United Nations Office for Disaster Risk Reduction

GAR

Global Assessment Report on Disaster Risk Reduction

2022

CONTRIBUTING PAPER

The need for a new narrative in an era of existential threats

Susanne Hanger-Kopp
John Handmer

Disclaimer:

This is not an officially edited publication of the United Nations. The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country or territory or of its authorities or concerning the delimitations of its frontiers or boundaries. The designations of country groups in the text and the tables are intended solely for statistical or analytical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of the names of firms and commercial products does not imply the endorsement of the United Nations.

Note: The designations employed and the presentation of maps in this report do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities or concerning the delimitation of its frontiers or boundaries.

Citation: UNDRR (2022), *The need for a new narrative in an era of existential threats,* United Nations Office for Disaster Risk Reduction (UNDRR).

For additional information, please contact:

United Nations Office for Disaster Risk Reduction (UNDRR)
7bis Avenue de la Paix, CH1201 Geneva 2, Switzerland, Tel: +41 22 917 89 08

The need for a new narrative in an era of systemic existential threats

Authors

Susanne Hanger-Kopp

Population and Just Societies (POPJUS) Program, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria; Department of Environmental Systems Science (DUSYS), ETHZ, Zurich, Switzerland

John Handmer

Population and Just Societies (POPJUS) Program, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria

Abstract

The modern concept of risk was developed to share commercial losses, and is now ubiquitous across sectors and issues regardless of issue, scale or complexity. Systemic risks and existential threats increasingly threaten human and natural systems. These risks are compounded by the potential of impacts to cascade across interconnected systems, to irreversibly breach system boundaries, and to impose intolerable burdens.

Most models and approaches to risk were developed for specific purposes or for commercial application where the dimensions of the risk are well known and bounded. Even in these circumstances, risk assessment is often hard to get right, and it is not clear that assessments in the environmental arena do much more than legitimise prior decisions. Given that these approaches were not developed with systemic or global catastrophic risks in mind, it seems reasonable to question their applicability to such threats.

It may be that the idea of risk as generally used and developed over several centuries is not appropriate for the complex systemic and cascading threats now being faced. The refinement of the concept and its application has been about increased precision and accuracy. The global systemic risks do not lend themselves to this approach, and existential risks should not, by definition, be traded off against other objectives – although in current risk assessments we implicitly trade the future against a continuation of business as usual.

As solutions are unlikely to be found within the mindsets that led to the problems, substantially different approaches are needed. Workable alternatives to conventional formal risk assessment processes could for example, include variations of the precautionary principle, innovative approaches to identifying and managing uncertainties, and the application of the ideas of boundaries, tipping points, and planetary and social limits. This paper will examine the utility of conventional ideas of risk in an era of systemic and existential threats, and suggest pathways for improvement.

Keywords: systemic risk; existential risk; standardization; risk concepts

Contents

Old and new threats of global catastrophe.

> *"…the task is large, the window of opportunity is short, and the stakes are existential" Mark Carney* (2019)

In an era of climate risk, cascading and systemic risks, extinctions, global catastrophic and existential risks to the planet, planetary boundaries, adaptation limits and tipping points, perhaps approaches that work well for tightly bounded risks like housefires and shipping losses, are no longer satisfactory?

This is not to argue that the risks that have long concerned us – the technological risks that led to the Seveso Directive and the US Superfund, risks from occupational hazards and transport, as well as those from accidents and disease, aren't very concerning – but that they are compounded by additional and interlinked hazards and being joined by a plethora of apparently more serious possibilities. These complex risks surround us, and also come from among us (Beck, 1992). This means that most of the identified potential global catastrophic risks are anthropogenic in nature, i.e. they are generated by our science, technology and lifestyles. These include destructive bio or nano-technology, artificial intelligence, nuclear war, global warming, loss of biodiversity, economic system collapse and ecosystem services and famine.

This background paper is about these more serious threats which can be existential with the potential to eliminate humanity or our life support systems (Bostrom, 2013; Marques, 2020; Matheny, 2007), and certainly have major systemic impacts on societies and economies, including on critical systems. It is important to note here that existential and systemic risks are not necessarily the same, although they share attributes[1]. Such major risks seem easy enough to identify, but they defy precise definition or quantification as illustrated in the 2019 Global Risk Assessment Report or the annual Global Risks Report of the World Economic Forum. They are the subject of widespread debate for example in the case of artificial intelligence, where a high profile argument is ongoing between Elon Musk and Marc Zuckerberg. Any serious attempt at management requires global cooperation, itself currently at best defined by words rather than actions, and is subject to sabotage. Improved measurement and assessment of the risks in conventional terms, i.e. calculating and mapping probabilities and pricing impacts, are unlikely to help drive the needed action (EEA, 2013). The IPCC (Inter-governmental Panel on Climate Change) experience is illustrative: its 1990 report called for urgent action to reduce greenhouse gases (itself a decade after the US Academy of Sciences Charney Report), and the arguments continue despite the largest collaborative scientific effort ever, numerous statements about the risk, Global agreements and increasing popular pressure. Compliance still fluctuates with shifts in political power. Some national central banks, many global corporations and lower levels of government are increasingly pulling ahead of national governments in terms of action on this issue. This is illustrated for example,

[1]Particularly for systemic risks definitions are emerging and have not yet become sufficiently established. For existential risks, a small dedicated research community is creating a sizable body of research (Bostrom, 2013; Jebari, 2015; Moynihan, 2020; Tonn and Stiefel, 2013). However, this article does not aim to contribute particularly to this work on existential risks, but uses the term only for highlighting the magnitude of risk at stake.

by the efforts of the World Business Council on Sustainable Development, whose 200 members committed to net-zero emission targets and halting biodiversity loss by 2050[2].

A history of loose definition

The idea of risk is ubiquitous in modern society and is used to refer to everything from being late for an appointment to existential threats to the planet. Its origins and continued primary use in commerce have encased it as a term suitable for well identified "tame" risks. Still, understanding of the concept by many who use the term professionally is often very limited, and while attempts at global consistency, e.g. through standards and agreements on terminology, have worked well in some sectors, we doubt their applicability to complex global threats.

Risk has a long history of disagreement and a lack of understanding and appreciation of the many different views on risk from across research disciplines and professional and commercial sectors – including those that are based on risk such as insurance and much engineering, as well as risk science itself. Differences are not confined to research and different sectors, but come also from worldviews and ideologies varying from the precision of engineering and insurance to the all-encompassing nature of Beck's *Risk Society* (1992). The highly quantified approach of engineering and transport assumes that knowledge is fully or nearly complete, as do many sectors of the insurance industry. In contrast are the qualitative approaches of cultural risk theorists (e.g. Thompson and Rayner, 1998), and the large uncertainties confronting those dealing with political risk such as Brexit and responses to Covid-19, and aspects of financial markets (Garonna, 2020). Another research area addresses the individual and collective perception of risk, which may vary considerably between groups and between specialists and lay people (Kasperson et al., 1988; Slovic, 2000). This is relevant for understanding risk attitudes, behaviour, decision making under uncertainty, and in turn for risk communication. In this area risk is typically defined qualitatively highlighting the context-dependency of the term. National differences can also be important, with the UK traditionally being prepared to live with uncertainty and to work towards an "as low as reasonably practical" level of risk, in contrast to the US with its focus on precisely defined sources of risk (Dessai et al., 2007; Hanger et al., 2012). Differences in risk perception, trust in risk governance, and blame for the virus, is dramatically revealed by public approaches to Covid-19 and attempts by governments to reduce the risk (Mordecai and Connaughton, 2020).

One view is that this definitional vagueness didn't matter much so long as those discussing the risk worked more or less within the same discipline or area of practice, and were reasonably clear on what each other meant. It might have even helped us make progress by not spending a lot of time and effort arguing over definitions, and trying to resolve arguments across disciplines and worldviews. Nevertheless, communication and thus problem solving across areas has long been challenging. This has been true for both long-term slow onset events such as climate change, and "surprise" events such as the COVID-19 pandemic. It also applies across groups of actors and stakeholders, where frequently considerable discrepancies have been observed between expert assessment and lay perception.

[2] https://www.eco-business.com/news/200-of-worlds-largest-corporations-commit-to-net-zero-emissions-by-2050-reverse-biodiversity-loss-and-fight-inequality/

Limited and diverse understandings of risk.

Research and debates around climate and transition risks show potential issues when using common concepts such as risks where a lot of meaning remains implied, potentially affecting productive discussions, and effective management and governance processes. Our recent experience in this context is that researchers from different areas not so much disagreed about definitions, but had trouble clearly articulating how risk was conceptualised, precisely what was at risk, whether risk referred to the cause or the potential impact of the risk. To illustrate this more clearly. The task in the H2020 project TRANSrisk was to identify and assess risk and opportunities associated with climate mitigation polices. The following issues arose: First of all, whether opportunities are considered a (positive risk) or should be seen as different from risks. In some branches of economics risks can also be positive in impact, whereas in most other contexts risk is seen as inherently negative. Second, what is a policy risk. In some contexts, a policy risk is used synonymously with barriers to the design, adoption, implementation, or continued functioning of a policy. This has been frequently the case in the context of renewable energy policy (Díaz et al., 2017; e.g. Lilliestam and Patt, 2015). However, recently in the context of the energy transition, policy or transition risks are actually the negative impacts resulting from climate mitigation policies (Collins et al., 2021). Which for some is confusing as these policies are actually risk management policies, intended to help solve the problem of climate change. It most often comes down to the issue that in any given context the emphasis is either on the cause or the impact while the other component is neglected. Moreover, underlying implications of who or what is amplifying causes and bearing impacts remain vague (Hanger-Kopp et al., 2019). More generally, different and incomplete understandings can make it very difficult to discuss the risk problem, much less to quantify the risk. It also makes it difficult to have meaningful discussions on how to tackle new and complex risks such as climate and transition risks – with, as with other global and systemic risks or threats, their attributes of unknowability, ignorance and contingency, and lack of boundaries in space and time.

Existential global risks are distinctive in that often knowledge about them appears to be almost entirely in the hands of specialists, and they are characterised by immense uncertainty and disagreement in their most basic dimensions. Values and politics can be key. This highlights that the different specialists need to be able to talk with each other, and with holders of other sources of knowledge, as values should be an explicit part of the discussion. Existential risks cannot, by definition, be traded off against other objectives: with such risks or threats any tradeoffs imply that we are prepared to accept the possibility of extinction. In addition to this existential reason, there are also strong moral and ethical grounds for avoiding tradeoffs (Marques, 2020; Schubert et al., 2019). This is especially the case when considering intergenerational equity (Aven, 2016). Although we argue that they cannot be traded, in reality we explicitly trade the future against a continuation of business as usual. A useful recent overview of some of the issues is found in (Currie and Ó hÉigeartaigh, 2018).

Global efforts to improve the quality and relevance of risk assessment and management.

Many national and international groups have devoted much effort to developing risk processes and terminology, for risk identification, analysis and management. These efforts span detailed formal standards and procedures, most often as sector/research area specific approaches. However, it is an open question as to how useful these are for complex and systemic risks potentially threatening human existence.

For example, countries, national societies and commerce have participated in the development (and use) of the **international standard ISO 31000** on risk management and its derivative standards and guides (eg NERAG, the Australian *National Emergency Risk Assessment Guidelines*), as well as the pre-existing national standards that informed its development.

> *ISO31000 2018 "Risk is now defined as the "effect of uncertainty on objectives", which focuses on the effect of incomplete knowledge of events or circumstances on an organization's decision making. This requires a change in the traditional understanding of risk, forcing organizations to tailor risk management to their needs and objectives – a key benefit of the standard.*

In practice, uncertainty is generally seen as a probability and avoiding consequences (or impact) the objective. This focus on known largely quantifiable risks clearly bounded in space and time with few unknown dimensions is a significant limitation of the international standard. Most of not all standard approaches to risk are similar. A further limitation in these approaches is that outliers are generally ignored, and step changes poorly handled.

This is in contrast to the risks associated with climate change and global scale social and economic transitions, where we are dealing with outliers, where many dimensions of the risks are unknown, resistant to quantification, or contested, and where even the description of the risk is itself in dispute. The standard may be of limited value when applied to complex unbounded risks (Handmer and Dovers 2013).

Nevertheless, the focus on objectives could be valuable, and enables the standard to apply much more broadly than at first appears. An objective could be the continued functioning of critical infrastructure, avoidance of flood or fire deaths, transport safety, maintenance of ecosystem services, halting a pandemic or avoiding a planetary boundary. The objective is something we want to achieve and is usually therefore positive or beneficial. In some sectors, such as the financial sector, risk is often seen as a positive opportunity – we take a risky investment because the potential payoff is very beneficial. This way of thinking can also apply to natural hazards as expressed by the early researchers in the field (although they used different language): we occupy floodplains for the benefits and in doing so take the risk of flooding and the associated losses (Burton et al., 1968).

For climate risk, **the IPCC** has spent time trying to gain agreement on risk, for example in its Special Report on Extremes - SREX (IPCC, 2012). The definition, where risk is a function of hazard, exposure, and vulnerability, is fairly general to accommodate a wide range of approaches with good alignment with the term as used by many in the fields of disaster science and natural hazards including the Global Assessment Report (GAR) on Disaster Risk Reduction (UNDRR, 2019). It includes a broader reference highlighting the subjectivity of risk considering risk as "the potential for consequences where something of value is at stake and

where the outcome is uncertain, recognizing the diversity of values". The GAR 2019 includes extensive discussion on emerging systemic risks. However, while these definitions are used rather consistently in the disaster risk community and have found entry into the closely related work on climate impacts and adaptation in Working Group II of the IPCC, this consistency is not reflected in other IPCC work. Working Group III – chapter 2 proposes a different, broader definition, where risk is "[t]he potential, when the outcome is uncertain, for adverse consequences on lives, livelihoods, health, ecosystems, economic, social and cultural assets, services (including environmental services), and infrastructure" (IPCC, 2014). This definition is however, not used consistently across the remaining Working Group chapters.

The **World Economic Forum in cooperation with private and academic partners has been publishing Global Risks Reports (GRR) since 2006**. The first report stated identifying and assessing risks as one of its main objectives. It noted that "*our collective ability to mitigate global risks is still seriously hampered by divergent perceptions of the nature and importance of such risks;". The GRRs are* not an explicit effort at standardization. Indeed, only the 2020 GRR provides a definition for global risks as "an uncertain event or condition, that if it occurs, can cause negative impact for several countries or industries within the next ten years." *However,* given its relevance as a visionary platform for global economics, the annual risk chart list should not be underestimated as a hub for mainstreaming risk perceptions. The WEF uses actuarial methods were possible, but also considers risks that can only be qualitatively assessed based on expert knowledge. Impacts are measured in economic damage, human lives lost, and impact on economic growth. Both dimensions are measured for short-term (1 year) and long-term (10 years) for both baseline and worst-case scenarios. Risks are presented in several categories – economic, geopolitical, social, technological, and environmental.

Two general implications flow from this discussion. The first is that some of the main global definitions are focused on measurement in an environment where uncertainties are well understood and quantified, where risk management options are generally known and there is a high degree of agreement about most risk dimensions, including management options. These limit the applicability of the approaches concerned to novel or emerging complex risks. The second is that there are some general principles and concepts that have broad applicability and that could be useful in examining existential and other global risks.

The options

Whatever path is taken to improve our understanding of risks and threats, there is a need for enhanced clarity and inclusion in statements on major risks. Discussing new risks that are more complex and encompass higher levels of threat, requires a more diverse set of people to join the discussion – including importantly those most affected. To ensure effective risk management and governance a clear understanding of what is at stake and how the threat might impact these. The ISO standard could be seen to cover this through its statement on objectives, but in application this is generally applied in a very narrow technical sense. Clarity is especially needed with a term that has been handled loosely outside of some highly specialized areas. In saying this, we recognise that systemic, cascading and complex risks and impacts are not fully knowable in advance.

Drawing on the discussion there are a number of options or pathways towards improving the applicability of the concept of risk to the more systemic and existential threats facing humanity and the planet today:

- The potential of a spin-off standard on global risks?
  A new, or better an additional, standard, might be an opportunity to clarify applicable risk statements and enable wide(r) communication on its use and ultimately its management. However, it is challenging to overcome long-standing conventions – even if loose – around a term that is so comprehensively used; an ISO standard might actually not have the reach required to address new systemic risks. Thus at least a standard might need to be developed on a different platform. The WEF still uses traditional likelihood vs. impact equations. More innovative seem the efforts in the context of the UNDRR GRAF. The SDGs (Sustainable Development Goals) could provide an alternative sustainability-focused frame for risk assessment (Deloitte, 2019; Douma et al., 2017). Given the new networks for risk governance that are being created around these and similar institutions, an appropriate global standard might be welcomed. Against this stands the fact that risk is context-dependent and there is no "one size fits all" approach to risk management (Etkin, 2016) and associated calls for a plurality in conceptualizing and so-called 'standardising' of alternative forms of threats and risks to various spheres (e.g., humanity, individual lives, our resources, economy, assets).

- Replacing the term risk
  A more radical suggestion is that the concept of risk as generally used and developed over several centuries is not appropriate for the global threats now being faced. The refinement of the concept and its application has been about increased precision and accuracy – despite the statement in the standard concerning "objectives". The global systemic risks do not lend themselves to this approach. It might be easier to abandon the old terminology for something new without the baggage of the past. Terminology that is adequate to the all-encompassing issues involved when we talk about global and systemic risks, and which include the underlying and dynamic drivers. This could also take into consideration the need to change risk communication is approached, particularly where impacts from climate change are concerned (Stoknes 2015). New definitions might consequently lead to more openness, inclusiveness and creativity with respect to new approaches to risk analysis, risk statements and management encompass complex and cascading risks.

- Will we dare to trust qualitative and narrative approaches?
  Either way, it is becoming increasingly evident that traditional risk assessment approaches are not fit to address many complex risks. By definition, complexity includes a level of uncertainty that defies quantification. Besides expert judgement, approaches based on qualitative and fuzzy data have been viewed critically or as second-class options. They include, but are not limited to story-telling such as made use of in the Talanoa Dialogue process accompanying the COP2019, warm data labs (Bateson, 2017), Wardley maps (Wardley, 2018), Design Thinking (Nishant et al., 2020; Razzouk and Shute, 2012), and Soft Systems Analysis (Checkland, 2000). Some have been around for a long time, others are relatively, new. Not all are academic approaches, but they have in common, that they might be able to complement, and in some instances replace quantitative methods, in cases where they are not accessible or insufficient for governing global, systemic, and/or existential threats.

Conclusions

Existential and systemic threats increasingly threaten human society and the global systems on which it depends. These risks are compounded by their potential to cascade across interconnected socioeconomic systems, to irreversibly breach system boundaries, and to impose intolerable burdens on whole nations. Existential risks cannot, by definition, be traded off against other objectives – although we explicitly trade the future against a continuation of business as usual.

There are many aligned, albeit loosely, standards and approaches to risk mostly developed for specific purposes or for commercial application where most aspects of the risk are well known and bounded. Given that these standards were not developed with global catastrophic risks in mind, and that in any case they are subject to loose definitions, contested meanings, misunderstandings, and ignorance of the basic concepts of risk, it seems reasonable to question their universal applicability. We doubt that these approaches are useful in situations of immense uncertainty and ignorance, where the risk boundaries are not well known or understood. The major international attempt at a uniform approach is an ISO standard. Although it is likely not applicable to global threats, its focus on clear objectives is valuable. Similarly, the IPCC in the *Special Report on Extremes* (2012) sets out an approach, which can accommodate complexity and high levels of uncertainty – as demonstrated by its application in the GAR 2019. However, it has been tailored to disasters triggered by natural phenomena, and would need renewed efforts to encompass broader definitions of risk.

Workable alternatives to formal risk assessment processes could include a variation of the precautionary principle, and the application of the idea of limits. The latter certainly applies to existential threats if not to lessor global ones.

We have recognized that the growing level of complexity of the risks we face today, and the lack of agreement on many dimensions, is unprecedented and requires new approaches. Leading experts identified the turn of the decade as single-most important positive tipping point for how we govern these risks (e.g. Lenton, 2020). This means it is also a crossroads for reflecting on How the concepts and language can be changed to align with the magnitude and species of threat: a new narrative is needed.

References

Aven, T., 2016. Risk assessment and risk management: Review of recent advances on their foundation. Eur. J. Oper. Res. 253, 1–13. https://doi.org/10.1016/j.ejor.2015.12.023

Bateson, N., 2017. Warm data. Hackernoon.

Beck, U., 1992. The risk society. Sage.

Bostrom, N., 2013. Existential risk prevention as global priority. Glob. Policy 4, 15–31. https://doi.org/10.1111/1758-5899.12002

Burton, I., Kates, R.W., White, G.F., 1968. The human ecology of extreme geophysical events (Working Paper No. 1). University of Toronto, Toronto.

Carney, M., 2019. A New Horizon.

Checkland, P., 2000. Soft systems methodology: a thirty year retrospective. Syst. Res. Behav. Sci. 17, S11–S58. https://doi.org/10.1002/1099-1743(200011)17:1+<::AID-SRES374>3.0.CO;2-O

Collins, A., Florin, M.-V., Sachs, R., 2021. Risk governance and the low-carbon transition. https://doi.org/10.5075/EPFL-IRGC-282764

Currie, A., Ó hÉigeartaigh, S., 2018. Working together to face humanity's greatest threats: Introduction to the Future of Research on Catastrophic and Existential Risk. Futures, Futures of research in catastrophic and existential risk 102, 1–5. https://doi.org/10.1016/j.futures.2018.07.003

Deloitte, 2019. Sustainability Risk Management: Powering performance for responsible growth.

Dessai, S., O'Brien, K., Hulme, M., 2007. Editorial: On uncertainty and climate change. Glob. Environ. Change 17, 1–3.

Díaz, P., Adler, C., Patt, A., 2017. Do stakeholders' perspectives on renewable energy infrastructure pose a risk to energy policy implementation? A case of a hydropower plant in Switzerland. Energy Policy 108, 21–28. https://doi.org/10.1016/j.enpol.2017.05.033

Douma, K., Scott, L., Bulzomi, A., 2017. The SDG Invsestment case. PRI Association, London.

EEA, 2013. Late lessons from early warnings - science, precaution, innovation (EEA Report No. 01/2013). European Environment Agency, Copenhagen.

Etkin, D., 2016. Disaster theory: an interdisciplinary approach to concepts and causes. Butterworth-Heinemann, Amsterdam ; Boston.

Garonna, P., 2020. The world of finance facing the great uncertainty. Int. Bank. URL https://internationalbanker.com/banking/the-world-of-finance-facing-the-great-uncertainty/ (accessed 2.17.21).

Hanger, S., Pfenninger, S., Dreyfus, M., Patt, A.G., 2012. Knowledge and information needs of adaptation policy makers: a European study. Reg. Environ. Change Rev.

Hanger-Kopp, S., Lieu, J., Nikas, A., 2019. Narratives of low-carbon transitions: understanding risks and uncertainties, Routledge Studies in Energy Transitions. Routledge.

IPCC, 2014. Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC, 2012. Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of working groups I and II of the Intergovernmental Panel on Climate Change. Cambridge, New York.

Jebari, K., 2015. Existential Risks: Exploring a Robust Risk Reduction Strategy. Sci. Eng. Ethics 21, 541–554. https://doi.org/10.1007/s11948-014-9559-3

Kasperson, R.E., Renn, O., Slovic, P., Brown, H.S., Emel, J., Goble, R., Kasperson, J.X., Ratick, S., 1988. The Social Amplification of Risk: A Conceptual Framework. Risk Anal. 8, 177–187. https://doi.org/10.1111/j.1539-6924.1988.tb01168.x

Lenton, T.M., 2020. Tipping positive change. Philos. Trans. R. Soc. B Biol. Sci. 375. https://doi.org/10.1098/rstb.2019.0123

Lilliestam, J., Patt, A., 2015. Barriers, Risks and Policies for Renewables in the Gulf States. Energies 8, 8263–8285. https://doi.org/10.3390/en8088263

Marques, L., 2020. Pandemics, existential and non-existential risks to humanity. Ambiente E Soc. 23, 1–11. https://doi.org/10.1590/1809-4422ASOC20200126VU2020L3ID

Matheny, J.G., 2007. Reducing the risk of human extinction. Risk Anal. 27, 1335–1344. https://doi.org/10.1111/j.1539-6924.2007.00960.x

Mordecai, M., Connaughton, A., 2020. Public opinion about coronavirus is more politically divided in U.S. than in other advanced economies. Pew Res. Cent. URL https://www.pewresearch.org/fact-tank/2020/10/28/public-opinion-about-coronavirus-is-more-politically-divided-in-u-s-than-in-other-advanced-economies/ (accessed 2.17.21).

Moynihan, T., 2020. Existential risk and human extinction: An intellectual history. Futures 116. https://doi.org/10.1016/j.futures.2019.102495

Nishant, R., Kennedy, M., Corbett, J., 2020. Artificial intelligence for sustainability: Challenges, opportunities, and a research agenda. Int. J. Inf. Manag. 53, 102104. https://doi.org/10.1016/j.ijinfomgt.2020.102104

Razzouk, R., Shute, V., 2012. What Is Design Thinking and Why Is It Important? Rev. Educ. Res. 82, 330–348. https://doi.org/10.3102/0034654312457429

Schubert, S., Caviola, L., Faber, N.S., 2019. The Psychology of Existential Risk: Moral Judgments about Human Extinction. Sci. Rep. 9. https://doi.org/10.1038/s41598-019-50145-9

Slovic, P., 2000. The Perception of Risk. Earthscan, London ; Sterling, VA.

Thompson, M., Rayner, S., 1998. Risk and governance part I: The discourses of climate change. Gov. Oppos. 33, x–165.

Tonn, B., Stiefel, D., 2013. Evaluating methods for estimating existential risks. Risk Anal. 33, 1772–1787. https://doi.org/10.1111/risa.12039

UNDRR, 2019. global Assessment report on Disaster Risk Reduction. United Nations Office for Disaster Risk Reduction (UNDRR), Geneva.

Wardley, S., 2018. Wardley maps: Topographical intelligence in business. medium.com.