Between continuous presents and disruptive futures: Identifying the ideological backbones of global environmental scenarios

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A B S T R A C T

Despite the great relevance of global environmental scenarios for the study of environmental change and sustainability transitions, they have rarely been the object of analysis for scholars of the social sciences. In this article, we analyze the ideological assumptions of 993 global environmental scenarios contained in 243 academic works. By developing a new categorization of environmental scenarios, we investigate the economic and governance organization reflected in the scenarios, as well as the portrayed human-nature relationships. We find that global environmental scenarios developed and used by the scientific community largely reproduce rather than break with dominant power structures in the economic, governance and cultural domain. The majority of scenarios reflects an anthropocentric worldview and assumes that the logic of global capitalism and of the Westphalian state-based governance system will not change radically during the 21st century. The implicit solution of sustainability problems dominating these scenarios is a combination of continuous economic growth, rapid technological progress and an international (environmental) agreement. 'Alternative scenarios' are scarce, often only problematize one dimension of the social structure of world society and frequently lack explicit drivers of change or pathways to desirable futures. To increase the diversity of scenarios, future research should focus on refining and quantifying existing post-capitalist, post-state-centric and/or ecocentric scenarios, and on developing a range of scenarios whose storyline systematically problematize or even break with current power structures.

1. Introduction

Given the enormous socio-ecological problems society will have to face during the 21st century, as well as the inherent unpredictability of the future, global environmental scenarios (GES) are widely used and developed by the scientific community. These scenarios - defined as plausible stories or descriptions about how the future, given a set of assumptions, might unfold (Aguiar et al., 2020; Van Vuuren et al., 2012) - serve to explore the range of possible futures (explorative scenarios), to identify desirable futures and pathways to reach them (backcasting scenarios) as well as to support decision-making by simulating certain policies (policy scenarios) (Van Vuuren et al., 2012).

However, scenarios are not neutral objects derived from a purely scientific process. Rather, they are boundary objects linking

different sciences (e.g. natural and social science) and social worlds (e.g. science and non-science), which are politically favored and contested (Garb et al., 2008; Pielke & Ritchie, 2021). Scenario development is inevitably influenced by political ideologies, paradigms and sociocultural context (Rounsevell & Metzger, 2010). Consequently, scenarios reflect certain values, prevailing worldviews, and are inherently political (De Vries & Petersen, 2009; Pulver & VanDeveer, 2009). As such, scenarios have framing power: They narrow down the range of imaginable futures or highlight certain imaginable futures (Van Vuuren et al., 2012) for example by deciding which aspects of the world are fixed, i.e. excluded from policy interventions, and which are changeable (Garb et al., 2008). Even the language, images and metaphors used in scenario descriptions implicitly shape the cognitive landscape of desirable or undesirable futures (Garb et al., 2008). Consequently, critical social science analyses of scenarios are important as they can make the scenarios' ideological and political dimensions explicit, detect biases and broaden the realms of the imaginable. They can also mobilize social action and strengthen the research for environmental justice, for example by asking how scenarios reproduce or challenge global patterns of inequality, consumption and representation (Pulver & VanDeveer, 2009).

Existing social science informed critiques of GES focus mainly on climate or energy scenarios and highlight the relevance of discursive contexts, worldviews and politics (Beck & Mahony, 2018; Braunreiter et al., 2021; Ellenbeck & Lilliestam, 2019; Hughes & Paterson, 2017). With regard to the scenarios used by the IPCC, studies find that critical and contextual perspectives continue to be excluded (Lucas, 2021) and that groups which challenge mainstream assumptions like degrowth or climate action against or beyond the state, are not fully taken into consideration (Nikas et al., 2020). Also, studies criticize the economic growth assumption in the IPCC scenarios and the lack of co-production processes in scenario development which includes a plurality of perspectives, e.g. perspectives from the Global South (Kuhnhenn, 2018; Pereira et al., 2020). In general, studies find that there is a lack of GES exploring extremes or surprises such as the possibility of collapse or structural reorganization characteristic for discontinuous futures, i.e. scenarios incorporate a 'continuity bias' which converts them in 'extended presents' in which basic features of societal organization remain unchanged (Raskin & Swart, 2020; Rothman et al., 2023; Van Vuuren et al., 2012).

However, a systematic empirical analysis of the 'ideological backbone' of GES used by the scientific community is to the best of our knowledge currently missing. From the many dimensions of this 'ideological backbone' three aspects appear as especially relevant: The economic organization assumed in the scenarios, the governance structure, and the ethico-cultural worldview with regard to 'nature' reflected in the scenarios. We chose these three dimensions because they are fundamental to the organization of the world society and the way it produces, perceives and solves problems. Changes in one or more of these dimensions pictured in scenarios will mean a break with the 'continuity bias'. Thus, in this paper we ask: To which extent do global environmental scenarios used or developed by the scientific community reproduce or challenge dominant economic, political and cultural power structures?

To answer this question, we develop a new scenario categorization which places the scenarios in a three-dimensional space whose axes are the organization of the economic system, the organization of the governance system, and an anthropocentric or ecocentric cosmovision. By applying this categorization to a comprehensive dataset of existing GES, covering climate, energy and biodiversity scenarios, we show that the great majority of scenarios internalizes and reproduces dominant power structures, i.e. they display a 'continuity bias' (Raskin & Swart, 2020) which not only impedes imagining and visualizing radically changed, emancipatory futures but also increases the risk of future environmental and social tragedies.

2. Method

2.1. Data collection

To build the database of GES used or developed by the scientific community we draw on the compilation techniques used in a systematic literature review. This yields representative data on the frequency with which specific scenarios are used by scientists in their works, and allows us to cover a broad range of different GES currently circulating within the academic community. We followed the five-step approach outlined by Xiao and Watson (2019) to compile the data.

(1) Inclusion and exclusion criteria

Scientific publications using or developing a scenario storyline of global scope, which describes aspects of future society-environment interactions until at least 2050, were included in the database whereas scenarios describing regional, national or local developments were excluded, as well as scenarios confined to the high sea. We did not require the scenarios to have quantitative elements or a specific pathway but a qualitative narrative was necessary for inclusion. In the case of works existing as working paper and peer-reviewed article, only the article was included. Works referring to scenarios of purely biophysical character (e.g. the spread of certain plant species under various representative concentration pathways (RCPs)), as well as review articles that did not develop or use GES for their analysis were also excluded. Non-peer reviewed material was not excluded per se but checked for its quality; however, the overwhelming majority of works included in the final data base are articles published in peer-reviewed journals. We only considered documents published in English which arguably introduces a bias in our database and possibly reduces the diversity of compiled scenarios.

(2) Literature identification

We used GoogleScholar to build our database and to identify the relevant literature because compared with other scientific data bases (Scopus, Web of Science) the GoogleScholar searches gave us the greatest number of results and also displayed different types of scientific works, including theses, books and working papers beside peer-reviewed articles (Gehanno et al., 2013). We used two slightly different search strings with the objective of covering a maximally broad range of relevant environmental scenarios, and only searched for results published between January 2000 and January 2024 in order to take into

account recent developments of the GES literature. The first search string consisted of the keywords (("global scenarios") OR ("global scenario")) AND (("narrative") OR ("storyline")) that were combined with the attributes (("environment") OR ("environmental") OR ("climate") OR ("energy") OR ("biodiversity") OR ("post-growth") OR ("degrowth") OR ("green deal") OR ("green growth") OR (("environment") AND ("explorative")).

The second string consisted of the keywords (("scenario") OR ("scenarios")) AND ("global") AND (("narrative") OR ("storyline")) AND (("environment") OR ("environmental") OR ("climate") OR ("biodiversity") OR ("energy")).

After removing duplicated titles these searches yielded a total number of 2813 scientific works.

(3) Screening for inclusion, (4) quality and eligibility assessment and (5) iterations

We skimmed through the title and abstract of each document and applied our inclusion and exclusion criteria (see step (1)). In the case of scenarios that were not developed in the article or work itself, we consulted the original source. The derived papers were then read entirely to check their quality and consistency. We completed the database by back and forward searching starting from the retrieved articles. In this way, we found seven more suitable publications.

In the last step, we identified the number of scenarios contained in a single paper in order to analyze them separately, and we homogenized the scenario names of different articles referring to the same scenario. Our final database consists of 243 suitable studies. These contain 993 GES of which 342 are different from each other (cf. Section 3). Although our database arguably covers the great majority of existing GES, the field of GES is so broad and so quickly evolving that it was impossible to identify all suitable scenarios even through the systematic literature review. Additionally, in some specific cases, our decision to include or exclude a certain scenario based on the developed criteria might be contested, for example, when the temporal or regional scope of the scenario was not entirely clear from the storyline and the article. Last, as the keywords used for the search illustrate, we focused on environmental, climate, biodiversity and energy scenarios. This might have left some scenarios focusing on water related issues out of the analysis, which could be addressed in future reviews of the literature. Nevertheless, we think that the compiled GES can be considered representative for the literature of the last 20 years.

2.2. Development of categorization

Categorizing scenarios in order to characterize them according to certain criteria is common in the literature and plenty of alternative categorizations exist (Rothman, 2008). For example, scenarios can be categorized as quantitative or qualitative, single or multi-scalar and global or regional (Raskin, 2005). Often, authors use the archetype approach to group scenarios, i.e. they categorize them according to their end state (Hunt et al., 2012; Raskin, 2005; Raskin et al., 2002; Van Vuuren et al., 2012; Wardropper et al., 2016). Also scenarios are frequently categorized along the two main drivers of uncertainty influencing future developments (Lacroix et al., 2019; Van't Klooster and Van Asselt, 2006). Last, proposals have been brought forward to categorize scenarios according to their function such as risk reduction of probable futures, preparedness for multiple futures or social mobilization for desirable (Muiderman et al., 2020; Pereira, Kuiper et al., 2021a). However, to date, no categorization has been developed that makes the often implicit economic and governance structure, as well as assumed society-nature relationship explicit. We argue that such a categorization is
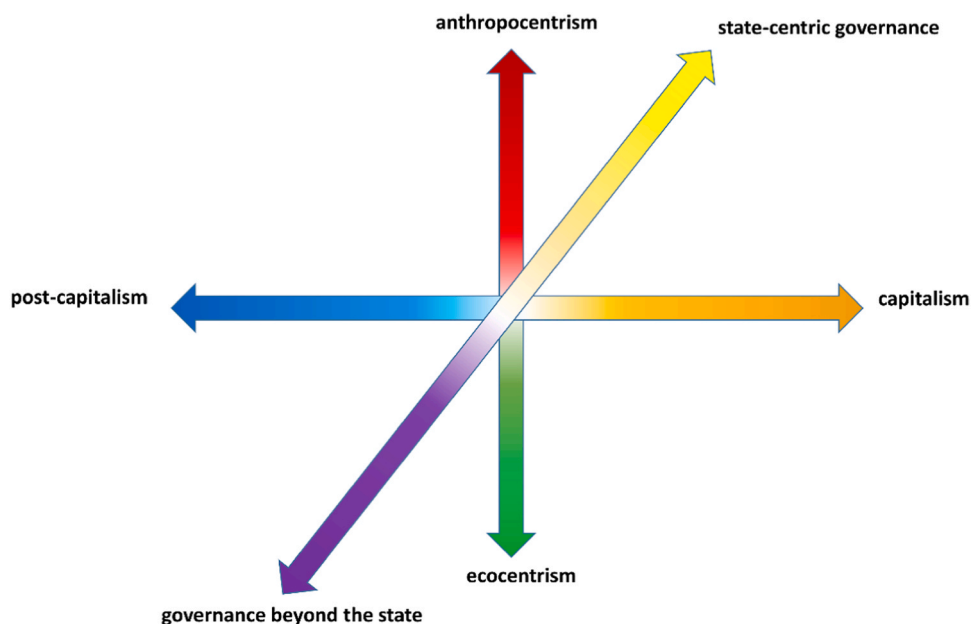

Fig. 1. Three-dimensional scenario categorization space.

relevant especially for thinking about sustainability related problems, given that changes in the economy, in the governance system and in culturally mediated ways of interacting with human and non-human life have been stressed as crucial by the literature on transformative change (Klinke, 2017; Loorbach, 2022; Richardson & Erdelen, 2021). Rather than only focusing on technological solutions, studies on transformative changes pay attention to the interlinkages between economy, governance and/or culturally mediated human nature relationships (Biermann, 2021; Fletcher et al., 2023; Leonardsson et al., 2021; Schot & Steinmueller, 2018). In this way, problems of the capitalist economy (Feola et al., 2021; Newey, 2018), different types of governance systems (Jensen et al., 2020), and anthropocentric human-nature dichotomies (Raymond et al., 2023) are analyzed in a holistic manner. Thus, the economic, governance and cultural human-nature relationship constitute the three dimensions form the main axis of our categorization. We follow existing categorization approaches by defining polar alternatives for each axis. One pole of the axis represents the currently existing, dominant economic, governance, and cultural structure. The other pole represents a state of the world radically different from this dominant structure. This polarization allows us to clearly position the scenarios in a conformist/reformist space which takes the currently dominant socio-economic structures as given, and a radical/revolutionary space which assumes a future with significantly different structures. With regard to the three dimensions, the world society today is essentially characterized by a capitalist economic system (Milanovic, 2019), a Westphalian governance system centered on (nation) states (Bummel, 2014; Buzan & Little, 1999), and an anthropocentric cosmovision (Ferrando, 2016). Consequently, their opposite are post-capitalism, governance beyond the state, and an ecocentric cosmovision. Fig. 1 shows the three-dimensional scenario space constructed by our categorization.

The terms (post-)capitalism, state-centric governance, anthropocentrism and ecocentrism do not only reflect aspects of our reality; they are also abstract, value-laden, contested discursive constructs. However, in order to be able to characterize a certain scenario as capitalist/post-capitalist, state-centric/post-state-centric or anthropocentric/ecocentric, we needed tangible and clear-cut working definitions. Therefore, we operationalized the six main constructs ('capitalism', 'post-capitalism', 'state-centric governance', 'governance beyond the state', 'anthropocentrism', 'ecocentrism') by defining them as the sum of certain key variables (for a sensitivity analysis varying this assumption see the Supplementary File). To arrive at these key variables, we conducted a non-systematic literature review on the defining characters of the six terms.

To characterize a highly capitalist system we construct the following variables:

- $E+1$: The organizing principle of the system is competition combined with self-interest (Jahan & Mahmud, 2015).
- $E+2$: The goal of the system's key actors is accumulation, i.e. profit maximization (in Marxian language: M-C-M') (Blauwhof, 2012).
- $E+3$: As a consequence of E + 2, the system has the tendency to expand (Richters & Siemoneit, 2019). This is reflected in economic growth, growth in production which needs growth in consumption and investments (Pirgmaier & Steinberger, 2019; Wiedmann et al., 2020), as well as in a productivist paradigm (Hatt & Osawa, 2019). This is not to say that non-capitalist regimes cannot be productivist or growth-based.
- $E+4$: The means of production are dominated by private property from which profit is derived. This implies the importance of private ownership/property (Jahan & Mahmud, 2015).
- $E+5$: Wage labor is the principal way to earn a living and to produce goods (Blauwhof, 2012)
- $E+6$: Markets using a price mechanism which equilibrates demand and supply are the central institutions to acquire and sell goods. Consequently, money decides about the allocation of good. (Alexander, 2015; Jahan & Mahmud, 2015; Trainer, 2012).
- $E+7$: There are class inequalities and hierarchies enabling the exploitation of workers and the accumulation of capital, which are reflected in income and wealth inequality (structural inequality type 1) (Moore, 2017, 2018; Pirgmaier & Steinberger, 2019).
- $E+8$: There are gender inequalities and hierarchies enabling the exploitation of the non-remunerated care work done mostly by women, i.e. there is a reproductive 'economy' less appreciated than the formal economy but essential for its survival (structural inequality type 2) (Bauhardt, 2014; Lourdes et al., 2011).
- $E+9$: There are geographical inequalities and hierarchies related to the core-periphery, urban-rural and Global North-Global South divides. This enables the appropriation of 'cheap nature' and 'cheap labor' from the peripheries and is reflected in unequal material and energy consumption and flows (structural inequality type 3) (Moore, 2017, 2018; Pirgmaier & Steinberger, 2019). As material and energy can be expressed in monetary terms, this translates into global wealth and income inequalities.
- $E+10$: The finance sector is of great importance; exchange flows are enabled by debt-based, interest-bearing money (Alexander & Gleeson, 2020; Binswanger, 2009; Davis & Kim, 2015; Harvey, 2014)
- $E+11$: The role of the governing entity consists in providing the necessary institutions to enable capitalist accumulation (Jahan & Mahmud, 2015; Wood, 2002) (e.g. guaranteeing private property, markets, tolerating existing inequalities, refraining from social and environmental policies which would make 'nature' and 'labor' less cheap).

We define the variables characterizing a post-capitalist economic system in relation to the variables of a capitalist system, and whenever possible as their opposite.

- $E-1$: The organizing principle of a post-capitalist system, as opposed to capitalism, would be cooperation and coordination combined with common interest
- $E-2$: The goal of the system would be to fulfill needs instead of maximize profits
- $E-3$: In opposition to E + 3, the goal of a post-capitalist system would be a shrinking or stable size of the economy; this would entail sufficiency in consumption (Alexander, 2015; Trainer, 2012) and/or a subsistence paradigm (Brownhill & Turner, 2020; Singh, 2019).
- $E-4$: Property other than private property, e.g. common or public property, dominates the economic system. The focus would be on cooperative production, and on use and access rather than on ownership (Pirgmaier & Steinberger, 2019)

- *E-5*: As opposed to a capitalist system, in a post-capitalist system there would be reduced hours of wage labor, and more self-production (Mason, 2015)
- *E-6*: Markets are not the only allocation institution; there are non-market means to acquire necessary goods and non-money criteria of allocation, for example a need-based allocation (Trainer, 2012)
- *E-7*: As opposed to E + 7, there are reduced class/social inequalities which translate in reduced income and wealth inequality (Mason, 2015; Piketty, 2019)
- *E-8*: As opposed to E + 8, society would value and not exploit care work and other non-remunerated work (Bauhardt, 2014; Mason, 2015)
- *E-9*: As opposed to E + 9, there would be more equilibrated flows of money, material and energy and an end of 'cheap nature'. This could be reflected in strongly reduced extractivism, a moratorium on the further expansion of the 'commodity frontier' (Beckert et al., 2021) and strong redistribution.
- *E-10*: The finance sector would shrink massively; the system would be backed by debt-free, interest-free, public money (Trainer, 2012).
- *E-11*: The governing entity provides the necessary institutions to realize and enable a post-capitalist paradigm.

To characterize a governance (G) system as state-centric and based on the Westphalian paradigm in international relations (Suter, 2018), we construct the following variables:

- *G+1*: States have the power to fulfill the core imperatives guaranteeing their longevity, namely internal stability and protection against threats (Hausknost, 2020). This translates into the existence of police forces, an army, and national security policies.
- *G+2*: States decide on fiscal policies and national public expenditures (e.g. social policies) (Hausknost, 2020).
- *G+3G+ 3*: There are three core elements constituting a state: population, territory and the monopoly on the use of force (Heintze, 2009). Consequently, states control migration through national migration policies and border policies (Uerpmann-Wittzack, 2019).
- *G+4*: States control money through national monetary policies (currency, quantity, interest).
- *G+5*: States control trade through national trade policies
- *G+6*: States control environmental policy through national legislations
- *G+7*: There are competitive relationship between states due to the absence of a supra-national regulator, i.e. no cooperation (Berger & Weber, 2006; Buzan & Little, 1999)
- *G+8*: States are the only actors which shape outcomes of global (read 'international') governance (Suter, 2018)

A Post-Westphalian governance system beyond nation states, is defined in relation to the currently dominating Westphalian system, and, whenever possible as its opposite.

In *G-1* to *G-6* non-state actors, i.e. local, transnational, international or supranational actors, partially or fully take control of….

- *G-1*: Non-state actors, i.e. local, transnational, international or supranational actors, partially or fully take control of the internal and/or external security of a population
- *G-2*: Non-state actors partially or fully take control of fiscal or social policies.
- *G-3*: Non-state actors partially or fully manage or control migration.
- *G-4*: Non-state actors partially or fully control monetary policies
- *G-5*: Non-state actors partially or fully control trade policies
- *G-6*: Non-state actors partially or fully control environmental policies
- *G-7*: There is strong cooperation and coordination between governing entities

- *G-8*: Non-state actors, e.g. business, civil society, transnational organizations etc. shape the outcomes of global governance (Suter, 2018)

Lastly, to speak of an anthropocentric cosmovision, we construct the following variables:

- *C+1*: Humans are perceived as and live separated from the environment (Purser et al., 1995; Reddekop & Trownsell, 2021).
- *C+2*: Humans are perceived as superior to the rest of nature (Mylius, 2018).
- *C+3*: There is an optimism with regard to techno-scientific progress (Bakari, 2017).
- *C+4*: Nature is perceived as an object or machine (Brügger, 2020; Purser et al., 1995).
- *C+5*: Nature only has instrumental value (Lundquist et al., 2021).

Conversely, to speak of an ecocentric cosmovision, we construct the following variables:

- *C-1*: Humans are perceived as and live integrated in nature (Bakari, 2017).

- *C-2*: Humans are perceived as part of a greater entity (e.g. Gaia/ a living Earth) (Borie & Hulme, 2015; Donahue, 2010).
- *C-3*: There are limits to human expansion (Bakari, 2017).
- *C-4*: Nature is perceived as a living being (Borie & Hulme, 2015; Donahue, 2010)

- *C-5*: Nature has intrinsic value (Lundquist et al., 2021)

Table A1 in the Appendix displays all variables in a compact form.

We want to stress that our aim here is *not* to provide a universally valid, overarching and exhaustive operationalization or definition of a capitalist, state-centric and anthropocentric system since each of the variables presented could be criticized on various grounds depending on the theoretical strand one follows, and additional variables could be added, especially to the cosmovision/cultural (C) dimension. In the latter case, we are aware that these variables by far do not encompass the existing diversity of worldviews on 'culture/nature', which are tied to social positions and epistemic beliefs (Mäkinen-Rostedt et al., 2023), and that the two poles of anthropocentrism/ecocentrism leave out other concepts such as the 'relational' value of 'nature' (Stålhammar & Thorén, 2019). Thus, rather than a final description of these dimensions, we present a theory-based working definition useful for our purposes, i.e. enabling us to clearly differentiate conformist from radical scenarios (for example, a capitalist, anthropocentric from a post-capitalist, eco-centric scenario).

2.3. Qualitative content analysis

To locate each scenario in our database on each of the three axes, we conducted a qualitative content analysis (Erlingsson & Brysiewicz, 2017). By reading the scenarios in their context (report, article, supplementary material), using codes to represent the condensed meaning of a passage, and hermeneutic circling (Erlingsson & Brysiewicz, 2017), we determined for each of the 48 variables whether the variable was reflected in the text. To ensure consistency in coding, all scenarios were coded by the first author according to a codebook, while difficult cases were left to the end and discussed together. Iterations and revisions were realized after having coded the first half of the scenarios, and again after the first coding of all scenarios to ensure that scenarios were coded in a comparable way.

If the variable was reflected in a GES, it was assigned a value of 1 (-1) if the variable characterized a capitalist, state-centric or anthropocentric (post-capitalist, post-state-centric or ecocentric) system. If a scenario contained elements of both systems, it was assigned a value of 1 and -1, resulting in a final value of 0, although this was only exceptionally the case. After analyzing a scenario in this way, we summed up the numerical values across the variables for each dimension to derive at three final values. Consequently, every GES could have a punctuation between (E)-11 (highly post-capitalist) and (E)$+11$ (highly capitalist) for the axis representing the economic structure; a punctuation between (G)-8 (governance independent from or in the absence of states) and (G)$+8$ (governance relying purely on states) for the governance structure; and a punctuation between (C)-5 (highly ecocentric) and (C)$+5$ (highly anthropocentric) for the axis describing human-nature relationships/cosmovisions. In this way, we were able to distinguish the different degrees to which scenarios reproduced or challenged the dominant economic, governance and cultural structure. For example, a GES describing a coordinated market economy (Kang, 2006) would be less capitalist than a liberal market economy because the variable *E+6* would not be fulfilled. For simplicity, we assumed that each variable has the same weight in making up the respective construct. Suppl. Table 2 in the Supplementary File shows the results of a sensitivity analysis that breaks with this assumption. Whenever an article used a scenario from another source, we took the original scenario description as basis for the categorization. Furthermore, if an article used a scenario, or a slight variation of a scenario, which was already categorized, we adopted the values from the original article or source. When there was no explicit information on a variable in a GES it was assigned a default/fallback value, which reflects the value of the variable in the present given that, if a scenario does not describe certain changes it implies that the respective aspect of reality will stay like it is at the moment. This approach entails a certain risk of overestimating the continuity bias of scenarios, since scenarios critical with current structures might not explicitly provide information on all variables. However, rather than in the exact position of the scenarios we are interested in systematic changes away from the capitalist, state-centric and anthropocentric system, and those are not determined by single variables that might be assessed contrary to the intention of the scenario developers due to missing information. Furthermore, through our analysis we found that scenarios deviating from the current state for one variable tended to simultaneously break with other variables since they showed a general higher awareness for changes in socio-economic structures. The default/fallback values for each variable is given and justified in Suppl. Table 1 while Suppl. Table 3 lists the title of the studies considered, the scenario names, and the final score of the GES for each dimension.

3. Results

3.1. The global picture: continuity bias in existing GES

With values assigned to each of the variables described in Section 2.2, the 342 different scenarios in our GES database can be positioned in the three-dimensional scenario space describing the economic, governance and cultural backbone of the scenarios. Fig. 2a-c show the distribution of the analyzed GES in the scenario space. Two dimensions are represented by the x and y axis, while the third dimension is represented by colors corresponding to the coloring of the three axes in Fig. 1. Suppl. Fig. 1 depicts the same figure considering all 993 GES identified in the analyzed scientific works, taking into account those 651 scenarios constituting duplicates or slight adaptations of other GES, which will be discussed in Section 3.3.

Three global patterns are clearly illustrated by Fig. 2a-c: First, the scenarios are not randomly spread in the scenario space but strongly concentrate in the top-right corner of the figures, reflecting a strong bias of existing GES toward the status quo. These GES positioned in the top-right corner implicitly or explicitly assume that current power relationships remain unchanged by reproducing capitalist, state-centric and anthropocentric power structures. Consequently, they can be characterized as being 'continued presents' reflecting a continuity bias. 65% of the analyzed GES were subsequently quantified through model simulations while 35% remained on
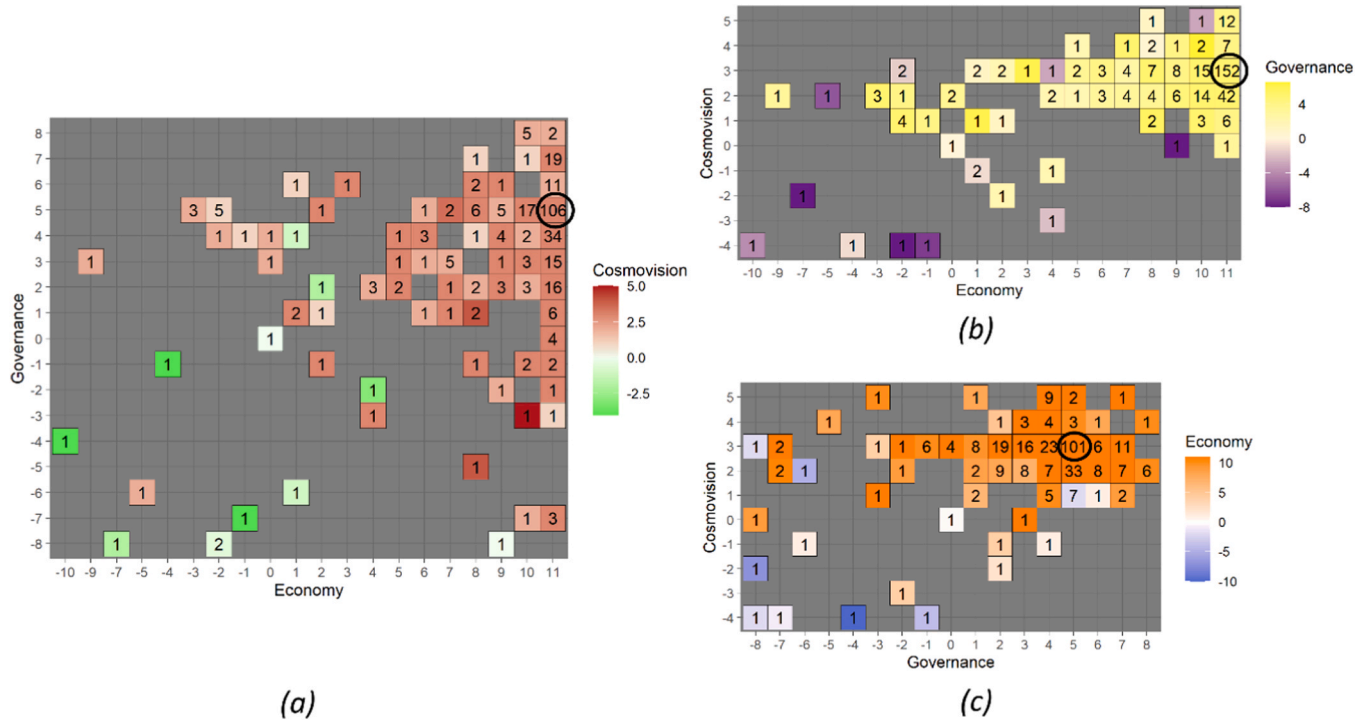
Fig. 2. Distribution of different GES over the scenario space. (a): economy-governance space with the cosmovisions/cultural dimension expressed as color (green/red ~ negative/positive values). (b) economy-cosmovision space with governance expressed as color (purple/yellow ~ negative/positive values). (c) cosmovisions-governance space with economic structure expressed as color (blue/ orange ~ negative/positive values). In the case of multiple scenarios occupying the same square, the color reflects the median value for the third dimension. The black circle corresponds to the present state of the world system. This illustration was preferred to a three-dimensional figure to facilitate the legibility of the data points.

qualitative descriptions. On average, the quantified scenarios (E: 9.7 | G: 4.4 | C: 2.8) had higher values (E: 8.2 | G: 2.4 | C: 2.2) than purely qualitative scenarios in all three dimensions, i.e. scenarios with a quantitative dimension tend to be closer to the current status quo represented by the point (E: 11 | G: 5 | C: 3).

Second, the values of the GES for the three dimensions are correlated. Thus, if a scenario has both positive value for two dimension, with high probability it will also display a positive value for the third dimension, as illustrated by the strong split in the color of the third dimension between the top right and the bottom left corner of Fig. 2a-c. The one hand, this indicates that in the present, capitalist structures, state-centric governance and an anthropocentric cosmovision constitute a block that cannot be easily disentangled. On the other hand, it also implies that challenging one dimension of the economy-society (governance & human-nature relationships) complex in scenario development will sooner or later lead to a break in the other two dimensions and the formation of a new, post-capitalist, post-state-centric and post-anthropocentric block reflected in the scenarios.

Last, the bias toward existing structures is most pronounced in the case of the anthropocentric human-nature relationships (cosmovision/cultural dimension) and least pronounced in the case of governance systems: 13 scenarios can be regarded as post-anthropocentric (having values for this dimension of zero or lower) while 31 can be regarded as post-state-centric (values of zero or lower for the governance-axis) and 21 scenarios can be regarded as post-capitalist.

Sensitivity analyses (Section 2 Supplementary File) show that the key findings just described are robust.

3.2. Exploring the scenario categorization space

Since we consider three different dimensions with two possible attributes each (E+/-, G+/-, C+/-) the scenario space can be divided into eight equal cubes containing GES with different combinations of attributes in the three dimensions (E+G+C+, E+G+C- etc.). These cubes can be further arranged into four blocks: First, scenarios reproducing the status quo with regard to the socioeconomic structure of the world are found in the cube E+G+C+. Second, scenarios challenging one dimension are positioned in the cubes E+G+C-, E-G+C+, and E+G-C+. Third, scenarios challenging the status quo in two dimensions are found in the cubes E-G-C+, E+G-C-, and E-G+C-. Last, scenarios departing from the status quo in all dimensions are located in the cube E-G-C-.

Additionally, there is one scenario located in the origin of the scenario categorization space that constitutes an outlier. This scenario, which is considered an archetype based on an analysis of 140 science fiction films about the future (Fergnani & Song, 2020), is called *Inversion archetype* and does not fit in the developed categorization category since in this storyline the human species no longer dominates the planet but is outpaced or controlled by a superior civilization or organism.

3.2.1. Reproduction of the status quo

294 different GES, i.e. 86% of the scenarios in our database are to a stronger or lesser degree capitalist, state-centric and anthropocentric. 83 of these scenarios concentrate in the point (E + 11|G+5|C+3). This point is also the result of summing up the default values for the variables as explained in Section 2.3, and, thus, reflects the current social economic, governance and cultural structure. Many scenarios located in this point are *business as usual* or *baseline scenarios* used as reference scenarios in simulations, such as in Ansari and Holz (2019), Lundholm et al. (2020), Hejazi et al. (2013) or Grewe et al. (2021). However, the scenarios developed by different institutional bodies and companies can also be found here, such as the *SSP2* scenario used by the IPCC (Fricko et al., 2017), the Stated Policies (*STEPS*), the Announced Pledges (*APS*), and the Sustainable Development (*SDS*) scenarios developed by the IEA, the *Waves* scenario developed by Shell or the *Reform* scenario of Equinor (Statoil) (Blondeel et al., 2024). Although these GES are not developed by scholars, they are used and/or discussed in academic papers while alternative storylines developed by non-academics, are absent from the academic scientific 'production' process.

In the extreme upper right corner of this part of the scenario space, there are 16 different GES that are even more state-centric than the status quo and feature the same (or even higher level) of capitalism and anthropocentrism. These scenarios picture a lack of coordination and cooperation between states and geopolitical rivalries which leads to a failure in solving environmental problems. Most of these scenarios draw a rather dark image of the future which is also reflected in their names: *Fractured World* (Berghof, 2005), *Overexploited World* (Öborn et al., 2013), *Grim reaper* (Vorster et al., 2012), *Security foremost* (Elshkaki et al., 2020), *Climate Wars* (Pereira, Morrow et al., 2021b), *Self-Reliance* (Kikstra et al., 2021), *Survival of the fittest* (Ansari & Holz, 2019), *Crowded chaos* (Hejazi et al., 2014), *Totalitarian society* (Roura-Pascual et al., 2021) or *Gatekeepers: international fragmentation and confrontation* (Frame et al., 2022).

Below the top right corner, there are another 11 different GES that can be labelled 'mainstream' although they are slightly less capitalist, state centric and anthropocentric ((E)+ 6 to + 10; (G)+ 2 to + 4; (C)+ 2). In these scenarios, there is cooperation and coordination between independent states, the latter are still central in governing environmental, economic and especially security, fiscal, migration and monetary issues. The majority of the scenarios found here are 'sustainability' scenarios such as *SSP1* (O'Neill et al., 2017) and its variants for the forests (*FSP1*) (Daigneault et al., 2019) and oceans (*OSP1*) (Maury et al., 2017), the *Optimising Nature* scenario based on the Nature Futures Framework (Durán et al., 2023), the *Global Sustainability* scenario based on SSP1 (Humpenöder et al., 2022) or the *Regional sustainability scenario* (Ercin & Hoekstra, 2014).

Last, there are three 'reformist' scenario with low degree of capitalism and state-centrism ((E)+ 1 to + 2; (G)+ 1 to + 2; (C)+ 1 to + 3). The scenarios are called *Prosperity* (Pereira et al., 2020), *Global sustainability by accommodation*, and *Global sustainability by cooperation* (Althouse et al., 2020). The scenarios reflect either an agrowth or a degrowth perspective on economic growth (Van den Bergh, 2011), combined with work-time reductions and the public provisioning of goods, or societies which can sustain themselves. Also, they picture strong and effective policies promoting global fairness and redistribution. Regarding the governance system, they describe fiscal coordination between states and the partial internationalization of fiscal policies for distributive and environmental

matters. In general, international cooperation is very high in these scenarios, and states coordinate their national environmental policies to some extent.

3.2.2. Challenges to the status quo in one or two dimensions

Out of the 37 different GES that deviate in one dimension from the current social structures 4 are post-anthropocentric, 13 are post-capitalist and 20 are post-state-centric. The most ecocentric scenario is *SSP0* (Otero et al., 2020) with a value of −2 for the cosmo-visions dimension, the value of −5 being the highest theoretically achievable expression of ecocentrism. Conversely, four scenarios, albeit being capitalist and anthropocentric, foresee fundamental changes of the current nation-based system to governance by powerful corporations or an institutional breakdown and the disappearance of nation states such as in the scenarios *Breakdown* (Raskin et al., 2002) and *Hunting humans* (Wright, 2016). In the *Ecohumanist revolution* scenario corporations are forced by environmental movements to realize environmental governance whereas they reign free from ecohumanist ideas in the *Suboptimal situation* scenario (Pereira et al., 2021b). Last, several 1.5° climate scenarios, namely the *Societal Transformation Scenario* (Kuhnhenn et al., 2020) and different *Degrowth* scenarios (Keyßer & Lenzen, 2021) can be considered strongly ((E)−9) and rather ((E)−3) 'post-capitalist'. They are examples for those scenarios whose economic structure undergoes major changes but that do not make explicit statements about the future and role of nation states or non-state actors in driving those changes, nor do they problematize the effects of current human-nature relationships on the feasibility of the proposed economic transformation. Thus, they implicitly assume that post-capitalist economies, where the growth paradigm is replaced by attention to human needs and sufficiency, coupled with strong intra- and international redistribution policies, will form without fundamental changes of the Westphalian state system and that nation states will by themselves decide to implement these policies. All these 37 GES are displayed in Table A2 in the Appendix.

Finally, five more different GES significantly depart from the status quo in two of the three dimensions of interest: Two scenarios based on the Nature Futures Framework (Durán et al., 2023; Pereira et al., 2020), i.e. *Water* and *Arcology*, feature governance beyond the state as well as strong ecocentric and post-anthropocentric[1] cultures. Likewise, two scenarios of the Global Scenario Group (GSG) picture new forms of governance on the local and global level that are at the same time ecocentric and barely capitalist (*Great Transition*) or post-capitalist and moderately anthropocentric (*Eco-communalism*). A further narrative is called the *Wasteworlds archetype*, which, echoing *Mad Max* imaginaries, pictures the collapse of the current system due to (environmental) catastrophes, followed by local, often despotic, governance through tribal organizations and non-capitalist economic formations based on barter or natural currencies such as water and oil. There is no scenario which is post-capitalist and ecocentric but also features state-based governance.

3.2.3. Challenges to the status quo in three dimensions

Five scenarios break with the current structure in all three dimensions. They are called *Innovative Commons*, *Reciprocal Stewardship* and *Dynamic Natures* (Durán et al., 2023), *New Welfare* (Sessa & Ricci, 2014) and *Post-Growth World* (Crownshaw et al., 2019). These scenarios have in common that they describe new forms of governance, ranging from self-sufficient communities to global confed-erations, as well as new forms of economic organizations, based on common property and new models of ownership, local currencies, less monetized work and effective cooperation instead of competition in the economic and the political realm. Evidently, current paradigms are replaced by new social economic and cultural paradigms which also include lost forms of interacting and viewing 'nature' such as developing a spiritual connection with nature, exercising modesty in the use of technology and overcoming the binary thinking that separates the human species from the rest of the Earth. Table 1 summarizes the characteristics of the different blocks constituting the scenario space.

3.3. Different weights of scenarios in the literature

Although there are 342 different GES in our database, not all of them are used with the same frequency to conduct scientific analysis. Fig. 3 depicts the scenarios as points in the economy-governance plane with the coloring indicating worldviews, and with the point size indicating how often the scenario appears in the analyzed 243 academic works.

Considering the weight of different GES in the literature, we find that the GES mostly used by scientists are those, which maintain capitalist, state-centric and anthropocentric structures in their storylines. In this way, the status quo bias of GES spreads through the general field of global environmental change. The only exceptions are the GES *Policy Reform* and *Great Transition* of the GSG which deviate from the mainstream by featuring for example strong global governance beyond the state. From the 993 GES identified in the articles included in our database, 588 are based directly on SSP1–5 (combined with all different levels of radiative forcing), A1, A2, B1 or B2 (Nakicenovic et al., 2000; O'Neill et al., 2017).[2] Additionally, a scenario developed after the SSPs, the *LED* (low energy demand) scenario (Grubler et al., 2018) has made it to some prominence in the literature (Table 2). All these scenarios were created in order to be used as alternative baselines in climate studies, particularly those assessed by the IPCC, whereas former scenario exercises of the UNEP were influenced by the work of the GSG.[3] We also find various GES reflecting other scenario development approaches related to

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[1] Final value of zero for the cosmovisions dimension.

[2] Notably, these are only articles that fit our keyword search (cf. Section 2.1) and do not even include all articles in the literature referring to the SSPs.

[3] For example, UNEP's 4th Global Environmental Outlook contained the scenarios *Markets First*, *Policy First*, *Security First* and *Sustainability First*, which roughly correspond to the *Market Forces*, *Policy Reform*, *Fortress World* and *Great Transition* scenarios of the GSG.

Table 1

Summary of results.

Dimensions departing from status quo	Considered parts of the scenario space	Number of scenarios
0	E + G+C+	294
1	E + G-C+ ; E + G+C-; E-G+C+	37
2	E + G-C-; E-G-C+ ; E-G+C-	5
3	E-G-C-	5
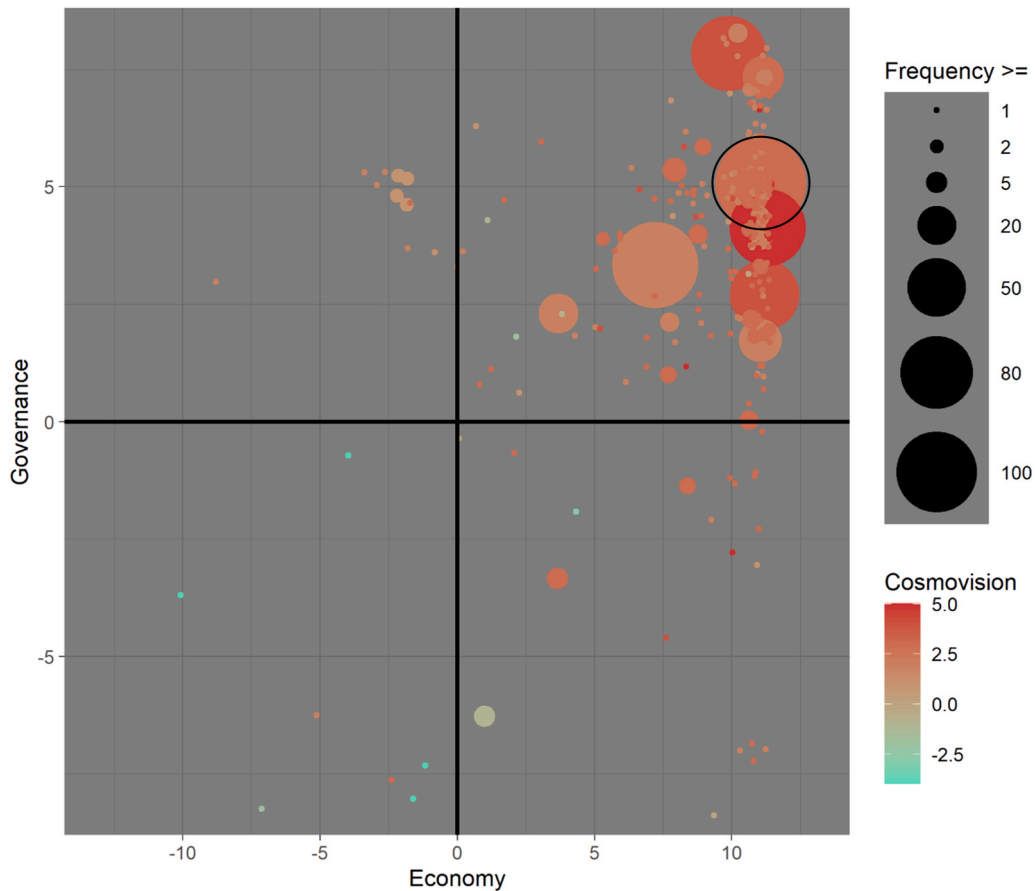
Fig. 3. Scenarios in the categorization space. The size of the points reflects their weight in the scientific literature. Points are jittered to reflect the fact that rather than a quantitative analysis producing concrete numbers our analysis has qualitative character. The black circle indicates the current state of the world system.

Table 2

The 12 GES used with the highest frequency in the academic literature.

Scenario	Frequency of appearance in the database comprising 243 academic works	Characterization
SSP2: Middle of the Road	130	(E)+ 11; (G)+ 5; (C)+ 3
SSP1: Sustainability	116	(E)+ 7, (G)+ 3, (C)+ 2
SSP5: Fossil-fueled development	90	(E)+ 11; (G)+ 4; (C)+ 5
SSP3: Regional rivalry	86	(E)+ 10; (G)+ 8; (C)+ 4
SSP4: Inequality	73	(E)+ 11; (G)+ 3; (C)+ 4
B2	25	(E)+ 11; (G)+ 2; (C)+ 2
A1	24	(E)+ 11; (G)+ 4; (C)+ 5
A2	23	(E)+ 11; (G)+ 7; (C)+ 3
B1	21	(E)+ 4; (G)+ 2; (C)+ 2
LED	7	(E)+ 8; (G)+ 5; (C)+ 3
Policy Reform & Great Transition	5	(E)+ 4; (G)−3; (C)+ 3
		(E)+ 1; (G)−6; (C):0

international bodies such as the IPBES (Durán et al., 2023; Lundquist et al., 2021; Pereira et al., 2020), although, in contrast to the SSPs, the use of these scenarios for quantitative simulations has only begun in recent years (Alexander et al., 2023; Dou et al., 2023). Among the SSPs, SSP2, SSP1 and SSP5 are most frequently used, whereas SSP3 and especially SSP4 have less prominence in the literature. Given that SSP3 describes increased rivalry between nation states, and SSP4 increasing inequality, we argue that there is a certain desirability bias in the selection of the scenarios (Schirrmeister et al., 2020) that acts independent from the question which SSP is the most likely one, based on recent political and economic developments.

3.4. Explicit deviation, implicit maintenance of status quo

The analyzed GES do not provide the same amount of information for each of the variables making up the economic, governance and cultural dimension of the scenario space. While a deviation from the status quo of a given variable is necessarily explicit, the variables were commonly maintained unchanged to their present manifestation given that the GES simply did not provide any information for the variable. Especially those scenarios positioned near or in the black circles in Fig. 2 tend to be placed in this part of the categorization space not *because* they explicitly affirm the current state by providing the respective information for the different variables but rather because they do *not* describe any change away from the current structures. These scenarios take the current socio-economic and cultural structures as given and normalize them to such extent that they do not even mention them. Consequently, the status quo, described through the default values for every variable, is implicitly maintained: From the absence of any description of change in fundamental characteristics of the current system as portrayed through the different variables, the reader must infer that they will stay as they are in the present. Across all scenarios, about 72% of the final position of the scenario is determined by the implicit maintenance of the status quo while 28% stems from an explicit affirmation of, or break with, current structures. This result illustrates that the different characteristics of the world's socio-economic structures and their importance in enabling or obstructing transformative change towards sustainability receive insufficient attention in the majority of current GES.

Within the economic sphere, regarding the property regime, only in 51 GES there is any information to be interpreted as maintaining or departing from the status quo. The same is true for 53 GES in the case of the goal of the system (profit maximization or need satisfaction). Also, the gendered character of the economy is notably missing, with only six scenarios mentioning women explicitly (in relation to land tenure rights, work or education), another four scenarios containing the word 'gender' (in relation to gender inequality in access to resources), and another four scenarios mentioning care work or care for the environment. Conversely, the tendency of the system to grow (or to shrink) is mentioned in 241 GES. Thus, while private property and profit maximization seem to be so 'natural' that they are not even mentioned, the scenario discourse places great attention to the problem of economic growth.

Within the governance sphere, information on who governs migratory and monetary issues is only provided in 56 GES while, the variables with the most information are the extent of cooperation between governing entities, trade and, unsurprisingly, environmental governance (information in 112, 118 and 174 GES). Last, within the cosmovisions sphere, which has the least amount of information across all variables, compared to the other two spheres, the variables describing whether humans perceive 'nature' as object/machine or living being is only minimally addressed in 34 GES, whereas in 117 GES there is information on the (mostly instrumental) value of 'nature', and in 241 GES there is information reflecting faith in technological progress, such as nuclear fusion, space mining, continuous efficiency gains or artificial meat. Table A3 in the Appendix provides examples for information contained in the analyzed GES for every variable.

Finally, we also found several variables for which GES tend to deviate more frequently from the status quo than for other variables that are often not even addressed. Within the economic sphere, the variables that most contribute to a post-capitalist orientation of the respective GES are *E-11* (role of the governing entities for the realization of a (post-)capitalist paradigm; 39 cases), and *E-9* (great reduction of geographical inequalities; 37 cases), whereas a deviation from competition as guiding principle (*E-1*), the market economy (*E-6*) and financial capitalism (*E-10*) only occurs in 9 GES. Within the governance sphere, variables working toward breaks with the status quo are increased cooperation/coordination between governing entities (*G-7*; 100 GES) and governance beyond the state in the realm of environmental policies (*G-6*; 59 GES), whereas governance beyond the state in questions of migration (*G-3*) only occurs in 12 GES. With regard to human-nature relationship, the variable indicating limits to human expansion applies in 61 GES, while only in 9 cases Earth is perceived as living being (*C-4*), and only in two GES it can be argued that humans are considered a part of a greater entity (*C-2*). Given that the scenarios analyzed are global *environmental* scenarios the scarcity of attention to human-nature relationships, compared to the focus on techno-scientific progress and economic growth, is remarkable.

4. Discussion

4.1. Shortcomings of mainstream approaches to sustainability

The majority of GES takes the current social structures as given and, thus, limits its search for possible solutions to the socio-ecological problems of humanity to three key variables compatible with existing structures which have to be influenced in the 'right' direction: growth, progress, and environmental policy. Our comprehensive analysis of 342 different GES seems to point to a formula for success: Continuous economic growth combined with continuous technological progress, including occasional technological breakthroughs, and an effective international (climate, energy or biodiversity) agreement.

However, there are some biophysical and social-political factors threatening the success of this formula: First, infinite biophysical growth on a finite planet is clearly impossible which also sets limits to the size of the overall economy (Georgescu-Roegen, 1971; Murphy, 2021). Everything points to the fact that world society as a whole has already grown beyond its limits by crossing several

planetary boundaries, endangering the very conditions that enabled the development of human civilizations (Meadows et al., 1992; Richardson et al., 2023). The technological salvation of growth by absolute decoupling has not occurred (Haberl et al., 2020; Parrique et al., 2019). Thus, it could be argued that capitalism's main tools to solve its contradictions – growth and technology – have failed to solve sustainability problems and instead massively deteriorated the environmental state of the Earth.

Second, many of the GES assume that it is possible to reach an effective international agreement without deep changes in the current governance system. This assumption is problematic because the Westphalian system is based on competition rather than on cooperation and coordination (Berger & Weber, 2006; Buzan & Little, 1999). In a system whose logic is based on the survival of the sovereign state and in which there is no superior instance that can regulate the states or guarantee their security, states will tend to accumulate power by growing their economic and military capacities which are tightly connected to natural resources. The very structure of current international governance puts incentives to not reach and not comply with international agreements which could endanger the core imperatives that states need to fulfill in order to survive, i.e. national security, capitalist accumulation and social welfare for legitimation (Hausknost, 2020). A strong international agreement like a global cap on carbon and other resources as well as strong distribution measures would render the fulfillment of these imperatives significantly more arduous, and there is no reason for the wealthier and mightier states to support such an agreement in the current governance system. Hence, scenarios picturing far-reaching sustainability solutions within the currently dominant structures could be criticized as overly optimist or logically inconsistent.

4.2. Post-growth scenarios and pathways of change

9% of the analyzed GES can be called 'post-growth' scenarios that problematize one component of the 'success formula' (Section 4.1.) There have been repeated calls for the development of post-growth and degrowth scenario in the literature that point toward the problems of continuous unequal economic growth (Hickel et al., 2021; Otero et al., 2024). However, in the case of our database, the great majority of post-growth scenarios (29 out of 32) is to some extent anthropocentric, state-centric and/or capitalist. Thus, post-growth scenarios are not necessarily post-capitalist or 'radical' although post-capitalist, radical scenarios will probably always be post-growth scenarios. Post-growth scenarios in our database differ in the detail of their storylines and the breath of social change and economic policies they envision. Most post-growth scenarios focus on the economic system, especially on growth and regulations by the governing entity. However, they rarely pay attention to the governance system or explicitly describe changes to governance structures beyond states. That states are the actors which will implement post-growth policies is mostly taken for granted. Thus, post-growth scenarios could be said to move on a spectrum between reformism and 'revolution', i.e. radical changes of social power structures.

Post-growth scenarios like other scenarios which break in some aspect with currently dominant patterns face the problem of explaining how society gets from the status quo to the future described in the GES. Of the 49 scenarios which incorporate a break with at least one dominant social structure, 26 avoid this problem by simply describing a future where significant changes already happened without specifying a transition pathway. In contrast to these static scenarios, 23 scenarios integrate a pathway of change, i.e. their storyline contains some information about how the transition from the currently dominating structure to a radically changed structure occurs. Drivers of change are on the one hand external pressures: a deteriorating environment causing intense social, institutional and environmental crises, conflicts or collapse, thus increasing the pressure to act in more radical manners. On the other hand, there are social factors such as the gradual emergence of new visions and paradigms, enabled for example by environmental education, a global participatory dialogue and/or strong community, business and government leaders pushing these ideas. Although scenarios do not aim to predict the future, those scenarios that describe radically transformed futures could profit by integrating insights from sustainability transformation studies (e.g. Lam et al., 2020; Lederer et al., 2018) in order to add or improve pathways leading to desirable futures.

4.3. Neutrality of science and diversity of imaginaries

Our research results affirm that GES are not 'neutral'. Rather, by using and/or developing scenarios which do not question and problematize current social structures and power relations, the scientific community sometimes actively and often passively reproduces existing social power structures leading to environmental collapse. Excessive conservatism in scenario development regarding social change, combined with excessive optimism regarding technological change, constraints the range of possible futures and artificially limits the option and solution space with respect to sustainability problems. Due to their *performativity*, the majority of the analyzed scenarios not only represent certain futures but legitimize power structures, action and inaction today (Beck & Mahony, 2018; Braunreiter et al., 2021). Conversely, given the inertia of social systems, those GES describing fast and deep structural change in the three dimensions appear less plausible.

Since every scenario will integrate certain values and ideologies, there are two consequences for science: First, scientists should try to explicitly state ideological and political assumptions. Second, a greater variety of worldviews reflected in scientific scenarios is necessary to provide society with a broader picture of which socio-ecological futures are possible and which are impossible.

To achieve a greater diversity in GES circulating in the scientific community, scientists could draw on existing 'alternative' scenarios developed at regional and local scales (Neuvonen et al., 2014; Raudsepp-Hearne et al., 2020; pp. -; Svenfelt et al., 2019; also the numerous regional case studies found in the Biosphere Futures database) which narrate breaks with current socio-economic and/or cultural paradigms. Additionally, scientists could increasingly experiment with scenario creation methods fostering creativity and imagination, for example through storyline formats emphasizing the narrative character of a scenario or containing fictional elements, such as illustrated by recent scenario exercises (Lübker et al., 2023; Merrie et al., 2018; Pereira et al., 2023; Wyborn et al., 2020).

Broadening the circle of people included in scenario development and focusing on qualitative and quantitative methods that account for discontinuities, structural shifts and bifurcated pathways would also lead to more nonconventional views on the future (Rothman et al., 2023). Last, scenarios could come up with novel and more effective approaches to sustainability problems once they begin to problematize capitalism, the Westphalian system, and anthropocentrism in a holistic manner.

5. Conclusion

Global environmental scenarios (GES) developed and used by the scientific community to a great extent reproduce rather than break with dominant power structures in the economic, governance and cultural domain. The majority of scenarios reflects an anthropocentric world view and assumes that the logic of global capitalism and of the Westphalian state-based governance system will not change radically during the 21st century. Consequently, they suffer from a continuity bias preventing them from imagining and preparing for discontinuous environmental and social futures (Raskin & Swart, 2020; Rothman et al., 2023). The implicit solution of sustainability problems which dominates these scenarios is a combination of continuous economic growth, rapid technological progress and an international (environmental) agreement. Due to their performative character, these scenarios legitimize political action and inaction in the present and sideline alternative approaches to the sustainability dilemmas of world society which require more fundamental changes in the way we produce and distribute goods, in the way we take decisions and in our relationship to our environment. 'Alternative scenarios' are scarce, often only problematize one dimension of the social structure of world society and frequently lack explicit drivers of change or pathways to desirable futures. Therefore, future research should focus on making explicit the ideological assumptions in global environmental scenarios, increasingly quantify existing scenario storylines challenging the status quo, and develop a range of diverse GES integrating plausible pathways toward alternative and more sustainable economies, governance systems and human-nature relationships.

CRediT authorship contribution statement

Óscar Carpintero: Writing – review & editing, Supervision, Methodology. **Carlos de Castro:** Writing – review & editing, Supervision, Methodology. **Arthur Lauer:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

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Table A1
Overview of variables used for GES categorization.

$E+1$: Organizing principle: competition & self-interest	$E-1$: Organizing principle: Cooperation/coordination & common interest
$E+2$: Goal: accumulation	E-2: Goal: Fulfill needs
$E+3$: Economic growth; productivism	E-3: Shrinking economy / constant size; sufficiency, subsistence
$E+4$: Dominance of private property	E-4: Dominance of non-private property
$E+5$: Dominance of wage labour	E-5: Reduced wage labor
$E+6$: Allocation: Markets and price mechanism	E-6: non-market allocation
$E+7$: Class inequalities	E-7: social equity
$E+8$: Gender inequalities	E-8: gender equity
$E+9$: Geographical inequalities	E-9: geographical equity, equilibrated monetary, energy and material flows
$E+10$: Importance of finance; debt-based, interest-bearing money	E-10: Little finance sector, debt-free, interest-free money
$E+11$: Governing entity provides and garantizes capitalist institutions	E-11: Institutions to realize post-capitalist paradigm
$G+1$: States control security policy	G-1: Non-state actors control security policy
$G+2$: States control fiscal & social policy	G-2: Non-state actors control fiscal & social policy
$G+3$: States control migration policy	G-3: Non-state actors control migration policy
$G+4$: States control monetary policy	G-4: Non-state actors control monetary policy
$G+5$: States control trade policy	G-5: Non-state actors control trade policy
$G+6$: States control environmental policy	G-6: Non-state actors control environmental policy

Table A1 (*continued*)

E + 1: Organizing principle: competition & self-interest	E-1: Organizing principle: Cooperation/coordination & common interest
G+7: Anarchic, competitive relationship	G-7: Strong cooperation and coordination
G+8: States are shape global outcomes	G-8: Non-state actors shape global outcomes
C+1: Separation human-nature	C-1: Humans integrated in nature
C+2: Human superiority	C-2: Humans part of greater entity
C+3: Techno-scientific progress/optimism	C-3: Limits to human expansion
C+4: Nature = object/machine	C-4: nature = living being
C+5: Instrumental value of nature	C-5: Intrinsic value of nature

Table A2

Overview of scenarios that feature a break with the status quo.

Scenario name	Dimension with a break in the status quo
Culture (L. M.Pereira et al., 2020)	Human-Nature relationship
Marine (ibid.)	Human-Nature relationship
SSP0 (Otero et al., 2020)	Human-Nature relationship
Monumental legacies (Roura-Pascual et al., 2021)	Human-Nature relationship
The world awakes (Öborn et al., 2013)	Human-Nature relationship
Geopolity (WBCSD, 1997)	Governance structure
Policy reform (Raskin et al., 2002)	Governance structure
Fortress World (ibid.)	Governance structure
Breakdown (ibid.)	Governance structure
Unfinished symphony (World Energy Council, 2016)	Governance structure
Global villages (Roura-Pascual et al., 2021)	Governance structure
Agrimonde-Terra: Regionalization (Mora et al., 2020)	Governance structure
Agrimonde-Terra: Households (ibid.)	Governance structure
OSP4: Global elite & inequality (Maury et al., 2017)	Governance structure
Mad Max (Mistry et al., 2014)	Governance structure
A world in balance (Öborn et al., 2013)	Governance structure
Growth & Decay archetype (Fergnani & Song, 2020)	Governance structure
Threats & New Hopes archetype (ibid.)	Governance structure
Ecohumanist revolution (L.Pereira et al., 2021b)	Governance structure
Suboptimal situation (ibid.)	Governance structure
Coordinated city states (ibid.)	Governance structure
Climate chaos (ibid.)	Governance structure
Political/economic turmoil (Kuusi & Heinonen, 2022)	Governance structure
If humans were free (ibid.)	Governance structure
Hunting humans (Wright, 2016)	Governance structure
Societal transformation scenario (Kuhnhenn et al., 2020)	Economic structure
Nature's dynamics (L. M.Pereira et al., 2020)	Economic structure
Decent living energy (DLE) (Millward-Hopkins et al., 2020)	Economic structure
DLE_Higher Demand (HD) (ibid.)	Economic structure
DLE_Less Advanced Technology (LAT) (ibid.)	Economic structure
DLE_HD_LAT (ibid.)	Economic structure
Ecotopia (ECO) (van Dijk et al., 2020)	Economic structure
Ecotopia (Costanza) (Mistry et al., 2014)	Economic structure
Degrowth (Keyßer & Lenzen, 2021)	Economic structure
Degrowth_Full_NETs (Keyßer & Lenzen, 2021)	Economic structure
Degrowth_NoNNE (ibid.)	Economic structure
B Storyline: A prosperous, fair and green world (B.De Vries et al., 2000)	Economic structure
Economy of egalitarian sufficiency (Gough, 2022)	Economic structure

Table A3

Examples for information contained in GES for every variable.

Variable	Example	Variable	Example
E+1	Competitive, open and integrated global markets driving world development	E-1	Economic cooperation through the commons
E+2	Managing (oil) supply to maximize revenues; rewarding short-term profits	E-2	Needs-based approaches to decouple energy-use from human well-being; covered water and food choices and basic needs
E+3	Moderate economic growth in industrialized and middle-income countries, while low income countries lag behind	E-3	Post-growth world; development of new metrics such as a new Gross National Happiness Index
E+4	Expansion of property rights to ecosystem services	E-4	Move away from the ownership to 'usership'; collectively administered common properties
E+5	Most work in formal economy; automation as great threat to worker security	E-5	Universal basic income systems; Introduction of citizen/basic income coupled with active participation and civic duties

Table A3 (*continued*)

Variable	Example	Variable	Example
E+6	Global markets are increasingly integrated; creation of markets that allow equitable participation	E-6	Commoning, reciprocal credit, and barter trade prevail over market pricing
E+7	Broad-based social safety nets either do not develop or deteriorate	E-7	Property-owning democracy sustaining a much broader distribution of wealth
E+8	Women remaining largely outside the workforce and having high fertility	E-8	Putting care work at the centre; relationships of domination and inequity (e.g., epistemological domination, gender and social inequity) transformed into relationships of mutual respect
E+9	Gap widens between internationally-connected society and fragmented collection of lower-income, poorly educated societies	E-9	Fair trade, socially responsible investment; income floor and ceilings
E+10	Fast globalization of goods and financial markets	E-10	Stronger regulation of the finance sector; taxing financial transaction
E+11	Policy reforms focusing on global trade and economic liberalization	E-11	Highly fettered markets tamed to fulfill non-market goals
G+1	Governments establish policies balancing security, welfare and environmental concerns without much consideration for global impacts	G-1	World Union (n é e the United Nations) as global federation for co-operation, security and sustainability
G+2	States lowering the tax rate of firms because of international corporate tax competition	G-2	*Globally* implemented basic income partly financed by closing tax havens
G+3	Strictly closed borders for migrants	G-3	New and expanded international governance structures to manage migration over borders
G+4	Difficulties of States in coping with debt, monetary and financial crises	G-4	Localizing money and finance
G+5	Wealthier countries embracing economic protectionism	G-5	Economic localization; Re-localizing business
G+6	Lack of international climate regime	G-6	Strong local and regional scale decision-making connected to larger scales; governance crossing land-sea interface
G+7	International fragmentation and confrontation	G-7	Concerted efforts by governments to solve pressing problems
G+8	Governance at national level, irrespectively of international affairs, as dominant mode of governance	G-8	Supranational institutions well placed to deal with global environmental problems; collaboration of local, national, and international organizations and institutions, the private sector, and civil society
C+1	Green cities but general disconnection from "nature"; few "pristine" areas	C-1	Awareness of oneness between humans and their environment; deep ecology
C+2	AI-guided stratospheric aerosol injections; marine cloud brightening; genetically modified organisms	C-2	Humans as part of an Earth community; nature has rights
C+3	Nuclear fusion; asteroid mining, space colonization	C-3	Social and environmental goals define "boundary conditions"; Human infrastructures limited to urban areas
C+4	Highly managed and artificially created ecosystems	C-4	Earth is assumed to host a network of life; living rivers
C+5	Unrestricted coal extraction	C-5	Concern about biodiversity, beyond its direct utility for society

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.futures.2024.103460.

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