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Imagining the Future after Crisis: Science and Environmental Imaginaries in the Anthropocene

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Article

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Abstract

This article examines how scientists construct imaginaries of societal futures amid converging crises—pandemics, climate change, and zoonotic spillover. Drawing on ten semi-structured interviews across disciplines, we identify six recurrent narrative modes: dystopian warnings, modest utopias, and present extrapolations, reflections on failed futures, data-driven projections, and conditional planning. Using Causal Layered Analysis (CLA), we situate these modes across four nested layers, litany, systemic drivers, disciplinary worldviews, and cultural metaphors, showing how institutional logics, epistemic cultures, and affective registers shape what futures become thinkable and actionable. Rather than techno-optimism, these imaginaries exhibit ambivalence and relational reasoning. The study contributes to futures studies and STS by applying CLA to scientists' narrative practices, situating scientific imagination within epistemic cultures, and highlighting the plural, contested character of anticipatory knowledge in the Anthropocene.

Keywords

Futures thinking, Sociotechnical imaginaries, Zoonotic risks, Epistemic cultures, Climate imaginaries

Introduction

This article examines how scientists imagine societal futures amid overlapping crises—including the COVID-19 pandemic, accelerating climate change, and the intensifying risk of zoonotic disease. These converging disruptions not only strain socio-ecological systems but also unsettle the ways in which societies anticipate, plan for, and narrate the future. Scientific expertise plays a pivotal role in such processes, yet scientists do not speak with a single voice. Their future imaginaries are shaped by disciplinary orientations, institutional positioning, and broader societal tensions.

The research presented here is part of a larger project investigating the conditions under which individuals, institutions, and communities can build resilience in response to systemic crises. Within this broader agenda, our sub-study focuses on scientists as key epistemic actors who contribute not only technical knowledge but also narrative templates through which futures are made thinkable. In moments of crisis, such narratives can inform policy debates, shape public discourse, and influence how responsibility and agency are allocated.

Situated at the intersection of science and technology studies (STS), environmental humanities, and futures studies, this article approaches scientific futuring as a situated practice rather than a neutral act of prediction. Drawing on insights from these fields, we treat future-oriented scientific narratives as culturally and institutionally embedded, and as consequential for how collective responses to crisis are imagined and justified.

Empirically, the article draws on semi-structured interviews with ten scientists working in Croatia across environmental, life, and biomedical sciences. We identify six recurring narrative modes through which scientists articulate societal futures: dystopian warnings, modest utopias, present extrapolations, failed futures, data-driven projections, and conditional planning. These modes reflect both disciplinary differences and broader tensions surrounding agency, justice, and responsibility in the Anthropocene.

To analyze how these narratives operate at different depths of meaning, we employ Causal Layered Analysis (CLA) (Inayatullah, 1998). CLA enables us to examine scientific imaginaries not only at the level of surface narratives, but also in relation to underlying institutional dynamics, epistemic orientations, and cultural metaphors. By applying CLA empirically, the article contributes to futures studies and STS by showing how scientific futuring in times of crisis is structured across multiple, interacting layers of meaning.

Theoretical framework

To understand how scientists articulate futures under conditions of systemic crisis, we draw on theories that conceptualize the future as a sociotechnical, cultural, and epistemic construct. Our conceptual approach is grounded in science and technology studies (STS), environmental humanities, and critical futures studies. Taken together, these traditions allow us to consider futures not simply as forecasts, but as contested imaginaries structured by institutions, epistemic commitments, and cultural metaphors.

One important starting point is the concept of sociotechnical imaginaries, defined by Jasanoff and Kim (2009) as “collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through advances in science and technology.” Sociotechnical imaginaries are performative: they guide research agendas, legitimize technological pathways, and underpin policy choices. Related frameworks such as responsible innovation (Stilgoe, Owen, & Macnaghten, 2013) and public reason in post-

truth contexts (Jasanoff & Simmet, 2017) highlight the normative dimensions of anticipatory discourse, stressing that visions of the future always involve judgments about what is valuable, legitimate, and possible.

Closely linked to imaginaries is the sociology of expectations. Borup et al. (2006) argue that scientific work is "replete with expectations" that mobilize funding, define risk, and legitimate innovation even before technologies are realized. Expectations are thus not only descriptive but also performative, shaping present-day collaborations, research trajectories, and institutional priorities. Later contributions (e.g., Glerup & Horst, 2014; Versteeg, 2018) show how credibility in science is inseparable from these expectation-laden claims, embedding futuring practices in broader institutional logics.

These anticipatory dynamics unfold within what has been named the Anthropocene—a proposed epoch marked by the pervasive impact of human activity on Earth systems (Crutzen & Stoermer, 2000). Scholars in environmental humanities and STS have emphasized how Anthropocene framings require a rethinking of human agency, scientific responsibility, and socio-ecological entanglement (Haraway, 2016; Latour, 2014; Stengers, 2018). Critics such as Chakrabarty (2009) and Tsing (2005) caution that global narratives risk obscuring inequalities of responsibility and capacity, urging attention to situated struggles and uneven power. Brajdić Vuković and Domazet (2022) extend this by conceptualizing the Anthropocene as both a material condition and a distributional regime rooted in energy and capitalist modernity. Concepts such as anthromes (Ellis & Ramankutty, 2008) and "frictions of universals" (Tsing, 2005) illustrate how planetary imaginaries are refracted through local contexts. Within this scholarship, calls for "slow science" (Stengers, 2018) and "making kin" (Haraway, 2016) emphasize relational ethics as counterpoints to accelerationist or techno-fix futures.

The diversity of such future-making practices can also be illuminated through Knorr Cetina's (1999) concept of epistemic cultures, the "machineries of knowing" specific to different scientific disciplines. Each discipline cultivates its own evidentiary standards, temporal horizons, and rhetorical repertoires. This insight has been influential in showing how sciences generate not only knowledge but also distinctive orientations toward uncertainty and projection. Work on public understanding of science (Irwin & Wynne, 1996) and on science in an age of complexity (Nowotny, Scott, & Gibbons, 2001) further underscores that futures are mediated by the epistemic assumptions and institutional forms through which knowledge is produced and communicated.

Critical futures studies complements these perspectives by conceptualizing the future as a contested space of narrative, power, and possibility (Sardar, 2010; Poli, 2010; Andersson, 2018). Rather than privileging predictive certainty, this field emphasizes plural, alternative futures and situates anticipation within cultural and institutional contexts. Within this tradition, Causal Layered Analysis (CLA) (Inayatullah, 1998) provides a methodological lens for unpacking anticipatory discourse across four strata of meaning: litany, systemic causes, worldview/discourse, and myth/metaphor. CLA highlights how surface narratives are anchored in deeper epistemic and cultural structures, and how these strata interact to shape which futures are perceived as plausible, urgent, or foreclosed. Virmajoki (2022) has further shown that CLA can be connected to the philosophy of science, offering a tool to examine how epistemic assumptions and cultural metaphors together confer legitimacy and authority on visions of the future.

Taken together, these literatures provide a multi-layered framework for analyzing scientific futuring. They suggest that anticipatory discourse must be read

simultaneously as institutional practice, epistemic orientation, and cultural narrative. This theoretical grounding enables us to situate scientific imaginaries within broader debates on responsibility, pluralism, and epistemic authority in the context of planetary crisis.

Methodology

This research is part of the project Resilience of Croatian society due to the COVID-19 pandemic, funded by Croatian Science Foundation, which examined how individuals, institutions, and communities can strengthen their capacity to respond positively to systemic crises such as pandemics and climate change. Within this broader project, our sub-study focuses on how Croatian scientists from different disciplines conceptualize the future in light of zoonotic and ecological disruption.

We adopt a qualitative, interpretive approach, grounded in the assumption that scientists' anticipations are not only technical forecasts but also socially situated narratives. Data were generated through semi-structured interviews with ten scientists working across oceanography, agronomy, biology, meteorology, molecular biology, epidemiology, and food technology. Six of the participants were engaged in research directly connected to climate change, while the remaining four were active in biomedical and health-related fields. Purposeful intensity sampling (Patton, 2014) was used to identify participants with strong involvement in science communication, policy advising, or crisis-oriented research, ensuring that the interviews captured reflective and publicly engaged voices. An overview of the interviewed scientists, including disciplinary background, research focus, and gender, is provided in Table 1. All participants are scientists working in Croatia at the time of the interviews. Code names are used to preserve anonymity and are referenced throughout the analysis.

Table 1: Interviewed scientists by discipline, research focus and gender (N=10)

Participant	Discipline	Primary research focus	Gender	Code Name
P1	Agronomy	Climate change, soil	F	AGR_CC_1
P2	Biology	Biodiversity	F	BIO_CC_2
P3	Oceanography	Sea level rise	M	OC_CC_1
P4	Oceanography	Emissions modelling	M	OC_CC_2
P5	Food Technology	Nutrients, Indicators	F	FT_MET_1
P6	Meteorology	Risk modelling, governance	M	MET_GOV_1
P7	Molecular Biology	Genomic technology	M	MB_Z_1
P8	Epidemiology	Epidemic response	F	MB_Z_2
P9	Epidemiology	Epidemic surveillance	M	EPI_Z_1
P10	Agronomy	Environmental justice	F	AGR_CC_2

Interviews were conducted between 2021 and 2022, lasting approximately 60 to 90 minutes. The protocol included open-ended questions about experiences during the COVID-19 pandemic, scientific and public communication, imagined causes and consequences of crisis, and expectations about future societal developments. All interviews were audio-recorded, transcribed, anonymized, and conducted with informed consent.

For analysis, we followed Braun and Clarke's (2006) six-phase model of thematic analysis: familiarization, initial coding, theme identification, theme review, theme definition, and report writing. Coding was inductive but informed by theoretical constructs from science and technology studies, environmental humanities, and futures studies. In particular, we attended to how disciplinary epistemic cultures shape anticipatory narratives, how affect and values enter scientific discourse, and how imaginaries can be situated within different layers of meaning. To support this, we drew on Causal Layered Analysis (CLA) (Inayatullah, 1998), which provided a heuristic for organizing interpretations across surface accounts, systemic drivers, epistemic orientations, and cultural metaphors.

For clarity, the findings are presented in terms of six recurring narrative modes of the future that emerged across interviews. These modes serve as the organizing framework for the Results section and provide the basis for a layered interpretation through Causal Layered Analysis. In what follows, we outline these modes in detail, before turning to their disciplinary inflections and the deeper cultural layers that shape them.

Constructing the Future: Six Recurring Narrative Modes

Across the interviews, we identified six recurring narrative modes through which scientists imagine societal futures. These modes represent patterned ways of narrating crisis, change, and possibility rather than isolated statements, and they reflect distinct orientations toward uncertainty, responsibility, and action. While analytically distinguishable, the modes frequently overlap within individual accounts.

As summarized in Table 2, the six narrative modes are dystopian warnings, modest utopias, present extrapolations, failed futures, data-driven projections, and conditional planning. In what follows, each mode is elaborated through illustrative excerpts and interpretive analysis. Narrative modes are analytically distinguished but frequently overlap within individual interviews.

Table 2: Six recurring narrative modes identified in semi-structured interviews with scientists (N=10)

Narrative Mode	Core Characteristics	Illustrative Focus	Typical Disciplinary Orientation
Dystopian warnings	Emphasis on collapse, tipping points, irreversible damage, and catastrophic risk	Ecological breakdown, pandemics, biosecurity threats	Environmental sciences, molecular biology
Modest utopias	Cautious hope grounded in relational ethics, solidarity, and value shifts	Slower lifestyles, care, cooperation	Biology, food sciences
Present extrapolations	Linear projections based on existing trends and institutional capacities	Governance responses, surveillance, geopolitical asymmetries	Meteorology, epidemiology

Failed futures	Retrospective reflection on ignored warnings and institutional inaction	Climate inertia, pandemic unpreparedness	Oceanography, molecular biology
Data-driven projections	Reliance on models, indicators, and standardized measurement regimes	Risk modelling, metrics, evidence-based governance	Agronomy, modelling-intensive fields
Conditional planning	If–then scenarios linked to policy choices and justice-oriented interventions	Energy poverty, targeted governance measures	Agronomy, policy-oriented research

Dystopian Warnings: Imagining Collapse and Catastrophe

Many scientists articulated strongly dystopian visions of the future. They warned of cascading environmental collapse, irreversible climate tipping points, thawing permafrost, and the increasing likelihood of pandemics emerging from disrupted ecosystems. One scientist remarked on how human behavior was accelerating catastrophe:

There's nothing we won't destroy to make life easier, even too easy, for ourselves. (AGR_CC_1)

Another speculated about the weaponization of genomic technologies, expressing concern about biosecurity:

In 10, 20, or 50 years, it might be possible to develop a substance that will kill only you and no one else, because your genome is unique. (MB_Z_1)

These dystopian accounts were not just scientific; they were deeply moral. They framed humanity as reckless, shortsighted, and trapped in extractive logics. While grounded in disciplinary expertise, these visions also reflected emotional exhaustion and ethical disillusionment with the political status quo.

Modest Utopias: Imagining Solidarities

Some interviewees offered modest but meaningful utopian hopes. These were less about technological breakthroughs and more about relational ethics and value shifts. One scientist imagined:

A simpler, more modest, maybe even better life, less wasteful, more empathetic. (BIO_CC_2)

Such visions often referenced moments of solidarity from wartime or early pandemic lockdowns:

These are beautiful moments… they tend to pass quickly, but they matter. (BIO_CC_2)

These narratives revalued slowness, cooperation, and everyday human connection. They resonate with Haraway's (2016) call to "make kin," and Stengers' (2018) vision of "slow science."

Present Extrapolations: Imagining Linear Continuities

A pragmatic mode of imagining involved extending current trends into near-term futures. One participant commented:

China will handle this better… it has mechanisms to control anger and information. The West will lag but eventually catch up. (MET_GOV_1)

This view foregrounded institutional capacity, geopolitical asymmetry, and pandemic management as central drivers of future outcomes. Others pointed to deforestation and habitat encroachment as ongoing drivers of zoonotic risk:

It is going to keep happening… it is a matter of time and bad luck what kind of disease will jump next. (EPI_Z_1)

These narratives stressed risk management and continuity, not transformation—highlighting scientists' role as cautious forecasters rather than visionaries.

Failed Futures: Imagining Knowledge Ignored

Another group of narratives reflected on past prediction failures and the politics of inaction:

We always knew pandemics were likely, but no one really acted until it happened. (MB_Z_2)

Participants spoke of scientific knowledge being ignored, misused, or inadequately translated into policy, especially in climate science:

The best we have done is slow the rate of emissions. We have not reversed anything. (OC_CC_1)

These reflections align with Urry's (2016) emphasis on failed futures as a key to understanding present constraints. They also illustrate a growing skepticism toward linear techno-fixes and institutional inertia.

Data-Driven Projections: Imagining Through Measurement

For many, future making hinged on data. One participant insisted:

It has to be classical analytical data… measured with a widely accepted methodology. Nothing else counts. (FT_MET_1)

Others emphasized spatial resolution and social specificity:

Indicators must be tailored to population groups, national averages are not enough. (AGR_CC_1)

Though grounded in quantitative rigor, these imaginaries were not devoid of ethics. They revealed embedded concerns about equity, access, and how measurement structures shape what futures are seen as feasible or legitimate.

Conditional Scenario Planning: Imagining Contingent Futures

Some participants articulated conditional scenarios with clear policy implications:

If this lasts a decade, maybe we will see meaningful environmental change. (OC_CC_2)

Others critiqued gaps in policy targeting:

There is no national measure to address energy poverty with low-tech solutions—even though that's where the greatest need is. (AGR_CC_2)

These narratives reflect a form of anticipatory governance. Scientists positioned themselves as advocates for spatial justice, targeted subsidies, and long-term resilience strategies, not just neutral analysts. Scenario-building became a political tool: a way of making certain futures visible, actionable, and ethically urgent.

Taken together, these six narrative modes reveal not a unified scientific vision of the future, but a plurality of orientations shaped by epistemic commitments, affective registers, and institutional positioning. To further unpack these differences, the next section examines how disciplinary epistemic cultures inflect scientists' future imaginaries.

Disciplinary Inflections: Imagining Futures through Epistemic Cultures

The ways in which scientists imagined the future were deeply shaped by their disciplinary backgrounds. These disciplinary inflections influenced not only the tools and methods they relied upon, but also their temporal horizons, spatial orientations, and ethical concerns. As Knorr Cetina (1999) reminds us, disciplines operate as "epistemic cultures," cultivating distinctive norms of inquiry, valuation, and projection. Within our interviews, this diversity became especially visible in how participants articulated risk, resilience, and responsibility, whether in relation to planetary processes, viral mutations, or local socio-ecological conditions.

For example, climate scientists and oceanographers often operated within frameworks of deep time and planetary processes. They spoke of glacial melting, permafrost thaw and carbon accumulation as slow, cumulative phenomena with lagging indicators, phenomena that required thinking decades, even centuries ahead:

Even if we manage to stabilize emissions now, the concentration will remain high for decades. (OC_CC_2)

In contrast, molecular biologists and epidemiologists were more concerned with near-term dynamics: viral mutation rates, vaccine rollouts, biotechnological innovation, and the social responses to rapidly unfolding crises.

Spatial orientation also varied. Agronomists and biologists often invoked local specificity, soil degradation in certain Croatian regions, energy poverty among particular social groups, or zoonotic risks in biodiversity hotspots. Their imaginaries of the future were intimately tied to landscapes, biomes, and human communities:

We need to manage these areas sustainably, based on degradation indicators, or they will not benefit future generations. (AGR_CC_2)

Meanwhile, other scientists leaned toward global comparisons:

China already has control. The West will lag, but eventually it will catch up. (MET_GOV_1)

This juxtaposition underscored geopolitical asymmetries in preparedness and control.

Perhaps most striking were the differences in how complexity was understood and narrated. Some scientists described future scenarios through relatively linear chains of causality, e.g., emission increases lead to temperature rise, which alters precipitation and crop yields. Others stressed feedback loops, cascading risks, and nonlinear interactions among ecological, technological, and social systems.

This distinction often aligned with methodological preferences:

You can get whatever result you want if you cheat with statistics… but the numbers have to be contextualized. (MB_Z_2)

Quantitative modelers expressed concern with parameter calibration and scenario testing, while qualitative or systems-oriented researchers emphasized interdependence and uncertainty.

The emotional tones embedded in these narratives also differed. Participants from the life sciences often voiced ethical ambivalence or anxiety about unintended consequences—especially around vaccine technologies or gene-editing potentials:

The mRNA technology is not without concern… it is conceivable that gene-targeting could be weaponized. (MB_Z_1)

Environmental scientists, by contrast, more frequently expressed frustration over political inertia or resignation toward the inevitability of ecological degradation:

Unless this lasts a decade, we will not see meaningful shifts in environmental indicators. (OC_CC_2)

Across the board, there was a notable scarcity of techno-optimism. Few believed that science alone would drive transformative change. Instead, some articulated an ethos of patient observation, humility, and relational knowledge, echoing Stengers' (2018) advocacy for a "slow science" that resists urgency in favor of ethical attentiveness.

These disciplinary inflections underscore that imaginaries of the future are never neutral or uniform. They are conditioned by how disciplines define problems, what forms of evidence they privilege, and what they consider plausible, probable, or desirable. In the context of planetary crisis, such epistemic diversity may be both a strength and a challenge: it enriches the palette of possible responses but complicates the search for shared imaginaries or coordinated action. Recognizing these internal differences within "science" as a category is essential—not only for understanding how futures are constructed but also for designing inclusive, transdisciplinary approaches to resilience.

Reframing Scientific Imaginaries: A Causal Layered Analysis of Futures

To deepen the interpretation of our findings, we situate the six narrative modes within the framework of Causal Layered Analysis (CLA) (Inayatullah, 1998). As shown in Table 3, the modes operate across four interconnected layers – litany, systemic causes, worldview, and myth, revealing how scientists' future imaginaries are structured not only by surface narratives but also by institutional dynamics, epistemic cultures, and cultural metaphors. The CLA layers are analytically distinguished but empirically intertwined; individual interviews often mobilize multiple narrative modes and metaphors simultaneously.

Table 3: Positioning the six recurring narrative modes across four layers of causal layered analysis

Narrative Mode	Litany (Surface Narratives)	Systemic Causes	Worldview / Epistemic Culture	Myth / Metaphor
Dystopian warnings	Collapse, tipping points, pandemics, catastrophic risk	Institutional inertia, extractivist political economy, delayed governance	Planetary risk awareness; limits to control	Science as Cassandra
Modest utopias	Simpler lives, solidarity, care, slowed-down futures	Inequality, erosion of social cohesion, crisis-induced reflection	Relational ethics; interdependence	Science as kin-maker
Present extrapolations	Continuation of current trends; near-term crisis management	Governance capacity, surveillance infrastructures, geopolitical asymmetries	Pragmatic realism; institutional competence	Science as manager
Failed futures	Ignored warnings, missed opportunities, institutional failure	Short-termism, weak science–policy translation	Frustrated expertise; retrospective critique	Science as tragic witness
Data-driven projections	Models, indicators, measurement, evidence-based foresight	Metricization, standardization, audit cultures	Epistemic authority of quantification	Science as objective arbiter
Conditional planning	If–then futures; policy levers; justice-oriented interventions	Policy design, redistribution mechanisms, anticipatory governance	Strategic interventionism; responsibility	Science as steward

Litany

At the most visible level, scientists articulated narratives of dystopian warnings (collapse, tipping points, pandemics), utopian hopes (modest solidarities, slower and simpler lives), present extrapolations (linear continuations of current crises), and failed futures (warnings ignored, inertia entrenched). These modes echo public discourse and media headlines: they are affectively charged, problem-focused, and often framed in terms of urgency or loss.

Systemic causes

Beneath these surface accounts lie structural explanations. Data-driven scenarios exemplify the reliance on models, indicators, and measurement regimes as tools of governance. Conditional planning connects scientific imaginaries to institutional instruments, subsidies, policies, resilience strategies. Failed futures also belong here,

pointing to systemic inertia, short-termism, and weak translation of science into policy. At this layer, imaginaries reflect the constraints and logics of institutions, funding systems, and governance structures that shape what futures can be envisioned as actionable.

Worldview/Epistemic Culture

A deeper layer reflects the epistemic cultures of disciplines (Knorr Cetina, 1999). Environmental scientists foregrounded planetary processes and deep time, biomedical researchers emphasized immediacy and mutation, while agronomists and biologists invoked relational ethics and local specificity. These disciplinary orientations shape not only evidentiary standards but also temporal horizons, ethical emphases, and modes of narration. At this layer, imaginaries are less about particular crises than about the epistemological assumptions of what counts as valid knowledge and credible anticipation.

Myth/metaphor

At the deepest level, scientific imaginaries draw on cultural archetypes. We can detect myths of science as Cassandra, issuing warnings that go unheeded until catastrophe strikes; notably the myth of science as savior was largely absent, indicating skepticism toward technofixes; science as kin-maker, aligning with relational, modest utopias (Haraway, 2016); and science as witness, bearing testimony to loss, collapse, and ethical responsibility. These metaphors reveal how imaginaries are anchored in cultural stories about the role of science in the Anthropocene: not only to predict, but to warn, to connect, or to document.

Seen through CLA, the six narrative modes are no longer discrete categories but interconnected layers of meaning. A dystopian warning at the litany level, for example, is often linked to systemic critiques of institutional inertia, shaped by disciplinary worldviews of risk and uncertainty, and underpinned by a mythic image of science as Cassandra. Similarly, modest utopias are tied to systemic concerns with equity and justice, framed by relational worldviews, and sustained by metaphors of kinship and care.

This layered approach clarifies not only how scientists imagine the future, but why certain futures appear credible, urgent, or foreclosed within particular institutional and epistemic contexts. By situating narrative diversity across litany, systems, worldviews, and myths, CLA reveals scientific narration as a practice shaped by cultural meaning, ethical orientation, and epistemic responsibility. This insight provides a critical foundation for assessing what kinds of futures these imaginaries ultimately enable, or constrain, within contemporary science–society relations.

Taken together, the CLA analysis suggests that scientists' future imaginaries function less as coherent scenarios than as layered orientations toward uncertainty, responsibility, and action. These orientations do not simply describe possible futures; they shape which futures are rendered plausible, actionable, or unthinkable.

Discussion: What Futures Do These Imaginaries Enable or Foreclose?

Building on the Causal Layered Analysis presented above, the Discussion examines what kinds of futures scientists' imaginaries enable or foreclose. The findings show that scientific narration is neither unified nor purely technocratic, but marked by narrative plurality, ethical ambivalence, and layered meanings that reflect institutional constraints,

disciplinary worldviews, and cultural metaphors.

The analysis demonstrates that scientists' imaginaries of the future are diverse, fractured, and emotionally complex. Rather than offering a unified vision of resilience, they move between fatalism and hope, between data and story, between professional expertise and lived ethics. This plurality reflects not only disciplinary orientations but also broader sociotechnical imaginaries and cultural metaphors that shape how futures are envisioned, legitimized, or foreclosed. Seen through the lens of Causal Layered Analysis, these imaginaries reveal tensions across surface narratives, systemic structures, epistemic worldviews, and deep myths, clarifying why some anticipations resonate publicly while others remain marginal or dismissed.

Our participants' imaginaries, plural, ethically charged, and often ambivalent, resonate with what Mayo (2020) calls the postnormal condition: a cultural and epistemological rupture in which traditional ways of knowing fail to adequately engage with complexity, uncertainty, and digital fragmentation. As scientists narrate futures marked by both cautious forecasting and ethical concern, they inhabit a space between the "no longer" and the "not yet", where narrative serves not as closure but as navigation. These accounts reflect not only discipline-specific epistemes but also a broader postnormal tension between familiar norms and emerging ruptures, in which imagination must stretch beyond inherited certainties.

Viewed through Causal Layered Analysis (CLA), these imaginaries can be understood as layered constellations of meaning. At the surface litany level, dystopian warnings and modest utopias echo public discourse and emotional registers of risk and hope. At the level of systemic causes, data-driven scenarios and conditional planning highlight institutional logics, measurement regimes, governance instruments, and policy inertia, that constrain or enable futures. At the worldview/discourse level, disciplinary epistemic cultures shape temporal horizons, evidentiary standards, and ethical emphases. Finally, at the layer of myth and metaphor, enduring cultural archetypes appear: science as Cassandra, as savior, as kin-maker, or as witness. This layered perspective clarifies why certain futures are seen as urgent, credible, or foreclosed, while others remain marginal or unspeakable.

These divergent narrative modes also reflect broader sociotechnical imaginaries about post-crisis transformation. Frommelt (2020) outlines four structured scenarios for a post-pandemic world, ranging from a "Shut-In Economy" to "Digital Leninism", each shaped by ecosystem governance and health technology developments. Although our participants did not formalize their visions as scenarios, their narrative imaginaries often traversed similar ground: encompassing fears of surveillance, hopes for sustainable restructuring, and uncertainties around institutional trust. Unlike Frommelt's anticipatory scenarios, however, these accounts were affectively ambivalent and narratively plural, highlighting the moral entanglements and epistemic tensions that characterize futuring in postnormal times.

Jasanoff and Kim's (2009) concept of sociotechnical imaginaries helps illuminate how scientists envision futures not just technologically, but normatively. Yet rather than a coherent institutional imaginary, we see fragmented visions shaped by discipline, affect, and epistemic trust. Importantly, the absence of strong techno-optimism suggests that many scientists are skeptical of science-as-savior. They are more inclined toward what Stengers (2018) calls "slow science", a practice that resists speed and embraces ethical complexity.

Their imaginaries are also syncretic (Law, 2004): contradictory, layered, and unresolved.

Scientists often hold multiple, incompatible temporalities and affective tones, demonstrating that incoherence can be an honest response to crisis. The ambivalence many scientists express about transformation resonates with critiques of Anthropocene universalism. As Brajdić Vuković and Domazet (2022) argue, dominant narratives often obscure the unequal responsibility for ecological degradation and the differentiated capacity for resilience. Following Tsing (2005) and Chakrabarty (2009), imaginaries that appear global or collective can mask the frictional encounters of local and global actors and the contested universals, such as progress, growth, or modernity, that shape responses to planetary crisis.

Yet, very few articulated robust political theories of change. Imaginaries often lacked clarity about how transformation might happen, or who would lead it. This underscores the importance of future-making not just as scientific modeling, but as a site of democratic and ethical negotiation. Here, CLA is particularly useful, because it reveals not only what scientists imagine but also how those imaginaries are structured across layers—highlighting where narratives open space for action, and where they foreclose possibilities. This resonates with Virmajoki's (2022) argument that CLA can be productively connected to the philosophy of science: it allows us to interrogate how knowledge, institutional dynamics, and cultural archetypes intertwine in shaping futures.

Attending to the narrative plurality in scientists' imaginaries also has important methodological and practical implications. Rather than treating science as a unified epistemic voice, our findings suggest that transdisciplinary foresight processes must explicitly recognize and negotiate internal diversity. Scientists do not simply disagree over facts or projections, they bring different narrative forms, temporal sensibilities, and ethical commitments to the table. Acknowledging these differences can enrich participatory scenario-building by revealing hidden assumptions, affective investments, and alternative logics of action. Moreover, this pluralism challenges foresight practitioners and policymakers to design deliberative spaces that can accommodate both technical expertise and epistemic diversity, especially in contexts of uncertainty and contested values. In this sense, interdisciplinary tensions are not obstacles to be smoothed over but opportunities for critical reflection and mutual learning in the co-production of sustainable futures.

These six narrative modes thus expand the palette of futuring beyond institutional foresight or scenario typologies such as those developed by Shell (Wack, 1985; Shell International, 2005) or employed in policy-oriented foresight models (predictive, normative, exploratory). Unlike these frameworks, which emphasize coherence, utility, and decision-making support, the imaginaries voiced by our participants are often affectively charged, morally complex, or internally contradictory. Applying CLA reveals they function less as planning tools than as ethical registers and epistemic negotiations, challenging the assumption that futures must be instrumentalized to be actionable.

Limitations and Repercussions

This study is exploratory in nature and based on a small, purposively selected sample of Croatian scientists. While the interviews offer rich insights into how disciplinary cultures shape future imaginaries, they do not claim to represent all scientific perspectives in Croatia or beyond. The sample is also skewed toward individuals engaged in science communication or crisis-related research, which may amplify reflexive or ethically aware positions compared to other scientists who were not similarly involved in public or policy debates.

Furthermore, although the sample is situated in Croatia, a semi-peripheral context within

the EU, many themes resonate with broader global tensions. The imaginaries reflect what Tsing (2005) describes as the “frictions of universals”: how global aspirations like sustainability, resilience, or scientific progress are taken up, resisted, or reworked in specific cultural and geopolitical contexts. This perspective complicates North–South binaries by emphasizing uneven participation in global knowledge systems, while pointing to shared constraints in planetary governance. Future studies might compare such imaginaries across post-socialist, post-colonial, or small-state scientific cultures to explore these tensions further.

Moreover, the interviews were conducted during a moment of heightened uncertainty and emotional fatigue, between pandemic waves and amid growing climate anxieties. These conditions undoubtedly influenced how participants narrated the future, including their emphasis on ambivalence, caution, or moral reflection. A different temporal context might yield more assertive or optimistic projections.

Methodologically, our reliance on semi-structured interviews and thematic interpretation means that what is captured are articulated imaginaries rather than subconscious assumptions or institutional practices. The application of Causal Layered Analysis (CLA) in this study foregrounds the narratives scientists voiced at different levels of meaning, but does not fully capture how unspoken assumptions or institutionalized practices may shape futuring. Future research could extend this approach by incorporating longitudinal methods, discourse analysis of scientific outputs, or comparative cross-national studies of scientific futuring, thereby testing the robustness of CLA across different contexts.

Despite these limitations, the findings have significant implications. First, they challenge simplistic narratives of science as a uniform driver of progress, revealing instead a fractured epistemic field marked by ethical hesitation, emotional burden, and relational reasoning. Second, they caution against technocratic framings of crisis response, urging greater attention to justice, affect, and local context in both scientific modeling and policy development. Finally, by showing how scientific imaginaries operate across layered registers, from litany to worldview to metaphor, this study underscores the value of CLA for science governance. Facilitating inclusive foresight processes requires not only interdisciplinary literacy but also sensitivity to the emotional, ethical, and epistemic tensions that accompany scientific narratives of the future.

Conclusion

This article has shown how Croatian scientists imagine the future through six distinct yet overlapping narrative forms. These imaginaries are shaped not only by disciplinary culture, personal experience, and ethical orientation, but also by deeper epistemic and cultural layers. They reflect not only predictions but worldviews, about what is possible, what is worth preserving, and what is already lost.

In contributing to environmental humanities and futures studies, we emphasize that future-making is a cultural and relational act. Science does not speak with one voice. It narrates, hesitates, and reflects. Its imaginaries are sites of struggle, not only over facts, but over values, justice, and meaning in the Anthropocene.

Using Causal Layered Analysis (CLA) has allowed us to situate these narratives across litany, systemic structures, disciplinary worldviews, and cultural myths. This layered perspective clarifies why certain anticipations carry urgency, credibility, or resonance, while others remain marginal. It underscores that the diversity and ambivalence expressed by scientists are not simply noise or weakness, but resources for more inclusive and reflexive futuring.

The ambivalence, modest utopias, and ethical attentiveness voiced by our participants offer fertile ground for rethinking the role of science in shaping societal futures. Rather than treating scientific knowledge solely as a basis for prediction or control, this study invites a broader view: one that embraces narrative pluralism, honors disciplinary specificity, and foregrounds responsibility as much as expertise. In moments of planetary crisis, the future is not only what is forecast, but what is imagined, layered, and negotiated through the diverse epistemic and moral vocabularies we collectively inhabit. As narrators of the future, scientists carry not only epistemic authority but also a public responsibility to engage reflexively, ethically, and inclusively with the uncertainties and possibilities that shape our shared world.

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