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Environmental Sustainability Post-COVID-19: Scrutinizing Popular Hypotheses from a Social Science Perspective

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Abstract: There is an increasingly vocal debate on potential long-term changes in environmental sustainability spurred by the global COVID-19 pandemic. This article scrutinizes the social science basis of selected popular hypotheses regarding the nexus between the COVID-19 pandemic and the societal transitions towards environmental sustainability. It presents results that were derived through an interdisciplinary dialogue among social scientists. First, it is confirmed that the COVID-19 crisis has likely created a potential window of opportunity for societal change. Yet, to ensure that societal change is enduring and actually supporting the transition towards environmental sustainability, a clear and well-targeted political framework guiding private investments and behavior is required. Second, it is emphasized that there are important structural differences between the COVID-19 crisis and environmental crises, like time scales. Consequently, many strategies used to address the COVID-19 crisis are hardly suitable for long-term transitions towards environmental sustainability. Third, it is argued that transitions towards environmental sustainability—building both on reducing environmental degradation and building socio-techno-ecological resilience—may create co-benefits in terms of preventing and coping with potential future pandemics. However, research still needs to explore how big these synergies are (and whether trade-offs are also possible), and what type of governance framework they require to materialize.

Keywords: COVID-19; environment; pandemic; resilience; social science; societal change; transition; window of opportunity

1. Introduction

Since its sudden outbreak in late 2019, the COVID-19 pandemic and the measures taken to mitigate it have created disruptions to almost all aspects of individual and societal life (hereinafter referred to as COVID-19 crisis). In many instances, these disruptions have had an impact on the natural environment. This includes, among others, positive environmental changes such as a temporarily reduced emissions and improved air quality during lockdowns [1–3], reduced water footprint for electricity generation [4], and environmental noise reduction [5], but also negative impacts such as increased waste generation [6,7].

Despite their significance, the observed environmental effects are mostly short-term and may rebound over time as lockdowns are relaxed. In fact, recent data suggest the global CO_2 emissions have already started to bounce back [8]. Global December 2020 emissions were already 2% higher than they had been in the same month in 2019. The eventual impact of the COVID-19 pandemic on the use and conservation of environmental resources (hereinafter briefly referred to as environmental sustainability) remains uncertain. Hence, during the last months, there has been an increasingly vocal debate on potential long-term changes in environmental sustainability spurred by the COVID-19 pandemic. Similarities, parallels, but also dichotomies between the COVID-19 crisis, and respective political responses on the one hand and climate and sustainability crises on the other hand have been widely discussed in public opinion but also scientific discourse [9,10]. These narratives illuminate particular connections or raise specific questions concerning the possible nexus between the COVID-19 pandemic and the societal transition towards environmental sustainability. In this context, three questions are being posed in particular: (1) How does the pandemic affect the progress of transitions towards environmental sustainability? (2) What are the structural similarities between the COVID-19 crisis and environmental crises (e.g., the climate crisis)? (3) How do transitions towards environmental sustainability affect the ability to cope with potential future pandemics? In this article, we aim to identify and scrutinize selected popular hypotheses, which have been discussed in public and scientific debates with respect to these questions.

For instance, regarding the first question, it is argued that crises like the COVID-19 pandemic create a window of opportunity that may be used to enable transitions towards environmental sustainability. Aspects here range from the change of individual behavior up to massive public investment to overcome the COVID-19-induced recession, which can and should be channeled towards sustainability targets. In this regard, multiple scholars (e.g., [11,12]) point out that sustainability should be at the heart of the economic response to the current crisis, aiming to advance the climate agenda while we rebuild our economies.

Regarding the second question, it is often stated that the COVID-19 outbreak may provide an illustrative analogy for environmental sustainability challenges. It is often exemplified, for example, how the coronavirus crisis and the climate crisis, although occurring on different temporal scales, represent similar problem characteristics and response dynamics. Moreover, it is also argued that the societal strategies implemented to mitigate the COVID-19 pandemic may serve as a blueprint for mitigating environmental crises.

Finally, a popular hypothesis related to the third question is that the case for transitions towards environmental sustainability may be strengthened now because they may produce co-benefits in terms of preventing and managing future pandemics. Indeed, efforts to ensure the strengthening and enforcement of environmental regulations and green stimulus packages are seen as crucial for dealing with this and future pandemics [13,14]. Furthermore, it is discussed that the socio-techno-ecological resilience needed to cope with environmental crises may also help to cope with future pandemics [15].

Overall, these hypotheses express selective strands of arguing in a complex field, which results in limited analytical and predictive power. Furthermore, they may involve important ambiguities and uncertainties, or even unknowns. This is because the hypotheses rely on strong assumptions on how societal decisions are taken in general, and in particular, how societies deal with exogenous shocks as produced by COVID-19. Investigating these hypotheses thus requires a proper understanding of the inertia and dynamics of individual, societal, and organizational behavior and decision-making. These are a complex function of formal and informal institutions (e.g., norms, regulations and laws) as well as the techno-physical conditions (e.g., availability of technologies and resources). Testing the hypotheses therefore necessarily requires a social science perspective. Social sciences encompass a multiplicity of approaches to explore and assess the pandemic's societal drivers, costs, and impacts, as well as options to respond in an effective and legitimate way and enhance societal resistance.

However, what do the social sciences really tell us so far regarding these hypotheses? To answer this question, this article particularly examines the social science basis of popular hypotheses regarding the nexus between the COVID-19 pandemic and the societal transition towards environmental sustainability. We shed light on selected hypotheses for each of the three nexus questions pointed out above. Our results are derived through an expert dialogue among social scientists. By presenting the insights gained during this dialogue, we aim to highlight whether and under which conditions these hypotheses may hold true or not, and which ambiguities and uncertainties can be expected. Importantly, this article is not meant to provide a systematic literature review. Instead, we aim to provide a first perspective that maps key scientific debates on the nexus between the COVID-19 pandemic and the societal transition towards environmental sustainability. In this respect, we particularly stress the role social sciences need to play in understanding this nexus. Thereby, this perspective is meant to trigger future academic debate and research efforts.

2. Materials and Methods

To derive and review hypotheses regarding the nexus between the COVID-19 pandemic and the societal transition towards environmental sustainability from a social science perspective, an expert dialogue was organized and evaluated. Expert dialogues are a common tool to elicit expert knowledge regarding sustainability challenges in inter- as well as transdisciplinary contexts [16–20]. They may help to structure the sustainability problem and to identify suitable solutions as well as open research questions. They are particularly useful to explore emerging sustainability issues that have not yet been extensively studied and that therefore still involve important unknowns, uncertainties, and ambiguities. The COVID-19 pandemic and its impacts on and interactions with transitions towards environmental sustainability are excellent examples of such newly emerging sustainability issues.

The expert dialogue involved 11 scientists who eventually also authored this article. The group was deliberately composed of scientists representing different fields of social sciences to cover all relevant aspects of sustainability research in the field. They covered behavioral sciences, economics, environmental sciences, geography, political sciences, and sociology. All experts are experienced in interdisciplinary sustainability research. Their research expertise encompasses the various facets of analyzing complex socio-techno-environmental systems, including environmental impact assessment, behavioral analyses as well as governance analyses.

As a first step, the expert dialogue was used to inductively identify and cluster hypotheses regarding the nexus between the COVID-19 pandemic and transitions towards environmental sustainability. For this purpose, several moderated group discussions were organized, using established brainstorming techniques [21]. The first collection of hypotheses was subsequently reduced and condensed following several criteria: Hypotheses needed to (1) have a clear relation to transitions towards environmental sustainability, (2) be frequently discussed in public debates during the COVID-19 pandemic, and therefore have high relevance for public decision-making, and (3) be not obviously flawed or post-factual from the point of view of the experts. The public relevance of hypotheses was verified by an analysis of public discourses in traditional as well as social media during the COVID-19 pandemic. Finally, the hypotheses were grouped in three main categories, according to the main overarching questions they were related to (see Figure 1). For each step, a consensus was reached among the experts.

In a second step, the selected hypotheses were reviewed by the experts. For this purpose, additional moderated group discussions were organized to collect arguments supporting and challenging each hypothesis. The interdisciplinary composition of the expert group provided that arguments from various social science perspectives could be included and discussed. This process was supported by a traditional literature review [22]. We particularly searched for studies that tested the hypotheses or that discussed existing ambiguities and uncertainties. Studies considered included theoretical and more generic analyses from the social sciences as well as empirical analyses of previous global crises, like the 2007/8 global financial crisis. Moreover, we also screened scientific publications presenting the first empirical evidence regarding the hypotheses for the COVID-19 crisis.

To ensure that the outcomes of this review were robust, studies that represented different social science perspectives as well as various contexts were considered.

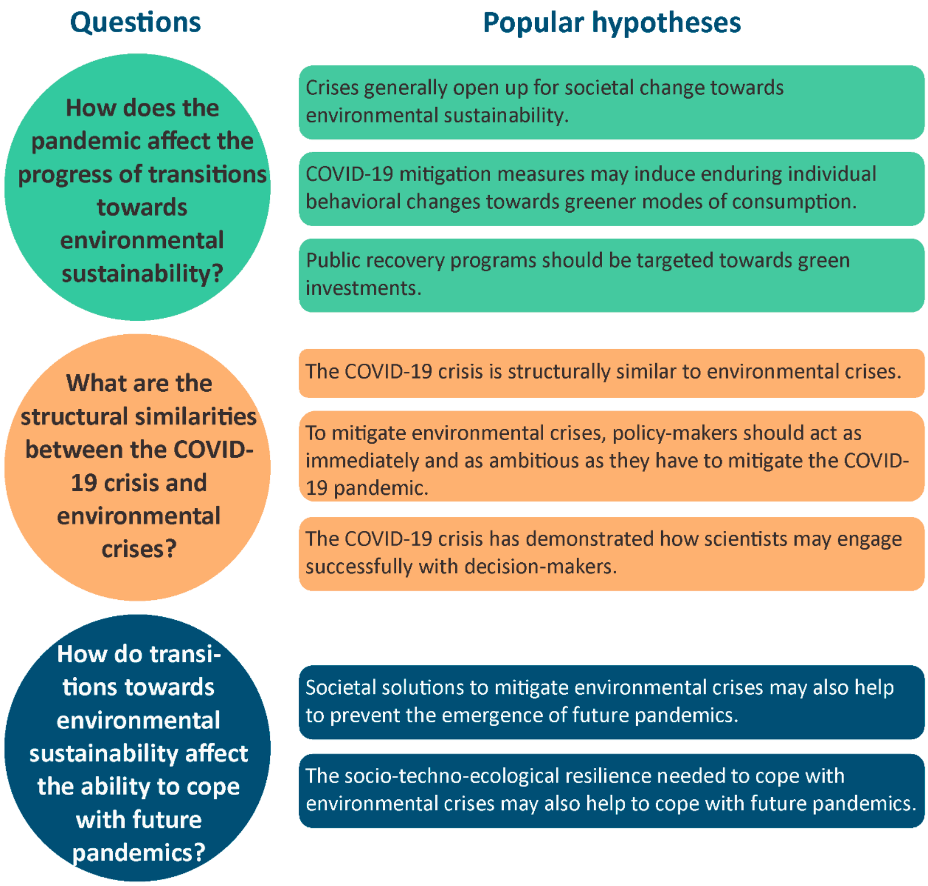

Figure 1. Questions and popular hypotheses regarding the nexus between the COVID-19 pandemic and the transitions towards environmental sustainability that are scrutinized in this study.

The insights from the expert dialogue are presented in the following. For each hypothesis, we first explain how it has been put forward in public debates so far. Subsequently, we relate each hypothesis to relevant debates in the social sciences. This presentation highlights the main insights gained during the structured knowledge elicitation process. The analytical arguments are supported and illustrated by references to theoretical insights as well as empirical observations made for previous crises. In addition, we underpin these arguments by the first empirical observations made during the COVID-19 crisis, where possible. Importantly, references to previous research are included selectively to illustrate the arguments. They do not claim to provide a structured literature review.

3. Results

Figure 1 summarizes the popular hypotheses that have been identified as particularly relevant during the expert dialogue and that will be scrutinized in the following.

3.1. How Does the Pandemic Affect the Progress of Transitions Towards Environmental Sustainability?

In this section, we examine three hypotheses frequently made: That crises generally open up for societal change towards environmental sustainability (Section 3.1.1), and, particularly, desirable changes in individual behavior (Section 3.1.2) and public policy and investment (Section 3.1.3). When discussing these hypotheses, we particularly look at the impacts of the economic crisis resulting from public measures taken to mitigate the COVID-19 pandemic. However, particularly when analyzing individual changes, we also highlight impacts of the pandemic crisis more generally, e.g., the effect of lockdowns on individual behavior, well-being, and environmental awareness. Table 1 summarizes the main observations pointed out in these sections.

Table 1. Popular hypotheses put forward regarding the question of how the pandemic may affect the progress of transitions towards environmental sustainability, and the respective indication provided by social sciences.

Hypothesis	Social Science Indication
"Crises generally open up for societal change towards environmental sustainability."	Crises are generally beneficial for initiating change processes because lock-ins may be weakened. Strength and direction of change, however, depend on political will, leadership and resources. For the COVID-19 crisis, empirical results are mixed so far and may only be judged ex-post.
"COVID-19 mitigation measures may induce enduring individual behavioral changes towards greener modes of consumption."	The COVID-19 crisis has questioned behavioral routines, e.g., in work practices and mobility. Corresponding changes can be observed and have brought about positive as well as negative environmental impacts. It is at present unclear whether these are temporary or longer lasting. From theory it has been argued that awareness for environmental protection and risk aversion may have been increased.
"Public recovery programs should be targeted towards green investments."	Mitigation of the COVID-19 crisis has stimulated massive public investment, containing a huge chance to support the transition towards sustainability. However, green stimuli have to be targeted appropriately and be accompanied by measures to phase out unsustainable practices such as fossil-fuel usage. Empirical evidence is mixed so far.

3.1.1. Crises Generally Open Up for Societal Change Towards Environmental Sustainability

An emerging societal debate suggests that the COVID-19 pandemic and particularly the economic crisis resulting from public measures taken to mitigate the pandemic can open up societal change towards environmental sustainability [10,23,24]. Indeed, (economic) crises often provide an opportunity for accelerating new, bold ideas about sustainability transformations [25]. They can act as a cataclysmic event that disrupts existing institutions and forces recognition of deeper cultural and structural roots [26]. A salient example is the case of the 2008/09 global financial crisis. To address the shortcomings highlighted by that economic crisis, regulatory, technological, and cultural changes were fostered [10]. For instance, China and many European states invested heavily in a stimulus packages that were at least partly targeting green technologies [26]. This has also been observed for the COVID-19 pandemic. Indeed, as part of the COVID-19 recovery program, 30% of the EU budget will be spent to address climate change in Europe (see Section 3.1.3 for more details).

Nevertheless, while windows of opportunity for change can occur, they are by no means guaranteed by crises [27]—rather they depend on a constellation of leadership, financing, and capacity. Previous experience suggests that whether or not crises are used for initiating or accelerating sustainability transformations depends on factors such as the severity and type of crisis, the public and media framing [28], socio-economic capacities, and interests to "rebuild better" [26,29]. For example, it may be argued that the EU stimulus package to respond to the COVID-19 crisis has been particularly green because it had already embarked on a green new deal track before the COVID-19 crisis. Thus, opportunities are often conditional and include a contingency to factors that have to be fulfilled to make them happen in the desired way. Even worse, historical evidence provides various indications of negative relations between crises and attention to environmental problems [26,30]. Crises can foster the conservation of previous states and, thus, potentially unsustainable forms of living. Economic crises in particular may hinder or delay sustainability transitions as unemployment and economic problems often dominate immediate political concerns and debate [31]. Preliminary evidence shows that, despite short-term reductions in CO_2

emissions, the COVID-19 pandemic has undermined progress in 12 of the 17 sustainable development goals (SDGs) [32,33]. Moreover, it may reduce the support for environmental policies [34] and, as recent empirical studies suggest, has put environmental sustainability in a backseat [35].

The overall picture of how the COVID-19 crisis will affect the progress of transitions towards environmental sustainability is thus quite ambiguous. Consequently, it may be worthwhile to look more thoroughly at two specific mechanisms: How the COVID-19 crisis affects individual behavioral change and political change.

3.1.2. COVID-19 Mitigation Measures May Induce Enduring Individual Behavioral Changes Towards Greener Modes of Consumption

It is often heard in news clippings, policy circles, and activist prose that the experiences during COVID-19 lockdowns—such as distance working or less travelling—may lead to behavioral changes that may last beyond the pandemic [36,37]. Public restrictions on mobility imposed on individuals during lockdowns have led to at least temporary changes in mobility and work practices [38,39]. However, behavioral changes enforced during the COVID-19 pandemic may also lead to routines being questioned, and hence to long-term behavioral changes.

The roll-out of new information technologies, such as video conferencing software, the adaptation of management practices, such as the eligibility of remote working, and positive experiences made with these socio-technical changes may have lasting effects on mobility and working practices. Consequently, remote working and online conferences substituting business travels may become more common in the future [10,40]. More fundamentally, the lockdowns may have raised the awareness of the value of a healthy environment. On the one hand, where possible, people used the lockdowns for increased outdoor activities (see e.g., [41]). On the other hand, those people being strictly confined to their homes may have experienced the absence of nature. In addition, many have experienced much cleaner air in urban agglomerations for the first time due to reduced traffic. In general, the experience of negative shocks as produced by COVID-19 may make people more risk-averse [42]. Such experiences may lead to a change in preferences and behavior towards modes of living that are more environmentally sustainable [43].

This notwithstanding, it is ex-ante unclear how enduring behavioral changes towards more environmental sustainability are, given that human behavior typically adapts only gradually and over time [42,44]. Moreover, COVID-19 may also spur behavioral modes that impair environmental sustainability. Most obviously, COVID-19 has fostered the usage of individual cars. It has magnified the role of cars as a safe place or even cocoon [45], which may now additionally help protect individuals from viruses and infections. Commuters especially are ditching public transport for their cars and by so doing indicating that they would rather spend time in traffic jams than set their bodies to contagious environments in shared transit systems [39].

Consequently, while the experiences made during the COVID-19 pandemic may induce environmentally friendly behavior in some sectors, the reverse may be true in others. Environmentally harmful behavioral responses can only be curtailed if individual decisions are guided by proper environmental regulation and norms.

3.1.3. Public Recovery Programs Should Be Targeted Towards Green Investments

As broadly demanded and expected, governments across the globe have issued massive stimuli programs to help their economies recover from the economic crisis produced by the COVID-19 pandemic and the related mitigation measures (for an overview, see, e.g., [46]). Leaders worldwide—like Fatih Birol, Head of the International Energy Agency, or the European Commission's Executive Vice-President, Frans Timmermans—called for public recovery programs early on that simultaneously help to recover from the COVID-19 economic crisis and to address environmental crises [47,48].

The COVID-19 crisis has certainly created an opportunity for political change towards environmental sustainability. The enormous number of fiscal stimuli programs issued by governments across the globe would not have been politically feasible without the COVID-19 pandemic. These programs can be used to support the transition towards environmental sustainability. Targeting fiscal stimuli to green investments is sensible for at least three reasons. First and on a generic level, by massive public spending, decision-makers actively strive to influence the (sustainable or not-sustainable) development of the societal-economic systems. Thereby, they assume responsibility for the resulting outcomes of this action and, hence, carry the obligation to help achieving the SDGs that have been agreed upon [49]. Second, trade-offs with other legitimate policy objectives, like mitigating climate change, must be avoided, where possible. If recovery programs led to new investments into long-lived, fossil-fueled assets and infrastructure, the existing path dependencies ("carbon lock-in") would be perpetuated [50]. This would make the necessary future transition towards environmental sustainability more difficult and costlier. Third, recovery programs should target those measures that promise the highest return in terms of successful recovery because government funds are limited. Evidence from the 2008/09 global financial crisis suggests that green stimulus policies often have advantages over traditional fiscal stimulus, e.g., due to higher job multipliers [51,52].

However, green stimuli programs also run the risk of being captured by interest groups. The expectation of huge amounts of public money being distributed at short notice brings interest groups of every shade to the scene—preferably with old wish lists on hand [53]. Thus, it needs to be safeguarded that green stimulus programs are actually effective and efficient in supporting the transition to environmental sustainability. As with any public investment program, green stimuli need to meet certain requirements. First, green recovery programs must not only be about green subsidies. Carbon pricing and removing environmentally harmful subsidies are equally important to steer investments towards sustainable choices [11]. Otherwise, green subsidies risk being ineffective and costly approaches to mitigating environmental crises—as, for example, the experience with the 2008/09 financial crisis has shown [32]. Second, if implemented, green subsidies need to meet certain criteria to spend limited public budgets reasonably [53]. Green subsidies must help stabilize the economy in the short run [30]. Moreover, they should focus on policy interventions that would also have been economically reasonable without the COVID-19 crisis—for example, to correct market failures related to the development of environmental technologies [52,54]. In addition, green subsidies should focus on measures that have the highest priority for environmental sustainability, for which rational concepts have been drafted already, and that can be realized promptly. Third, green stimuli programs should also contribute at least partly to funding the necessary government expenditures. Environmental taxation reforms—including the roll-out of carbon pricing and the dismantling of environmentally harmful subsidies—may play an important role here [52].

So, while targeting public recovery programs to green investments is sensible, this must not be misinterpreted as a rationale for subsidizing any allegedly green investment. Particularly in the light of limited public funds, green stimuli should be targeted themselves and be accompanied by measures to phase out fossil-fuel investments.

3.2. What Are the Structural Similarities between the COVID-19 Crisis and Environmental Crises?

In this section, we will shed light on three hypotheses. First, we revisit the hypothesis that the COVID-19 crisis is structurally similar to environmental crises (Section 3.2.1). Based on this discussion, we discuss whether and which lessons can be learned from the COVID-19 crisis for designing policy strategies to address environmental crises (Section 3.2.2), and for scientists to successfully engage with policy makers (Section 3.2.3). When referring to environmental crises, we will particularly use the example of the climate crisis throughout this section. This is because most of the public and academic debates on possible lessons learnt from the COVID-19 crisis refer to the climate crisis. Table 2 summarizes the main insights from these sections.

Table 2. Popular hypotheses put forward regarding the question of whether there are structural similarities between the COVID-19 crisis and environmental crises, and the respective indication provided by social sciences.

Hypothesis	Social Science Indication
"The COVID-19 crisis is structurally similar to environmental crises."	Both crises are non-linear global challenges featuring time lags, irreversibility, wide-spread and unevenly distributed social consequences and the prevention paradox. However, the COVID-19 crisis is less fundamental concerning time scale, level of fundamental change required and features more incentives for individual risk-prevention.
"To mitigate environmental crises, policy-makers should act as immediately and as ambitious as they have to mitigate the COVID-19 pandemic."	Policy responses to the COVID-19 crisis throughout the world have been mixed in ambition, appropriateness and timeliness. While direct and immediate impacts of a crisis—such as COVID-19—seem to foster fast and extensive action, the appropriate policy response is sensitive to the details of the situation at hand and numerous societal determinants.
"The COVID-19 crisis has demonstrated how scientists may engage successfully with decision-makers."	While scientific advice into policy making clearly played an important role, the importance and reception of even epidemiologic advice has been mixed in various countries and in the course of time. It is argued that policy makers and society tend to prefer under-complex techno-scientific solutions, and that social sciences, arts and humanities have been underrepresented at times. Science–policy interactions have been discussed and reflected upon in public in an unprecedented depth, intensity and publicity.

3.2.1. The COVID-19 Crisis Is Structurally Similar to Environmental Crises

Discussions in traditional and social media have promoted the hypothesis that there prevail obvious parallels between the COVID-19 pandemic and the climate crisis, such as the urgent need for global action, clear scientific advice on how to mitigate the crises but often tepid government responses (e.g., [55]). Recent research points to further structural similarities. First, both COVID-19 and Climate Change imply non-linear global challenges, including high-momentum trends and time lags, as well as possibly irreversible change [56,57]. Second, both crises give rise to self-refuting prophecies: Dire warnings may induce preventive measures, yet if successful, these measures are being attacked as overblown. In both cases, "there is no glory in prevention" (e.g., [58]). Third, the social consequences and side-effects may be similar: The crises affect nations and social groups within countries differently, thereby exacerbating social and spatial inequality [57]. This also seems to hold for conflicts between generations. Consider the "Fridays for Future" movement or the diversity of risk potential and risk avoidance behavior across age groups in the pandemic. Finally, international solidarity may be weakened, as evidenced by competition for protective gear or early access to vaccines in the pandemic and slow (if any) progress in transforming climate policy from a zero-sum game to a win–win situation (e.g., [59]).

However, both crises are characterized by three essential differences. First, COVID-19 unfolds on a much shorter timescale than climate change, whereas the latter is likely to fundamentally change the conditions of human living for a very long span of time if not irreversibly. Second, the climate crisis and its mitigation affect almost all of the bases of human life—water, food, security, housing/shelter, safety from weather hazards, etc. In that sense, it is more fundamental compared to the COVID-19 crisis, which is restricted to fewer aspects of human life. Third, on the spatial scale, COVID-19 is not a pure "public bad". It exhibits a clear relation between preventive efforts and the probability of incurring a loss within a given area. In contrast, climate change (and other global sustainability challenges as well) inevitably concerns everyone (i.e., it is a pure public bad). As a result, the relation between individual risk-prevention and the probability of incurring a loss is stronger for COVID-19 than for climate change. For both crises, mitigation requires sufficient preventive efforts on the individual level; yet in the case of climate change, it is more uncertain whether this effort also reduces individual damages; hence, the individual incentive to contribute to crisis mitigation is reduced.

The climate challenge, therefore, seems bigger and more fundamental by comparison. In a way, tackling the COVID-19 pandemic in the short-term might help to deal with the climate challenge in the medium term: While addressing time-lags and non-linearities in the policy responses to the pandemic already appears to be difficult, it might at least foster some sensitivity for the stronger feedbacks stretching over longer time-horizons of the unfolding climate crisis.

3.2.2. To Mitigate Environmental Crises, Policy Makers Should Act as Immediately and as Ambitious as They Have to Mitigate the COVID-19 Pandemic

It has been argued that, with respect to environmental crises, especially the climate crisis, policy answers should be as immediate, ambitious, and vigorous as could be allegedly observed in the COVID-19 case [60]. However, this thesis only holds if, firstly, policy answers around the world to the current pandemic can be in fact classified as immediate, ambitious, and vigorous, and if so, secondly, the crisis and policy analogy really strictly suggests similar policy answers in the field of other environmental crises.

Obviously, international and national mitigation policies to fight climate change manifest a significant lack of ambition and a remarkable sensitivity to opportunity costs of (early) action. In contrast, public health policy, at least in some countries and in some phases of the pandemic crisis, seems to reveal a stunning political willingness to prioritize health benefits compared to possible (social and economic) opportunity costs and to act quickly and vigorously at least when it comes to shutdown and lockdown measures. Against this background, it is argued that the COVID-19 crisis reveals that a quick and vigorous policy response is possible and can be accepted by the public and that there are, in general, no societal stumbling blocks hindering adequate crisis policy. Hence, the current pandemic could be a "recovery for climate" [12,60].

However, firstly, it can be questioned whether policy responses to the pandemic have really been that ambitious across the world. The "Oxford COVID-19 Government Response Tracker" clearly shows that policy stringency is high for specific countries at specific times but not for all countries for all the time. Rather, it turns out to be a particular policy pattern that works under specific conditions but not in general. In fact, nearly every country in the world has failed to act early enough to stop pandemic dynamics in advance. In almost every case, policy answers, especially vigorous ones, presuppose a clear epidemiological loss of control and a concrete threat to the people.

Is that comparable to the climate crisis already? Rather, the impact of the pandemic "appears clear and immediate, while the impact of climate change is diffuse, variable and uncertain" [61] (p. 4). Possibly, the willingness to govern as well as the willingness to accept clear cut and strong measures could correspond to the extent individuals can feel personal risks of potentially fatal impacts [62]. If this is still not the case, political support for measures with high opportunity costs could fail to appear, as does the policy answer that is expected in the climate case [63]. Thus, secondly, the crisis analogy may not hold true this asserted way. We have neither that perception of lack of time (measured in weeks or days) characteristic of a pandemic, nor do we have at our disposal that certainty of knowledge of what exactly has to be done immediately to prevent any harm with respect to climate change.

Thirdly, the massive response demonstrated in the pandemic crisis using command-and-control instruments neglecting opportunity costs at least in the beginning of public perception of the pandemic hardly ever suits for climate policy and even raises serious questions of constitutionality. What might be, as an exception, acceptable for a temporary state of emergency—does it also suit as a general blueprint for other issues of "high importance"? It can even be doubted whether public health policy will ever again be able to decree another general lockdown due to the meanwhile altered situation.

Thus, it turns out that (especially high and unconditional) political ambition is sensitive to numerous societal determinants that may either not be given in every crisis situation or that should at least not be mimicked by all means. Possibly, the policy pattern observed during the COVID-19 crisis may be just the same as for the climate crisis (just reacting and waiting for the "smoking gun" instead of real "silent" prevention), but merely executed very fast so that the public gets the make-believe impression of "early action" [64]. Although climate policy clearly needs more ambition, the COVID-19 pandemic, for several reasons, suits as a reference to only a limited extent—and possibly rather an example of how not to deal with environmental crises.

3.2.3. The COVID-19 Crisis Has Demonstrated How Scientists May Engage Successfully with Decision-Makers

The COVID-19 crisis is sometimes referred to as a blueprint for how (social) scientists may successfully engage with political decision-makers. Gallo [65] claims: "The current COVID-19 pandemic is an example of where all of these fields have come into play. It was an explosive shock that forced each field to contribute their tools and perspectives. [...][S]ocial science is entering a golden age, marked by the confluence of explosive growth in new data and analytic methods, interdisciplinary approaches, and a recognition that these ingredients are necessary to solve the more challenging problems."

There is already a large spectrum of arguments both supporting and challenging aspects of this hypothesis: This may be owing to the fact that governmental responses in different country contexts have been variable (even within the same country at different points in time), and so has been the importance and reception of epidemiologic advice [66–69]. A frequent claim is that the hesitant reaction to the pandemic by policymakers resulted in deaths that could have been avoided with a timelier response, further conflicting with the hypothesis [70]—see also Section 3.2.2.

Due to the currently immense social media engagement regarding COVID-19 [71–73] it can be argued that science–policy interactions have been discussed and reflected upon in an unprecedented depth, intensity, and publicity, highlighting the challenges for digital science communication in a fast-paced digital environment. Disciplinary communities reacted quickly, setting up huge collaborative research efforts—not just in epidemiology and public health, but also in the behavioral sciences [74–76], policy sciences [77,78], and other fields. The pandemic has spurred a wealth of surveys, research projects, and discussions specifically about science–policy interfaces and science portals [67,79]. It is still an open question, though, whether science advice committees have become more pluralistic over time and whether pandemic advice has drawn upon social sciences, arts, and humanities in different national contexts.

Challenging the hypothesis, Hulme et al. [61] note that there is a risk of policy makers (and society generally) preferring under-complex techno-scientific solutions during this pandemic and other crises. In contrast, they plead to broaden this knowledge base through the involvement of social scientific expertise that can grasp the social nature of the crisis and pay attention to, e.g., unintended secondary effects or the politics of evidence. A fuller appreciation is needed of how framings such as "crisis" and "emergency" mobilize, legitimate, and yet also constrain certain forms of action [61]. Additionally, note the controversy of the Great Barrington declaration (Greenhalgh et al. [80] on this and related, highly contentious papers) as an example of anti-lockdown mobilization in the name of science, which were drawn upon by proponents of opening up economies—a phenomenon that is replicated around the world where political discussions about measures to control infection rates are taking place within and beyond disciplinary borders, often aligned with significant economic interests.

A comparative study of 16 countries' responses to COVID-19 indicates that there is no one-size-fits-all pattern of science-society interactions [81]. It illustrates widely varying approaches based on the same evidence on the pandemics. Emerging controversies on science and mistrust against experts in countries such as the US, UK, or Brazil are less about the credibility of science than they are proxies for disagreements about competing ways of life and competing understandings of how to balance collective responsibility and individual liberty [66]. The acceptance of public health policies depends on trust, not merely in 'the facts', but also in the institutions that produce and evaluate evidence and weigh trade-offs. A critical finding is that the nature of the social compact between a nation's government, its experts, and citizens is of fundamental significance. What accounts for such divergence and variance in public uptake of science are features of the nation's social compact—such as its forms of constitutionalism and political participation [66,81].

There is much to learn from COVID-19 for science advice, and also for the forms of evidence that decision makers favor in times of crisis: Pandemic politics highlight how assumptions guiding projections (e.g., through epidemiological models) inform policy choices and need to be made a legitimate object of political debate and choice [82].

Especially given the uncertainty over how long lockdowns are necessary to be upheld to curb the pandemic, the pendulum between those who argue for stricter vs. more lenient measures is swinging back and forth in different countries (like Germany), whereas in other settings (like Australia or New Zealand), Zero-COVID strategies have been more consistently advocated. Apart from the divide between more techno-scientific and reflexive approaches, there are other ways in which certain scientific voices are heard more than others. The gendered impact of COVID-19 will also impact science advice itself [83–85].

The global COVID-19 crisis is still ongoing, and will, according to surveys, likely become endemic and stay with us for a long time [86]. Hence, it is too early for a full evaluation of the hypothesis: Any discussion about the ability of scientists to successfully inform policy making with evidence is likely to be incomplete and preliminary. At this current time, it seems that there are efforts made by both scientists and decision-makers while still leaving plenty of room for improvement. It is also important to not neglect the role of the public [66]. Both pandemic and climate crisis management can only be successful if experts maintain trust in their reports and the scientific evidence of political interventions [87]. Trust in science plays a huge role in that [88]. There is a persistent but misguided view that resistance to expertise mostly stems from public ignorance [89]. Social science research shows that more important reasons for such resistance might be basic value conflicts, distributive concerns, and failures of trust in governing institutions such as regulatory authorities and technical advice bodies. The first comparative study including 23 countries indicates that controversies emerged about the authority of experts to decide how people should live their lives: What looks like an attack on science may simply be the pursuit of politics by other means. The emerging controversies on expertise mirror competing understandings of how to balance collective responsibility and individual liberty [66]. Scientific controversies thus became a proxy for political battles over whether and how to react to the pandemic [90]. The comparative study concludes that a less paternalistic, more inclusive dialogue between science and citizens is crucial for informed consent and democratic governance. Three moves are essential: Make science more attentive to citizens' real concerns, make citizens smarter about how science works in governance, and make spaces for deliberating different interpretations of science without polarizing conflicts [91].

3.3. How Do Transitions Towards Environmental Sustainability Affect the Ability to Cope with Potential Future Pandemics?

So far, we discussed implications of the COVID-19 crisis for dealing with environmental crises, most prominently the climate crisis, and potential similarities. Now we take the opposite perspective and investigate whether a successful transition towards environmental sustainability bears potential for the prevention and management of future pandemics. This hypothesis has been brought forth in different variations and rests upon different connections made between COVID-19 and environmental health. Here we will primarily discuss the ideas of co-benefits of environmental sustainability in terms of preventing future pandemics (Section 3.3.1), and the role of socio-techno-ecological resilience in coping with future pandemics (Section 3.3.2). Table 3 summarizes the main observations made in these sections.

Table 3. Popular hypotheses made regarding the question of how transitions towards environmental sustainability may affect the ability to cope with potential future pandemics, and the respective indication provided by social sciences.

Hypothesis	Social Science Indication
"Societal solutions to mitigate environmental crises may also help to prevent the emergence of future pandemics."	It is argued that preserving biodiversity and limiting human impacts on ecosystems may help to prevent emerging zoonoses such as COVID-19. However, it remains unclear how much power this argument linking the pandemic to environmental issues can gain. Hence, policy making for sustainability should consider co-benefits for disease prevention but their actual contribution as compared to other options of prevention remains uncertain.
"The socio-techno-ecological resilience needed to cope with environmental crises may also help to cope with future pandemics."	Both pandemics and environmental crises may produce shocks to the socio-techno-ecological systems our society relies upon. Hence, synergies in building resilience to cope with environmental and pandemic crises can be expected. However, a better understanding is needed regarding aspects and types of resilience needed and the appropriate governance framework.

3.3.1. Societal Solutions to Mitigate Environmental Crises May Also Help to Prevent the Emergence of Future Pandemics

Much political and public debate evolved around the origin of the SARS-CoV-2 virus [92]. As studies indicated that COVID-19 is a zoonotic disease [93,94], ongoing discussions on the relation of environmental crises and future pandemic prevention intensified. A central hypothesis is that preserving biodiversity and limiting human impacts on ecosystems will be key to avoid transmissions of zoonotic agents at wildlife-livestock-human interfaces [95,96].

Research on the cross-species transmission of pathogens (e.g., [97,98]) has shown how anthropogenic changes to the environment can increase the chance of newly emerging zoonoses. This is emphasized for COVID-19 by invoking comparisons to other zoonotic diseases like Ebola or the Zika virus [99,100] and even by framing it as "the disease of the Anthropocene" [101]. Like other zoonotic viruses, SARS-COV-2 is linked to increased human contact with animals that serve as reservoirs and vectors for pathogens [102]. The main reason for this increase is human impacts on the environment. Deforestation, degradation of natural habitats, intensive farming, wildlife markets, or environmental pollution limit retreats for animals, encourage a movement into semi-natural habitats, and intensify human–animal interactions [99,103,104]. Such overexploitation of the environment increases the risk of animal human contact and the emergence of zoonotic diseases [100,105]. From this perspective, environmental issues are at the core of the COVID-19 outbreak and measures to mitigate the ecological crises are seen as an important part of future pandemic prevention [106]. Such measures could include the monitoring of viral agents in animals, limitations of wildlife trade, decreasing hunting activities, or improved food production and processing governance [107,108].

Another line of argument connects COVID-19 and the ecological crises based on a broader relation of environmental health and human health. Besides the risk of zoonoses, it stresses "how human and animal health are interdependent and bound to the health of the ecosystems in which they exist" ([97], p. 234). This "one health" approach highlights how health issues of various species are strongly interlinked and how efforts to mitigate ecological crises can increase resilience to infectious diseases [109]. For COVID-19, this is not only pointed out for human beings but also for apes [110].

However, it remains unclear if a framing that links the pandemic strongly to environmental issues, which, therefore, become important to fight future outbreaks, is going to gain interpretational power. There are indications of other narratives taking hold that make the mitigation of the environmental crises a less promising strategy to avoid future pandemics. Such narratives that see the causes for COVID-19 not in the natural but the political sphere (e.g., [111,112]) or that emphasize socio-technical or medical-technical fixes [113,114] draw attention to other paths of prevention. This might sideline environmental crises mitigation measures as viable options or boil it down to surveillance of human-wildlife interaction [115]. It is also argued that the emergence and spread of SARS-COV-2 may not lead to a perception of the environment as an ally but as a threat or obstacle, both having negative impacts on biodiversity conservation and sustainability efforts [116]. Furthermore, unintended effects of environmental protection need to be considered. For instance, limiting hunting activities or shutting down wildlife markets can have negative impacts on local food supply. Therefore, it is important to take local and global inequalities into account [13,117].

So, while certainly, the prevention of pandemics (or more generally human health) should be considered as an important co-benefit when designing strategies to spur the transition towards environmental sustainability, it should also be clear that environmental sustainability alone will not suffice to prevent future pandemics. The outbreak of a pandemic is a complex function of human–wildlife interactions, internationally interwoven economies and mobility, and not least the coincidence of mutations. Consequently, the relative importance of environmental sustainability for preventing pandemics as compared to other drivers remains unclear.

3.3.2. The Socio-Techno-Ecological Resilience Needed to Cope with Environmental Crises May Also Help to Cope with Future Pandemics

A second link between a successful transition towards environmental sustainability and the management of potential future pandemics concerns the socio-techno-ecological resilience of societies. Resilience is commonly defined as the capacity of a complex system to absorb shocks while maintaining its basic functions (e.g., [118]). As both pandemics and environmental crises may produce shocks to the socio-techno-ecological systems our society relies upon, it is now frequently pointed out that societies should take advantage of possible synergies in building resilience to cope with either crisis [119–121]. In this respect, the concept of socio-techno-ecological resilience stresses the complex interplay between social, technological and ecological systems when it comes to understanding how societies can cope with exogenous shocks, as those produced by the COVID-19 pandemic (see [122] for an overview). This involves the ability to flexibly adapt and transform these systems and their relations.

From a theoretical point of view, many of the factors promoting resilience may generate synergies in terms of combating pandemics and environmental crises (for an overview of factors, see [118]). First, the modularity of critical infrastructures and supply chains may help to avoid local failures that lead to systemic collapse [123]. This may help to reduce the global economic impacts of local lockdowns to mitigate a pandemic and provide security of supply if international trade is interrupted. It may also be well in line with sustainability agendas promoting, for example, the use of more decentralized, renewable energy supply systems. Second, diversity in food and agricultural systems may facilitate adapting flexibly to shocks by switching to different sources [124]. The same may apply to multimodal transport systems [125]. Such flexibility may help in responding to interruptions of supply chains and systems produced both by pandemics as well as climate change and related extreme events. Third, a certain degree of redundancy in critical infrastructures—e.g., regarding the dimensioning of energy and water supply as well as health systems—may be a prerequisite to cope with shocks produced both by pandemics and environmental crises and extreme events. This also suggests that the often assumed trade-off between economic efficiency and redundancy is misleading when taking a long-term perspective. While in a short-term perspective, redundancy—being costly—may seem to be inefficient, economic efficiency just implies non-wastefulness of resources (such as the build-up of critical infrastructure in a cost-effective way). As far as redundancies increase crisis coping capacities, they may very well be also economically efficient (the optimal degree of redundancy will depend on the concerned individuals' risk preferences).

However, options to increase resilience need to be reviewed carefully as they typically not only bring about benefits, but also costs. For example, the modularity of supply chains must not be misinterpreted as a general call for rolling back globalization completely. Strictly autarkic economic systems would forego the benefits of international trade and might also impair poorer countries in catching up. Moreover, the environmental benefits of shorter supply chains may be unclear. Regarding CO_2 emissions from food production, for example, there is evidence that it is not so much decisive where goods are produced but rather what types of goods are produced and how [126]. Moreover, social polarization and injustices have not only been revealed but also aggravated at a global scale by the COVID-19 crisis [127,128]. Here, we see a parallel to the climate crisis: Impacts and opportunities created by the crisis as well as respective policy responses vary substantially across individuals and societal groups. Overall, it seems to be important to further substantiate how and which type of socio-techno-ecological resilience can actually produce benefits in terms of both environmental sustainability and coping with pandemics in a socially fair manner.

Moreover, more insight is needed to understand under which circumstances private actors will take measures to increase resilience and what type of government intervention might be helpful for that. For example, the interruption of international supply chains may incentivize corporations "to make their operations more resilient and more sustainable as they experiment out of necessity—for example, with shorter supply chains, higher-energy-efficiency manufacturing and processing, videoconferencing instead of business travel, and increased digitization of sales and marketing" [129]. Similarly, private consumers may show a desire to support local businesses, and thus more localized food supply chains [130]. However, those developments are also not necessarily more sustainable: The development of the US-American consumption pattern of eggs under lockdowns shows a higher consumer demand for unprocessed eggs but also signals that willingness-to-pay for animal welfare and environmental sustainability has fallen as consumers seek to meet basic needs during the pandemic [131]. Yet, it is unclear how in sum the different effects can be steered towards the socially optimal level of resilience.

In sum, it can be expected that the socio-techno-ecological resilience needed to cope with environmental crises may also create synergies in terms of coping with future pandemics. Yet, it still needs to be better understood what degrees and types of resilience will actually bring about these benefits in practice and to what extent this resilience will emerge autonomously, or rather require directed government support. It is also crucial to discuss which forms of resilience are desirable and for whom, and which not. Not least, we have to scrutinize whether we are discussing appropriate responses to resilience challenges, and in which relation resilience and transformation should have as guiding principles to respond to crises.

4. Conclusions

In this article, we explored the nexus between the challenges of the COVID-19 crisis and the transformation towards environmental sustainability. Our analysis builds on an interdisciplinary expert dialogue among social scientists. This dialogue helped to structure popular hypotheses regarding this nexus and to investigate them in terms of their presumptions, content and plausibility. The main contribution of our article consists in providing a social science perspective on these hypotheses. This perspective reveals how important insights from social sciences are when it comes to understanding the short- and long-term impacts of the COVID-19 crisis on the transition pathways to environmental sustainability. Analyzing the barriers and drivers of individual behavior, of firms' investments as well as of political and societal decisions is key. Based on what is already known, social scientists already provide valuable advice for designing public policies to sustainably prevent, mitigate, and recover from pandemics. Perhaps unsurprisingly, the social science reflections presented in this article suggest that easy answers to the questions and hypotheses raised in public debates cannot always be provided. Oftentimes, statements only hold conditionally, and ambiguities and uncertainties remain. This notwithstanding, some messages do stand out.

We first examined how the COVID-19 crisis may affect the progress of transitions towards environmental sustainability. It can be confirmed that this crisis (as probably any crisis) likely creates a potential window of opportunity for societal change. However, it is ex ante unclear under which conditions and to what extent this change will happen, and whether decision-making will guide resulting changes into a favorable direction, i.e., foster transformation towards sustainability. Furthermore, it is not clear or self-evident how long the window of opportunity for initiating such a change will be. To safeguard that societal change is enduring and actually supporting the transition towards environmental sustainability, a clear and well-targeted political framework guiding private investments and behavior is required. This is particularly important as the COVID-19 crisis may otherwise also create new barriers to sustainability transitions.

Second, we shed light on the argument that there may be structural similarities between the COVID-19 crisis and environmental crises. If existent, these similarities could allow us to derive lessons on how to better address environmental crises. In spite of some similarities, such as time lags, irreversibility, wide-spread and unevenly distributed social consequences, and the prevention paradox, we conclude that this expectation is ultimately unfounded. First of all, policy strategies implemented to address the COVID-19 pandemic have been far from being an example of globally unified, ambitious, and immediate action. Moreover, there are important structural differences such as time scale that make mitigating environmental crises more challenging than mitigating the COVID-19. Consequently, many strategies used to address the COVID-19 crisis (e.g., lockdowns) are hardly suitable for long-term transitions towards environmental sustainability. At best, COVID-19 policy strategies may tell us how not to address environmental crises. Contrariwise, for significant similarities like the prevention paradox, the COVID-19 crisis does not provide any resounding lever for coping with crisis challenges.

Third, we were interested in understanding how transitions towards environmental sustainability may affect the ability to cope with potential future pandemics. Our results suggest that the transition towards sustainability building both on reducing environmental degradation and building socio-techno-ecological resilience may create co-benefits. How big these synergies are (and whether trade-offs are also possible) and what type of governance framework they require to materialize still needs to be explored.

Certainly, our article has shed light on only a selected set of hypotheses that showed up in public debates and were identified as particularly relevant by the social scientists involved. Moreover, we have focused only on environmental sustainability, not sustainability in general. In fact, possible interactions between the COVID-19 crisis and sustainability transitions may go beyond the questions and hypotheses looked at in this article. A next step could be to discuss the nexus between COVID-19 and sustainability transitions more thoroughly, using, for example, the more comprehensive framework of the sustainable development goals [132,133]. Moreover, our article does not carry out a systematic review of the social science literature for each of the hypotheses under consideration. Follow-up reviews could therefore analyze the social science basis and evidence for individual hypotheses more in-depth, also keeping track of the quickly growing empirical analyses for the specific case of the COVID-19 crisis. In this respect, it could be worthwhile to broaden the view beyond the climate crisis (on which we focused as an exemplary environmental crisis throughout much of our article) and also look at the specific interactions of the COVID-19 crisis with other global environmental crises, like the degradation of biodiversity or pollution with chemicals and plastics. In addition, our perspective on the social science literature also reveals avenues for future research related to the management of pandemics and environmental crises.

First and most fundamentally, the interaction between political systems and individual behavior for coping with pandemics still needs to be better understood. This includes the drivers of political decisions, the design of political interventions as well as their effects on risk perception, trust, and acceptance. In this respect, it is particularly important to properly account for the peculiarities of pandemic-induced crises, as compared to other economic and environmental crises. Within the coming months and years, individual, social, and political changes (e.g., public narratives, recovery policies) possibly resulting from the COVID-19 crisis will need to be monitored and evaluated.

Second, the possible nexus between sustainability transitions and coping with pandemic risks needs to be analyzed more thoroughly. In particular, the potential co-benefits (but also trade-offs) from specific sustainability strategies must be identified more precisely. On the one hand, this refers to the question of what the COVID-19 crisis implies for sustainability transitions. Which measures serve to adequately address multiple risks (e.g., behavioral adaptation, new technologies, recovery programs), and which lessons can be drawn for other sustainability challenges? On the other hand, the effects of sustainability transitions on pandemic risks both as regards emergence (e.g., zoonoses) and progression of diseases (e.g., the role of environmental health as a function of air pollution) merit further investigation. Our article also reveals the urgent need of in-depth studies on how the crisis has changed the discourse of opportunities and possibly new conflicts on resilience, sustainability, and transformation of societies' future.

Third, answering the above questions necessarily requires improved and more interdisciplinary modelling approaches. It is promising to investigate how integrated epidemiologic-ecological-socio-economic scenarios can help understand complex interactions (political interventions and individual behavior, socio-economic impacts, and feedback loops into epidemiological and ecological dynamics) and thus improve the design of interventions. This article thus argues for an integrative modelling approach for understanding zoonoses disease dynamics, combining process, pattern, and participatory models.

Finally, future research should also address the transdisciplinary challenge. How can scientific results be effectively communicated to the public (science–policy interface) and specific stakeholders in order to successfully cope with multiple societal risks (pandemics, climate crisis, etc.).

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