledge Approach
$K = f\left(\sum_{i=1}^2 I_i\right)$	f : critical screening and rigorous assessment of: (1) correlation (2) suitability (3) relevance to research inquiries	As a result of the transformation function (<i>tabula rasa</i>), through the summation of: (1) Best Available Knowledge (2) Explorative Knowledge	K (<i>Exploratory Best Available Knowledge</i>)
Formulation	Analysis	Results	Scenario Approach
$K = f\left(\sum_{i=1}^3 I_i\right)$	f : critical screening and rigorous assessment of: (1) correlation (2) suitability (3) relevance to research inquiries	As a result of the transformation function (<i>tabula rasa</i>), by the summation of: (1) Kahn Scenario Approach (2) Explorative Scenario (3) Unframed Scenario	K (<i>Kahnian Explorative Unframed Scenario</i>)
Formulation	Analysis	Results	Future Approach
$K = f(I_1)$	f : critical screening and rigorous assessment of: (1) correlation (2) suitability (3) relevance to research inquiries	As a result of the transformation function (<i>tabula rasa</i>) by the selection of: (1) Multiple Plausible Futures	K (<i>Multiple Plausible Futures</i>)

An Existential Security Scenario Framework for Non-Anthropogenic Catastrophes

Formulation	Analysis	Results	Complexity Approach
$K = f\left(\sum_{i=1}^2 I_i\right)$	f : critical screening and rigorous assessment of: (1) correlation (2) suitability (3) relevance to research inquiries	As a result of the transformation function (<i>tabula rasa</i>) by the summation of: (1) Non-Reductive Complexity (2) Metaphorical Complexity	K (Non-Reductive Metaphorical Complexity)
Formulation	Analysis	Results	Uncertainty Approach
$K = f\left(\sum_{i=1}^3 I_i\right)$	f : critical screening and rigorous assessment of: (1) correlation (2) suitability (3) relevance to research inquiries	As a result of the transformation function (<i>tabula rasa</i>), by the integration of: (1) Deep Uncertainty (2) Knightian Uncertainty (3) Ambiguity (VUCA Uncertainty)	K (Deep, Ambiguous, Knightian Uncertainty)

Structured Research Area for Existential Security Scenarios and Theoretical Framework for Existential Security Scenarios

The results revealed and delivered a concise representation of the interconnections and relationships among the most relevant and suitable theoretical approaches for the structured research area of existential security scenarios, and consequently produced a novel theoretical framework based on its capability to formulate and represent conceptualizations through the integration of Tabula Rasa and Symbolic Equation, as follows.

Discussion

On Existential Risks and Threats for Existential Security Scenarios

The authors acknowledge the assumptions that “threat provides the urgency to security in its direct and ‘looming’ nature, risks can be uncertain and distant,” and that “threat implies a direct causal chain of harm, while risk pertains more to second-order conditions of possibility for future harm.”⁶⁸ Based on these assumptions, and using conjunctively the lens of international security studies and global environmental studies, they argue that “Existential Security Risk” (anthropogenic) embodies existentially unfavorable outcomes of controllable human

⁶⁸ Tom Hobson and Olaf Corry, “Existential Security: Safeguarding Humanity or Globalising Power?” *Global Policy* 14, no. 4 (September 2023): 633-637, <https://doi.org/10.1111/1758-5899.13287>.

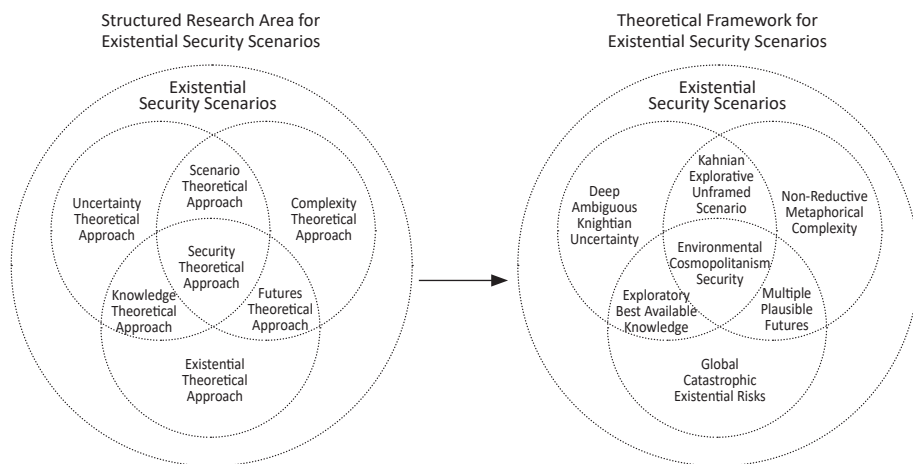


Figure 6: Process and Results: Uncovered Structured Research Area.

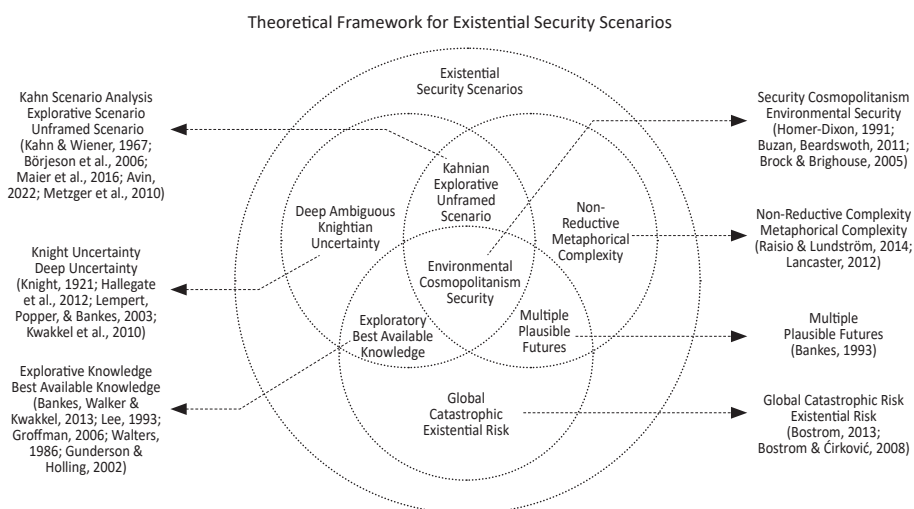


Figure 7: Process and Results: Novel Theoretical Framework for Existential Security Scenarios.

efforts, decisions, and actions, while “Existential Security Threats” (non-anthropogenic) are uncontrollable non-human events that embody existential negative outcomes.

While previous studies have dismissed the inclusion of non-anthropogenic catastrophes⁶⁹ due to their low probability compared to anthropogenic disasters, current studies have operationalized natural hazards and highlighted the vital importance of furthering research on non-anthropogenic catastrophic scenarios as existential for humanity's safety.⁷⁰ Firstly, non-anthropogenic environmental catastrophes, while low in probability, possess a high magnitude of potential devastation on a global scale. Secondly, non-anthropogenic catastrophes could exacerbate anthropogenic risks, characterized by high levels of complexity in the global strategic domains of humanity, e.g., through environmental cascading effects. Thirdly, historical precedents and empirical evidence of existential catastrophes have been extensively documented, especially concerning meteorite impacts on Earth. Fourthly, dismissing non-anthropogenic catastrophes from the development of a framework for existential security lacks justifiable empirical support, as the only empirical evidence of high-level threats to humanity's existence—despite their low probability—are non-anthropogenic environmental global catastrophes.

Table 2. Typology of Existential Security Risks and Existential Security Threats.

Anthropogenic Catastrophes	Non-Anthropogenic Catastrophes
Existential Security Risks	Existential Security Threats
<i>Example:</i> A planetary environmental risk that embodies the employment of nuclear weapons	<i>Example:</i> A planetary environmental threat where a near-earth object (NEO) meteorite could impact Earth
There is a <i>risk</i> , <i>not a threat</i> , as anthropogenic factors involve causally controlled, man-made efforts (decision-actions) and effects (outcomes).	There is a <i>threat</i> , <i>not a risk</i> , as non-anthropogenic factors are beyond causally controlled, man-made efforts (decision-actions) or effects (outcomes)
✓ Low uncertainty	✓ High uncertainty
✓ High complexity	✓ High complexity
✓ Can be prevented	✓ Cannot be prevented
✓ Can be mitigated	✓ Can be mitigated

On Complexity and Existential Security Scenarios

The literature and empirical evidence have demonstrated the predictive power of the classical scientific linearity, as applied, for instance, in chemistry, physics, and mathematics-based approaches, where the behavior of each element obeys universal laws. However, when studying complex systems in the natural and social sciences, this approach encounters a series of limitations, and the predictive

⁶⁹ Sears, "Existential Security: Towards a Security Framework for the Survival of Humanity."

⁷⁰ Mami, Erwin, and Johnson, "Natural Global Catastrophic Risks."

power of linear relationships has proven somewhat ineffective, as natural, biological, and human systems with social dynamics arguably do not obey these universal laws. In this regard, a *Tabula Rasa* process suggests that the most important characteristics of a complex catastrophic environmental scenario lie in the non-reductive complexity's core "non-linear" nature.⁷¹ This is characterized by the unpredictable behavior and interactions of elements coexisting within a particular system.

On the other hand, this study also suggests that the major difference between complicated and complex systems is that complexity is defined by the role of "emergence,"⁷² understood here as a disruptive, major causal factor in a system. Without emergence, a system does not possess the characteristics of a complex system, but rather of a merely complicated system. The complexity of a planetary non-anthropogenic as well as anthropogenic environmental catastrophic existential security scenario is triggered by emerging factors. These ultimately lead to a series of ramification effects throughout the whole system – in its interconnections, dynamics, and relationships. Consequently, it exhibits all the characteristics of a non-reductive complexity⁷³ approach.

On Uncertainty and Existential Security Scenarios

Uncertainty approaches in the literature vary greatly. In earlier studies, uncertainty has been classified into five distinctive vectors under the umbrella of risk analysis: (1) temporal; (2) translational; (3) metrical; (4) variables-based; and (5) structural. This classification is based on a systems approach and is characterized by a relevant lack of information.⁷⁴ From the perspective of organization theory, this lack of information can be referred to in abstract explanatory terms as uncertainty—either because the information does not exist or because it is lost in multiple interpretations—thereby highlighting the role of the decision-making process in mitigating uncertainty.

Consequently, the literature offers several different approaches to uncertainty, based on central factors that cause it. *Tabula Rasa* has traced these causes of uncertainty as follows: (1) due to unmeasurable outcomes and limited knowledge⁷⁵; (2) due to multiple possible futures without knowledge of their probabilities⁷⁶; (3) due to multiple frames used to examine the uncertain phenomenon⁷⁷; (4) due to situation in which analysts lack knowledge about the fu-

⁷¹ James Gleick and Robert C. Hilborn, "Chaos, Making a New Science," *American Journal of Physics* 56, no. 11 (1988): 1053-1054, <https://doi.org/10.1119/1.15345>.

⁷² Morin, "Restricted Complexity, General Complexity."

⁷³ Lancaster, "The Complex Systems of Practice."

⁷⁴ William D. Rowe, "Understanding Uncertainty," *Risk Analysis* 14, no. 5 (1994): 743-750, <https://doi.org/10.1111/j.1539-6924.1994.tb00284.x>.

⁷⁵ Sakai, "J. M. Keynes on Probability Versus F. H. Knight on Uncertainty."

⁷⁶ Hallegatte et al., "Investment Decision Making Under Deep Uncertainty: Application to Climate Change."

⁷⁷ Brugnach et al., "Toward a Relational Concept of Uncertainty."

ture or cannot agree upon decisions regarding potential futures,⁷⁸ where possibilities can be identified but not ranked or assigned likelihood⁷⁹; (4) due to existential threats with high levels of ambiguity in VUCA's uncertainty⁸⁰; and due to the limitation of lacking both scientific knowledge and information.

In this context, Tabula Rasa assessed that the most relevant uncertainty approaches to existential security scenarios for planetary non-anthropogenic and anthropogenic environmental catastrophes include characteristics of high levels of ambiguity related to a global existential threat. Therefore, it endorses the conceptualization of ambiguity operationalized in VUCA's Uncertainty approach⁸¹ and in Epistemic Uncertainty, since global environmental catastrophes share the characteristics of existential risk with high levels of ambiguity stemming from multiple frames used to examine uncertainty.⁸²

On the other hand, the analysis identified that the unpredictable nature of an existential security scenario for global non-anthropogenic environmental catastrophes results from unmeasurable outcomes and limited knowledge. This aligns with the central focus of Knightian Uncertainty and with the Multiple Plausible Future Scenarios suggested by a Deep Uncertainty approach. Furthermore, Tabula Rasa integrates the assumption that global non-anthropogenic environmental catastrophes embody a high level of uncertainty, with multiple possible futures and without knowledge of their probabilities, as previously stated by Helton, Hansen, and Sallaberry.⁸³

On Scenario Analysis for Existential Security Scenarios

This study detected that the two foundational paradigms of scenario analysis are clearly present in the literature, but are entangled, with their differences masked in the debate. The authors' interpreted definitions of scenario planning, attributed to Pierre Wack (1985), rightly highlight the focus of Wack's paradigm, dimensions, and theory: companies, markets, and managers in a competitive domestic and international market context. Consequently, based on the results of its critical appraisals, this study suggests implementing Kahn's approach to con-

⁷⁸ Lempert, Popper, and Bankes, *Shaping the Next One Hundred Years*.

⁷⁹ Maier et al., "An Uncertain Future, Deep Uncertainty, Scenarios, Robustness and Adaptation."

⁸⁰ R. Bradley MacKay and Veselina Stoyanova, "Scenario Planning with a Sociological Eye: Augmenting the Intuitive Logics Approach to Understanding the Future of Scotland and the UK," *Technological Forecasting and Social Change* 124 (2016): 88-100, <https://doi.org/10.1016/j.techfore.2016.08.026>.

⁸¹ Harry R. Yarger, *Strategic Theory for the 21st Century: The Little Book on Big Strategy* (US Army War College Press, 2006), <https://press.armywarcollege.edu/monographs/723>.

⁸² Brugnach et al., "Toward a Relational Concept of Uncertainty."

⁸³ Helton, Hansen, and Sallaberry, "Uncertainty and Sensitivity Analysis in Performance Assessment."

tribute to theory development in scenario studies for global planetary catastrophes. This is due to the inherent classical scenario planning paradigms of “unknown unknowns,” “what if,” and “thinking the unthinkable,” based on systems theory scenarios. This study refers to this as “classical scenario analysis,” the original conceptualization of scenario analysis from Kahn in strategic and international studies. It forms the basis of scenario planning in the context of existential risk (global nuclear catastrophe) and focuses on multiple plausible scenarios. It is therefore arguably most suitable for global existential complex threat dimensions, as it embodies by default an explorative⁸⁴ and unframed⁸⁵ nature, with high levels of uncertainty⁸⁶ – contrary to its later adaptation to organizational and business dimensions by Wack.⁸⁷

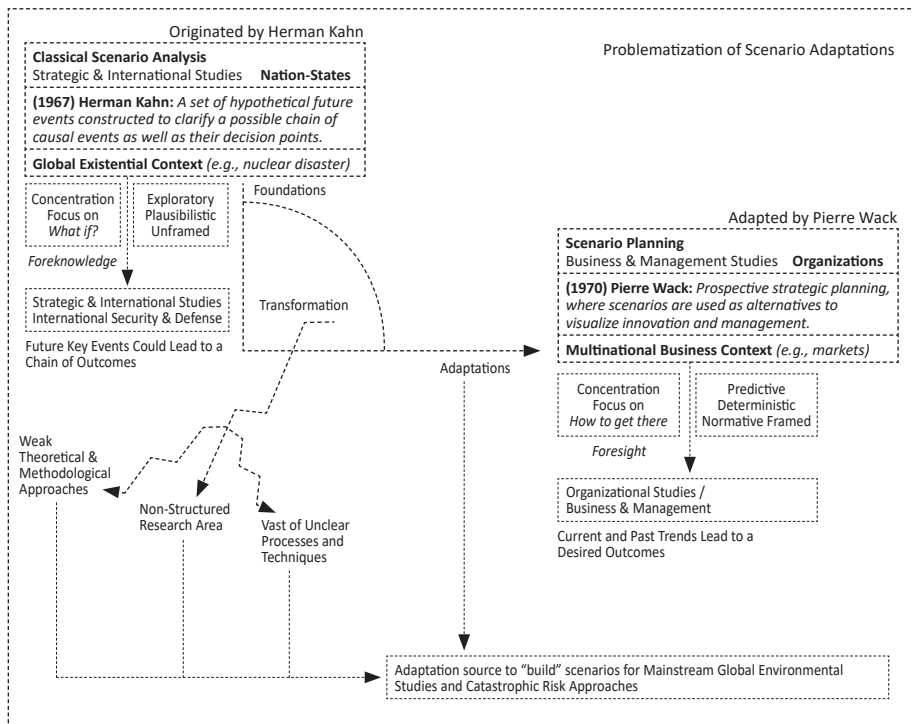


Figure 8: Problematization of Scenario Adaptions.

⁸⁴ Avin, Goodspeed, and Murnen, “From Exploratory Scenarios to Plans.”

⁸⁵ Börjeson et al., “Scenario Types and Techniques: Towards a User’s Guide.”

⁸⁶ Metzger et al., “How Personal Judgment Influences Scenario Development.”

⁸⁷ Wack, “Scenarios: Shooting the Rapids.”

Consequently, this study suggests not to operationalize scenario studies from organizational, management, and business studies approaches, arguably adapted by Pierre Wack. Instead, based on Kahn's original approach, the authors propose moving the debate on scenario studies away from business and organizational framings and related areas such as predictive foresight or predictive future studies. As a result, this study argues that the most suitable approach is classical scenario analysis (Kahn) of "unthinkable situations," since it constitutes the original theoretical roots and foundational approach of scenario analysis, as rightly highlighted by a precise theoretical review by Spaniol and Rowland.⁸⁸ Classical strategic scenario analysis in the spheres of strategic, international security, and defense studies operates in the realm of strategic and existential threats to humanity. However, despite useful contributions from organizational and business studies, the results of this study excluded approaches grounded in organization, business, and management studies, as those are not framed by existential threats. This study also excluded scenario approaches that aim to "predict" future outcomes, since classical scenario planning seeks to rationally unfold potential global existential threats to humanity, rather than predict events or scenarios. Therefore, this study integrated classical scenario analysis (Kahn) into the existential security scenarios framework.

Conclusions and Further Studies

This study explored and identified a structured research area for existential security scenarios and proposed a foundational theoretical framework that addresses the aforementioned inquiries by integrating complexity, uncertainty, future, knowledge, and scenario approaches for non-anthropogenic global planetary catastrophes. In doing so, this work contributes to the development of an existential security scenarios framework to address the emerging challenges of non-anthropogenic catastrophe scenario analysis and advances existential security study approaches from a theoretical-practical dimension.

The theoretical framework was developed through rigorous conceptual evidence-synthesis-based mapping analysis and critical integration of foundational literature, rather than immediate empirical validation. Maxwell emphasizes that theory-building research prioritizes conceptual abstraction and clarification prior to empirical application, underscoring the heuristic role of theoretical frameworks in guiding inquiry rather than serving as empirical tools.⁸⁹ Pretorius further distinguishes between theoretical frameworks, which

⁸⁸ Matthew J. Spaniol and Nicholas J. Rowland, "Defining Scenario," *Futures & Foresight Science* 1, no. 1 (March 2019): e3, <https://doi.org/10.1002/ffo2.3>.

⁸⁹ Joseph A. Maxwell, *Qualitative Research Design: An Interactive Approach* (Los Angeles, CA: Sage Publications, 2013).

are grounded in established theories, and conceptual frameworks, which organize and link concepts to explain relationships; neither of these inherently requires empirical evidence at the initial stage.⁹⁰

A critical impetus for this focus arises from the pervasive issue of theoretical stagnation within the field, which has contributed to the proliferation of inadequate and failed methods and models of analysis, as stated in the problematization. Recent scholarship identifies that such stagnation stems from entangled methodological and practical approaches that inhibit productive scholarly dialogue and cumulative knowledge advancement in scenario studies. As argued in this work, there is a lack of a structured research area that provides a foundational theoretical approach to the phenomenon. Hence, this study aims to establish such a research area, contributing to a theoretical framework for existential security scenarios. This foundational emphasis seeks to foster a coherent and integrative theoretical discourse, encourage further dialogue within the academic community, and mitigate the risk of perpetuating ineffective or narrowly contextualized premature methodologies, models, and techniques.

Furthermore, based on the study's findings, the authors recommend further research related to existential security scenarios—for instance, on existential risk, human survivability, space security, environmental security, and planetary defense—grounded in non-linearity with regard to uncertainty and complexity. Finally, the authors suggest framing global multiple-futures scenario analysis with unknown unknowns by operationalizing the original Kahnian scenario approach, as it inherently embodies existential threats and global risk in a planetary context, thereby returning to the classics.

Disclaimer

The opinions, findings, conclusions, and recommendations expressed in this publication are those of the authors and do not necessarily reflect the official policy or position of the Partnership for Peace Consortium, its participating institutions, or any governmental or international organizations affiliated with its governance structure.

⁹⁰ Lynette Pretorius, "Theoretical and conceptual frameworks in research," February 20, 2024, https://www.lynettepretorius.com/the_scholars_way_blog/theoretical-and-conceptual-frameworks-in-research/.

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