10 New Insights in Climate Science 2020 - a Horizon Scan

SUPPLEMENTARY MATERIAL

## 

## Methodology: questionnaire

This is the full text in the questionnaire to researchers for inputs on which are the key insights to cover:

“*In the "10 New Insights in Climate Science" Report, Future Earth and the Earth League aim to highlight the latest climate-related research across disciplines for the 4th consecutive year to support policy decision-makers. To do so, we need the input from you, the research community.*

*Please share with us what you think are the 1-3 most important new discoveries or advancements in your overarching field of research since 1st July 2019 and the key articles and reports highlighting them.*

*This poll takes from 5-10 minutes to complete. If you are writing long answers, we suggest you write these in a document and copy into the poll, to make sure that answers are saved in case there are any problems with the form. The poll closes at the end of 8th May 2020.”*

Response boxes:

1. *“Please suggest one (1) Insight or key fact/advancement*
2. *Please add a reference (article, report, etc) for the above insight*
3. *You can add a second reference*
4. *You can add a third reference”*

These four questions were repeated three times so all respondents could suggest three topics.

From the responses to the survey, 20 potential insights for 2020 were identified, see table 1 below. Of these, 8 were chosen as they were, 8 were rejected, and 4 were merged to form another 2 insights.

*Table 1: The 20 insight subjects originally proposed when synthesizing survey responses and the decision (“fate”) for each.*

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| --- | --- |
| **Proposed insight** | **Fate** |
| Model skill is better than expected but uncertainties around higher climate sensitivity in latest Earth System Models | Insight 1 |
| Increasing methane emissions from abrupt permafrost thaw | Insight 2 |
| Carbon uptake by land sinks - hopes and limits | Insight 3 |
| Climate change will severely exacerbate water crisis | Insight 4 |
| Climate Change has a significant impact on mental health | Insight 5 |
| The COVID-19 pandemic requires a climate-friendly system restart | Insight 6 |
| New narratives, future imaginings, are needed for action on climate change | Insight 7 |
| COVID-19 is a Reminder of New Approaches for governing Systemic Risks | Insight 7 |
| ‘Decoupling’ may not be a viable strategy | Insight 8 |
| Cost and benefits of a transition to low-carbon economies | Insight 8 |
| Urban electrification has the potential to reduce urban GHG emissions and improve local air quality | Insight 9 |
| Climate litigation an essential tool to urge States to do more to prevent dangerous climate change | Insight 10 |
| Marine ecosystems are under pressure | Rejected |
| Antarctica - a shuttering giant? | Rejected |
| Economic instruments and ‘biosphere stewardship’ are leading to mitigation and adaptation action | Rejected |
| Climate change likely to increase novel cross-species viral transmission | Rejected |
| Advances in monitoring emissions from space support the verification of national inventories | Rejected |
| Adaptation measures in place have shown positive effects but there might be limits to adaptation | Rejected |
| Addressing climate change can benefit human health and well-being | Rejected |
| Higher emissions of short-lived greenhouse gases than previously estimated | Rejected |

## Additional material for new insights

The following sections provide further evidence or details about the insights presented in the main paper.

### 5. Climate change can profoundly affect our mental health

The main paper described that changing climatic conditions, especially cascading and compounding risks, are adversely affecting mental health but there is also evidence that climate-related hazards or concerns start impacting mental health from before birth. Examples described by Pacheco (2020) are attention deficit hyperactivity disorder (ADHD), autism spectrum disorder (ASD) and other neurodevelopmental disorders; cognitive deficits; mood disorders; and schizophrenia later in life.

It was also noted that in 2016, mental and addictive disorders affected more than 1 billion people globally (Rehm & Shield, 2019) and that data for accurate statistics are still lacking, thus requiring more studies. To date, there are indications that the majority of cases can be observed in South Asia (Naveed et al., 2020).

Migration and displacement related to climate change have deleterious effects on psychosocial health including the mental effects of experiencing racism and discrimination in new host countries (Ziersch et al., 2020). Previous studies had attributed migration and displacement in this context primarily to thawing permafrost under the terminology of “climigration” based on population studies in Arctic Alaska (Hamilton et al., 2016). Recent studies found that rising sea levels and coastal erosion contribute to relocation, displacement and migration away from high-risk human settlements as well (McMichael et al., 2020; Palinkas & Wong, 2020). The impacts on mental health from this can be further amplified with studies on resettlement experiences indicating a significant number of refugees and asylum seekers are experiencing clear negative impacts on mental health. Thus, addressing discrimination is a key resettlement and health issue requiring urgent action.

It is important to highlight the pathological and non-pathological consequences of climate change so that they can be navigated. Non-pathological mental health consequences – which may include ecogrief, eco-anxiety, general climate distress – are considered normal reactions to a climate in crisis. Pathological mental health consequences of climate change are thoughts, behaviours and actions that affect our day-to-day living and/or are harmful to self and others, such as climate delusions and orthorexia (Clayton, 2020).

The manuscript section on mental health indicates proven suggestions to prevent and/or mitigate mental health issues, especially through access to blue and green spaces (Bratman et al., 2019). This section elaborates that the presence of green space during childhood has also been associated with better mental health later in life, even after taking into account differences in urbanization, socioeconomic factors, parental history of mental illness and parental age (Engemann et al., 2019). Hence, policies and measures to protect ecosystems can reduce risk factors for climate-related disasters and extreme events and reduce the burden of some mental health illnesses (Bratman et al., 2019). Further implications for decision-makers include the following:

* Vulnerability, capacity and adaptation assessments can further progress our understanding and lead to knowledge translations that can then also benefit appropriate policy development,
* Focusing on disproportionately affected groups is important to achieve social and environmental justice (Torres & Casey, 2017), and
* Culturally appropriate communication and outreach strategies, and assessing and strengthening mental health literacy are important measures to implement (Hayes, Berry & Ebi, 2019).

Research also shows that continued increases in air pollution impact mental health – particularly depression among youth exposed to higher levels of air pollution (Roberts et al., 2019; Khan et al., 2019). This indicates that tackling environmental issues can reduce both climate-related impacts and mental health issues.

### 8. Economic stimulus focused primarily on growth would jeopardize the Paris Agreement

The time to meet the Paris Agreement's goals is decreasing, the carbon budget shrinks, while there is at the same time an immediate need to stimulate the economy in the wake of the effects of the coronavirus pandemic. This may seem like a perfect time for policies advocating “green growth”. The proponents of the notion of green growth recognize the shortcomings of traditional growth and call for complementary measures of progress alongside gross domestic product (GDP). Three major international organizations – the OECD, the World Bank and UN Environment Programme – define green growth in similar ways, with slight variations. A key strategy for the greening of growth is the *decoupling* of growth from resource use and environmental impacts through technology, innovation and efficiency improvements while increasing production, employment and income.

In the short term, there is some scientific support for a combination of investments in low-carbon technology that can simultaneously reduce emissions within the remaining carbon budget while stimulating the current economy. Scientific evidence, however, establishes that there is a lack of support for a strategy relying on automatic decoupling of GDP growth and emissions as a safe method for achieving the goals of the Paris Agreement and long-term sustainability, including the SDGs. While technological advances increase resource efficiency and reduce emission intensities, they have historically been outpaced by increases in economic growth and consumption (Dyrstad et al., 2019). In general, high-income countries are also high-emission countries (Wiedmann et al., 2020).

A significant number of studies have been evaluating the evidence of decoupling of GDP from resource use and greenhouse gas emissions. A review (Haberl et al., 2020) of over 800 articles analysing the empirical evidence for absolute decoupling, i.e. decreasing the resource use and emissions at the required rate and scale while growing GDP, show that (1) in lower-income countries, there is a strong coupling between GDP, resource use (including energy) and GHG emissions with elasticities close to oneI. An elasticity = 1 indicates that GDP and emissions grow at the same rate; an elasticity between 0 and 1 indicates relative decoupling and elasticities < 0 indicate absolute decoupling.) (2) For higher-income countries, there is a clear tendency for relative decoupling with elasticities ranging from 0.22–0.81 measured from a consumption perspective. (3) In the case of GHG emissions measured from a production perspective in higher-income countries, there is on average a small negative average elasticity (−0.04) indicating a small average absolute decoupling. Other reviews (Vadén et al., 2020; Parrique et al., 2019) based on more than 200 articles covering 1990–2019 reach similar results, i.e. evident cases of absolute decoupling of CO2 from GDP but conclude that evidence of the needed absolute global fast-enough decoupling is missing.

There are, however, countries that have experienced absolute decoupling. Le Quéré et al. (2019) focused on analysing 18 developed economies in which CO2 emissions fell, both in terms of territorial and consumption-based boundaries, while GDP grew during 2005–2015. They found that almost half was due to a decline in fossil fuels in final energy use, and a little over one third was from reductions in energy use. The study shows that the reductions were a result of targeted policies but also profited from low GDP growth rates of 1–2% per year.

Hickel and Kallis (2020) and Parrique et al. (2019) examined not only historical empirical evidence of decoupling but also the theoretical potentials, analysing to what extent technological innovation and government policy might drive decoupling in the future, reviewing economic interlinkages and scenario analyses. IPCC mitigation scenarios are all based on green growth while being compatible with staying below 2°C by the end of the century (most with in-between overshoot). They (101 out of 116) however rely on bioenergy with carbon capture and storage, which is unproven at scale and depending on large-scale plantations of biomass, raising questions about land availability, biodiversity loss and competition with food and feed production. The International Renewable Energy Agency (IRENA, 2018) has modelled a scenario for continued GDP growth compatible with 2°C relying on a rapid shift to renewable energy. The scenario relies on energy intensities of the global economy to fall by two thirds, lowering energy demand in 2050 to slightly less than the level in 2015. Even this optimistic scenario accomplishes only 90% of the necessary reductions for 2°C.

Van Vuuren et al. (2018) consider alternative pathways that would rely less on the widespread use of negative emission technologies than in most model-based scenarios. In addition to inducing a set of cost-optimal responses in the model (such as increasing efficiency, moving towards renewable energy, carbon capture and storage and nuclear power), their scenario also includes several less conventional measures such as a low population scenario, a rapid decline in meat consumption, a move towards public transport as well as efficiency standards for cars, aeroplanes and production chains, and further changes. The different scenarios are able to comply with a 1.5°C target, with limited or even no net negative emissions. It should be noted that these routes will not be easy to implement. However, none of the above-mentioned scenarios include significant demand-side changes beyond meat consumption, which combined may reach the same level of magnitude as supply-side technological measures.

Current empirical evidence of small absolute decoupling rates will not reduce emissions fast enough to respect the carbon budgets for 1.5°C and 2°C (Hickel & Kallis, 2019). Calculations of the required decoupling rates needed to counter various growth rates show that GDP growth of 3% per year requires a decoupling of 10.5% per year for 1.5°C or 7.3% per year for 2°C. A growth rate of 0% requires decarbonization of 6.8% a year (for 1.5°C) and 4% per year (for 2°C) (Hickel & Kallis, 2019). A model by Schandl et al. (2016) indicates that technological decoupling can happen by at most 3% per year. The C-ROADS tool (developed by Climate Interactive and MIT Sloan) finds decoupling of at most 4% per year under the most aggressive possible policies.

Scientists’ reoccurring warnings to humanity (Steffen et al., 2015; Ripple et al., 2017) of climate emergency (Ripple et al., 2020) identify – according to Wiedmann et al. (2020) – population, economic growth and affluence as drivers of unsustainable trends. Their suggested solution, solidly based on scientific evidence, is to reduce overconsumption, not just greening of consumption. As this is not an easy task in a society dependent on growth, they call for research on how to best monitor progress towards human and planetary well-being, empowering people, strengthening equality and redistribution, how the transformation of economic systems can be supported with innovative business models and capacity building. The objective could, according to Hickel and Kallis (2019), be to find ways to decouple prosperity and development from growth rather than to continue to chase the phantom of green growth. According to Parrique et al. (2019) existing policy strategies aiming to increase efficiency have to be complemented by the pursuit of sufficiency.

The vast majority of studies of the link between GDP growth, resource use and environmental impacts do not question the GDP growth paradigm, even if the empirical evidence suggests that it contradicts officially committed climate policy goals (Haberl et al., 2020). By contrast, the logical interpretation of the empirical evidence is that there are no scientific grounds upon which we should not question growth if our goal is to avoid dangerous climate change and ecological breakdown (Hickel & Kallis, 2019). A plethora of alternative approaches to GDP growth are gaining ground in scientific literature, including steady-state economics (Daly, 2014), agrowth (van den Bergh, 2017) and degrowth. Degrowth can be defined as “an equitable downscaling of throughput, with a concomitant securing of wellbeing” (Kallis et al., 2018), where throughput is the energy and resource flows through an economy, strongly coupled to GDP. This aims to achieve a subsequent downscaled steady-state economic system that is socially just and in balance with ecological limits.

In stark contrast to climate scientists, one branch of climate economics fronted by William Nordhaus has been proposing that the world community should aim for a global warming of 3.5°C rather than 1.5°C or 2°C (Nordhaus, 2019). This conclusion was based on the use of integrated assessment models (IAMs), in particular, the Dynamic Integrated Climate-Economy (DICE) model where a key focus is about finding the optimal balance between economic benefits and environmental (and social) costs in line with the principles of welfare economics. Many of the most influential evaluations, including Nordhaus and Boyer (1999) and Stern (2007), equate GDP and welfare when evaluating welfare in terms of global GDP. However, human welfare is not well represented by GDP (Hoekstra, 2019) and numerous alternatives have been proposed (e.g. Stiglitz et al., 2009; Aitken, 2019) and practised (New Zealand Treasury, 2018).

The calculation of the future social cost of carbon in IAMs based on optimal trajectories has been criticized (Khabarov et al., 2020) and so has the choice of discounting functions and parameters, the omission of uncertainty and the risk for climate catastrophes and the treatment of non-market damages. When accepting the basic assumptions in IAMs, but updating some of the assumptions to the latest contributions in social and climate science, results are found to be in line with the UN climate targets, i.e. to limit global warming to well below 2°C and to actively pursue a 1.5°C limit (Hänsel et al., 2020).

One of the acknowledged shortcomings of IAMs has been the lack of including positive benefits from climate mitigation, and another one their weakness in modelling demand-side changes. The number of studies on co-benefits and behavioural change contributions to climate change mitigation have, however, increased significantly. A review found that climate policy co-benefits are large, often equalling or exceeding mitigation costs (Karlsson et al., 2019). One study focused on coal exit shows that phasing out coal would be economical in most regions, due to substantial local environmental and health benefits that outweigh the direct policy costs (Rauner et al., 2020). Other studies highlight the importance of demand-side change (Spangenberg & Polotzek, 2019), and the necessity to integrate them into modelling (van den Bergh et al., 2019).

In conclusion, recent scientific evidence confirms previous, but disputed, findings that any delay of climate mitigation in order to pursue economic growth jeopardizes the last chance of achieving the Paris Agreement while safeguarding people’s well-being and prosperous economic development. Green growth may be the result of a transition to a sustainable economy during a short, green investment phase but it requires meticulous design.

### 9. Electrification increasingly pivotal for just sustainability transitions and urban areas are at the forefront

Urban electrification has the potential to lead a just urban transition towards more sustainable energy sources, and less dependency on fossil fuels. Electrification has enormous potential. In the European Union, for example, electrification can halve the emissions from the industrial sector (to 0.5 GtCO2/year) with well-established technologies such as compression heat pumps, electric boilers and low-carbon heaters (Maddedu et al., 2020).

Urban electrification is particularly significant in the context of rapid urbanization, addressing the needs of rapidly expanding urban areas in West and East Africa, the Middle East, South Asia and South East Asia, as well as in highly urbanized and unequal regions like Latin America, particularly in its megacities.

Utilities and investors see changes in electricity supply and demand as new sources of investment and business, as can be seen from the global trends in investment in low-carbon electricity networks, which rose to its highest level in nearly a decade.

In regions with very low rates of access to electricity (sub-Saharan Africa and South Asia for example), electricity substitutes the use of charcoal and biomass in households in those areas, in whole or in part. This has direct benefits, reducing air pollution and improving health. However, the impacts of those substitutions are unknown.

Youth climate activists, community actors and transnational networks are engaging in a variety of actions. By and large, such actions are creating change, and have the potential to drive significantly more. However, many of these initiatives have remained on an experimental basis. Their larger-scale growth requires fundamental and dramatic changes in society, technology, governance, politics, markets and user practices.

However, these objectives can only be delivered hand in hand to a rethinking of current systems of electricity provision. For it to be sustainable, urban electrification should have low carbon intensity, that is energy production from renewable sources (e.g. Stewart et al., 2018).

Visions are fundamental to urban electrification as they define actors’ expectations about the future. Many actors hold dystopian visions of electric futures and there is considerable fear about breaking global dependence from fossil fuels. Divestment has emerged as a workable strategy to develop renewable alternatives for urban electrification. More research is needed to understand the structures of governance that will lead to urban electrification for all. We proposed a people-centred approach to think about electrification challenges, in line with the Global Tracking Framework.

Electrification can support reductions of emissions in transport, enhance thermal comfort systems for heating and cooling, and cooking. The introduction of the figure of Independent Power Producers or similar institutions has been a means to expand the use of renewables beyond the centralized grid. However, privatization also comes with unresolved questions of access and exclusion from energy resources.

Additional risks urban electrification may incur include privacy risks associated with the rise of smart energy systems, and the impact of extracting the raw material (such as lithium, for example) to build renewable equipment which may be located in developing countries, in traditional communities or indigenous lands, and may result in environmental conflict, contestation or other harm.

### 10. Rights-based litigation as an essential tool in climate action

On account of the considerable interest in and support from (inter-)national scholars for climate, efforts are being made to distil some general rules and principles. As an example, see the 2020 report “Model Statute for Proceedings Challenging Government Failure to Act on Climate Change” by the International Bar Association.

The roles of science and of judges in climate action have evolved. Courts in climate litigation cases use scientific evidence, to a significant extent from the IPCC, as a basis for determining the required conduct of governments. Given that the scale of emission reductions and temporal scope of the goal in Article 2 of the Paris Agreement are neither legally binding nor specifically defined, climate litigation cases are a window into an emerging science-adjudication nexus.

We slowly witness the development of a global language among judges and courts through a kind of cross-fertilization process of judges talking to each other across scales around the world. This demonstrates both what informs judicial decision-making (what judges use in their reasoning and how this new language emerges in their judgments), and how important the role of individual judges is.

The main paper referred to a recent example of the climate litigation and the rights and status of people who leave their country because it no longer sustains their life, with the case initiated by Ioane Teitiota, a citizen of Kiribati against New Zealand before the UN Human Rights Committee (United Nations Human Rights Committee, 2020). Teitiota argued that by deporting him back to his home country, which he felt had become uninhabitable due to the consequences of climate change such as sea level rise, New Zealand had violated his right to life. While the Committee did not agree with him, it did acknowledge that climate change might indeed constitute a breach of the right to life.

The Urgenda case (Supreme Court of the Netherlands, 2019) in the Netherlands is an example of public interest litigation against a government. The Urgenda case also may serve as an illustration of how the separate but interlinked issues of standing before (inter)national legal fora, representation of future generations, the rights of future generations and the right to a healthy environment are addressed in climate litigation. It raises the important question of how an NGO can claim to defend the interests of both present and future generations without being accountable to these citizens. At the same time, environmental NGOs, taking on the role of self-appointed watchdogs against national governments, *do* help in the enforcement of international and national law through climate litigation to ensure that governments keep to their environmental commitments. The Urgenda Foundation acted under Article 3:305A of the Dutch Civil Code, according to which any foundation – which is established according to its by-laws to protect a particular general interest – may bring to court any legal claim to protect that interest. This case, especially the appellate and supreme court judgments, is also a good example of the global trend of climate cases being primarily based on alleged human rights violations'.

Examples of climate litigation involving children and further innovations in who or what possesses rights in the eyes of the court:

* The case initiated by 16 children, including Greta Thunberg, involves the lack of effective action to combat climate change, which constitutes a violation of their child rights, in particular Articles 3, 6, 24 and 30 of the Convention on the Rights of the Child.
* On 3 September 2020, a group of Portuguese youth lodged an application at the European Court of Human Rights (ECtHR) against 33 States, holding them responsible for not doing enough to prevent dangerous climate change and/or mitigate the effects, qualifying it as a breach of Articles 2 (right to life) and 8 (family life) of the European Convention on Human Rights (ECHR), a breach affecting youth in particular (breach of Article 14). At the time of writing, the ECHR has yet to decide on the admissibility of the application, before it can decide on the merits.
* In the case *Urgenda Foundation v. State of the Netherlands*, already referred to above, Urgenda made basically the same argument (except for the youth discrimination part), and the Supreme Court of the Netherlands ruled in Urgenda’s favour on 20 December 2019.
* In the case *Friends of the Irish Environment v. Ireland*, the Supreme Court of Ireland ruled on 31 July 2020 that Ireland’s National Mitigation Plan was too vague about the measures Ireland intended to take to combat climate change, as required under Ireland’s own Climate Action and Low Carbon Development Act of 2015. Friends of the Irish Environment also alleged Ireland had breached the ECHR, but the Irish Court did not believe the Friends of the Irish Environment had standing to bring a claim based on that Convention.
* For examples of the difference of opinion on questions of standing between the lower and higher courts see the Urgenda case, and the Greenpeace case *People v. Arctic oil (*Bogarting Court of Appeal, 2020). The latter case is currently under appeal to the Supreme Court of Norway.
* For victimhood designation with regards to standing, see, for example, Article 34 of the ECHR.

Another example, this time from the Americas, where the rights of nature and youth action intersect in litigation:

* In a ground-breaking decision, the Colombian Supreme Court in *Demanda Generaciones Futuras v. Minambiente* officially recognized that, within national territorial limits, the Amazon River is a “subject of rights,” expanding an earlier ruling regarding the Atrato River. The *Demanda Generaciones Futuras* case was also notable in that it was brought by a group of children living in the area at issue, thus recognizing the ability of children to assert standing for the rights of nature under Colombian law.

Some additional points and examples regarding the role of international courts and tribunals (ICT):

* The challenges of resolving environmental disputes as demonstrated through ICT can be exemplified by the recent Judgment of the International Court of Justice (ICJ) in the *Certain Activities* *case* between *Nicaragua v. Costa Rica* (ICJ, 2018).
* The Vanuatu and other Pacific Island governments are examples of countries that have been exploring the option of seeking the ICT’s opinion upon legal questions concerning climate change.
* Fundamental for the success of potential claims relating to climate change, the ICT has increasingly engaged in and provided much-needed development and clarification of substantive and procedural obligations of international environmental law, especially their status under customary international law.

## Footnotes

I Ranging from 0.72 (for final energy measured from a production perspective) to 1.31 (for GHG also measured from a production perspective) meaning that an increase in GDP growth of 1% leads to an increase in final energy use of 0.72% and an increase in GHG emission of 1.31%.

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