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Systems-level risks of the climate crisis are currently missed: A mental health lens

Mikael A. Mikaelsson[1]*, **Neil R. Jennings**[2], **Emma L. Lawrance**[2,3]

1 Stockholm Environment Institute, Stockholm, Sweden, **2** Grantham Institute for Climate Change and the Environment, Imperial College London, London, United Kingdom, **3** Institute for Global Health Innovation, Imperial College London, London, United Kingdom

* Mikael.Mikaelsson@sei.org

Abstract

A lack of accounting for the systemic risks of the climate crisis in climate risk models, government policy and planning means that such risks remain poorly understood and largely overlooked, with detrimental consequences for action to mitigate them. Here we use climate risks to mental health as an illustrative example, drawing on existing evidence to highlight the interconnected nature of complex systems that propagate risks. We further stress the importance of research and policy to account for the ripple effects of the climate crisis for health and wellbeing, with implications for economies and societies over individual lifetimes.

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Introduction

The economic costs of any delays to a transition away from fossil fuels are mounting, with the price tag for economic costs of climate-related disasters more than doubling over the last 20 years to over $1trillion from the last 4 years alone [1]. A recent report highlighting the cost of inaction over climate risks noted the lack of accounting for 'indirect costs', such as the consequences to health, biodiversity and productivity [1]. These risks are significant and systemic: they cut across the life course, geographies, and generations, yet remain unaccounted for in climate risk models and cost–benefit analyses for policy and practice - and they are underestimated at our collective peril.

Systemic risks arise when climate hazards interact with the tightly interwoven fabric of social, ecological and economic systems. Rather than being contained within a single sector or moment in time, they ripple outward through feedback loops, amplifying vulnerabilities and producing cascading or compounding effects that cross borders, sectors, and even generations. Such risks demand a systemic response - one that recognises these interdependencies and entails coordination across policy areas, governance levels and disciplines, in order to break vicious cycles and instead foster reinforcing feedbacks that build resilience.

Here, we highlight how the systemic risks of the climate crisis and the way they interact, compound and spread in time and space must be considered to ensure

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an accurate accounting of the benefits of climate action and to ensure cross-sector and systemic responses to systemic risks. We use the mental health impacts of the climate crisis, mediated through impacts on food systems, as an illustrative example - not only to demonstrate one of the many underappreciated pathways of systemic risk, but also to highlight mental health as a critical and often overlooked dimension of systemic climate risk in its own right, with implications for how responses are designed and prioritised. This article does not present new empirical research; rather, it offers a new interpretation and synthesis of existing evidence to demonstrate how climate change is a dangerously unaccounted for systemic risk, that climate action therefore must be delivered with whole of government and whole of society responses – that can unlock systemic benefits – and throughout, how mental health provides a valuable lens for understanding systemic climate risks and opportunities.

The mental health costs of a changing climate are seriously neglected in policy and practice. Emerging evidence suggests that there are diverse and interacting pathways by which a changing climate worsens a range of mental health outcomes [2–4]. So far, researchers have linked direct exposure to extreme weather and other climate events, such as heatwaves, droughts, floods and storms, to higher rates of suicide, psychosis, post traumatic disorders, anxiety, depression, and substance misuse [5]. These are acute hits but remain poorly accounted for in climate adaptation planning and disaster preparedness and/or disaster risk reduction [6].

Beyond such immediate impacts, we know that these events lead to further cascading and compounding stressors on individuals and communities [7]. This may include exposure to food and water insecurity, livelihood loss, disruption to education, healthcare and cultural practices, higher rates of violence (including gender-based and child marriage), forced displacement and migration and infectious diseases [4]. All these exposures, which disproportionately affect already marginalized groups, can increase the risk of poor mental health outcomes [8].

People living with mental health conditions are particularly affected, as demonstrated in research showing a higher risk for these individuals of dying in heatwaves. This was exemplified in 2021 in British Columbia, when individuals diagnosed with schizophrenia were found to comprise 8% of those who died in the heat dome that occurred in the region, despite making up only 1% of the Canadian population [9].

The ways in which climate change undermines the determinants of good mental health and initiates cascading risk pathways for poor mental health outcomes is largely unaccounted for in climate adaptation policies [10–12]. Furthermore, these risks compound over the course of peoples' lives and even across generations. Epidemiological and epigenetic studies have shown that famine negatively affected the mental health of children born in the Netherlands in World War II [13–15]. We can conjecture – and there is already some evidence - that climate-induced famines in the future will have similar effects on increasing the risk of negative brain health, mental health and wellbeing outcomes for those affected [16,17].

Famine is not the only outcome of climate change that could impact early development and raise mental health risks: emerging evidence shows that exposure to air pollution – which is produced by burning fossil fuels, and the effects of which will

increase with climate change – and exposure to extreme temperature in utero and in early childhood can both raise the risk of neurodevelopmental, cognitive and mental health disorders across an individual's life course [18–23].

Against this backdrop, the following section will present, as a case in point, the intricate linkages between agricultural trade, intrauterine development and mental health in adulthood, to demonstrate how complex climate risks can propagate through risk pathways that transcend geographical borders, sectors and even generations. We then highlight the importance of cross-sectoral systems-level perspectives in assessing and responding to climate change, to create co-beneficial action pathways and protect human health, looking specifically at mental health solutions that can be enacted now to counteract climate impacts. Ultimately, we call for a systemic approach to account for the cascading impacts of climate change on public health, including mental and physical outcomes to deliver long-term societal resilience to multi-faceted climate impacts.

While a growing body of literature examines systemic risks in relation to finance, trade, infrastructure, and ecological tipping points, in practice these domains are still rarely modelled or managed in truly systemic terms, despite their recognition in rhetoric and strategy documents [24–27]. Systemic dimensions are recognized in global and public mental health research, but they receive far less attention than in other sectors, and mental health outcomes are rarely integrated into broader systemic risk analyses. This omission is significant: health is not only an outcome of systemic shocks but also a determinant of resilience, shaping societies' capacity to adapt and respond. This paper addresses that gap by demonstrating, through a mental health–based illustrative example, how climate-related risks propagate across sectors and generations, and why integrating health into systemic risk frameworks is essential for both research and policy.

How today's food crises can shape tomorrow's mental health

Complex and systemic risks stemming from climate change will impact ecosystems, economies and societies around the world. However, the scale and degree of the ultimate impacts will be determined by a multitude of climatic and non-climatic drivers acting in concert.

The compounding effects of this interplay will in many cases cascade across borders, sectors and even generations. As an example, the impacts of extreme weather on agriculture yields and food security can create spill-over effects that stretch across the world and far into the future, with significant implications for mental health. This dynamic is explored in the illustrative example below and depicted in Fig 1. Table 1 further highlights the spatial and temporal dimensions of these and related impact pathways arising from fossil fuel combustion, including some of the specific negative mental health outcomes that can result.

Global crop yield potentials have declined over the past decades due to a changing climate, and extreme weather events of severity and frequency made more likely by climate change are increasingly wreaking havoc on crops across the globe [41]. Widespread cases of extreme heat, droughts and water stress in Europe during the summer of 2022, for instance, caused substantial reduction in yields of main crops, including maize (–16%), soybean (–15%) and sunflowers (–12%) [42], that drove up food prices in supermarkets across Europe. At the same time, as many as 74% of farmers in the main agricultural states of the US experienced an average crop yield reduction of 38% [43,44]. Floods in Pakistan affected around 15% of the country's cropland and resulted in production losses of 61–88% for cotton, rice and sugarcane [45–47]. These losses have been linked to increased rates of very low weight babies by anemic and malnourished mothers [48,49].

Studies forecast that climate impacts on global agriculture production will only worsen in the coming years and decades. Many of the world's "breadbasket" regions, which account for large and disproportionate shares of staple crop (e.g., maize, rice and wheat) production globally, are located in climate vulnerable regions, and these breadbaskets are expected to see significant reductions in crop yields due to climate change [50]. This poses a serious threat to food security in countries around the world that are heavily dependent on agriculture imports. In fact, a recent study found that more than 44% of the EU's agriculture imports will become highly vulnerable to droughts in the next several decades, with key trading partners outside the EU expected to see a 35% rise in drought severity [51].

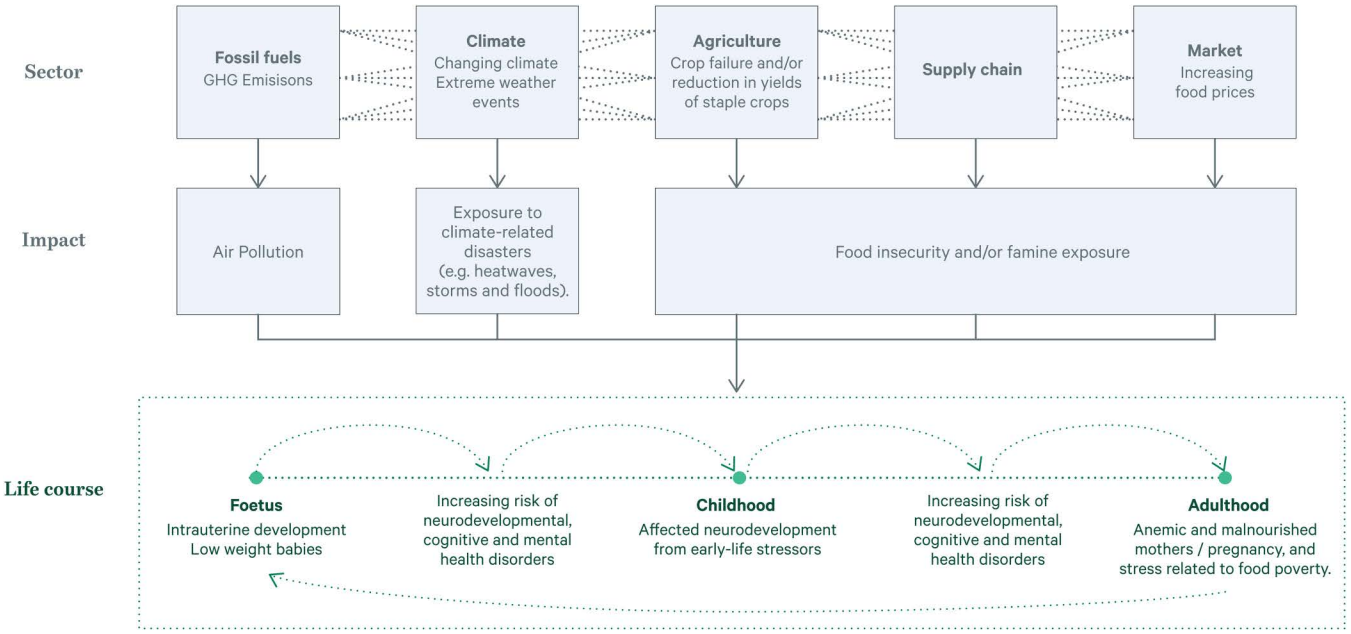

Fig 1. Illustrative pathway by which the effects of fossil fuel combustion and climate change on air pollution and agriculture affect mental health over the life course, with arrows indicating direction from cause to effect.

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Table 1. Examples of how the components of the pathway outlined in Fig 1 can lead to poorer mental health outcomes, and how those impacts are spatially and temporally distributed.

Component of pathway	Air pollution	Extreme weather or climate events	Crop failures, food insecurity and/or famine exposure
Impact on mental health	Air pollution increases rates of depression, anxiety, bipolar disorder, psychosis, schizophrenia, neurodevelopmental disorders such as ADHD, neurodegenerative disorders such as dementia, and increases suicide risk [28–31].	Exposure to extreme weather or climate events increases the risk of post-traumatic stress, anxiety, depression, substance misuse and suicide [32–35]. Exposure while in utero can increase risks for mental and behavioural challenges in the offspring years later [36,37].	Increased risk of poor mental health, for instance of depression, anxiety and suicide amongst farmers [38,39]. Reduced nutrition negatively affects brain development and can increase risk of mental disorders developing (e.g., schizophrenia) [40].
Spatial dimension of mental health impacts	**Local** Proximal to populations where fossil fuels are burnt and/or wildfires occur.	**Local** Proximal to populations affected by the extreme weather or climate events.	**Local to global** Proximal impacts on farming communities Regional to global impacts via the availability and affordability of food.
Temporal dimension of mental health impacts	**Days to years** Immediate and also cumulative impacts over the life course of people exposed to air pollution.	**Days to years** Immediate to long-term effects, e.g., higher levels of anxiety can persist years after the extreme weather event occurred, in utero exposure can have long term consequences.	**Days to decades** Immediate to long-term impacts on farming communities Immediate to long-term effects on people around the world via impacts on food insecurity and nutrition, e.g., through foetal development and effect on the life course of individuals affected.

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While these findings already paint a bleak picture, global food security may deteriorate far sooner in reality than these studies predict, as there is growing evidence that most climate impact models are significantly underestimating the impacts of climate change [52,53]. One recently published study showed that most climate impact models suffer from a serious blind spot, as they fail to sufficiently account for the growing risks from multiple simultaneous crop failures to

global food security [54]. As such, a catastrophic crop failure for a staple crop in two or three major breadbasket regions could result in a spike in global food prices that would not only have dire consequences for food security in vulnerable low-income countries, but could also leave lower-income households in more affluent parts of the world (e.g., the EU and US) struggling to foot the cost of their grocery bills.

Deteriorating food security will impact on people's physical health. Recent decades have also seen a growing body of evidence that indicates potentially serious consequences for mental health. Research has shown critical linkages between early life nutrition, brain development and mental disorders across the life course– these findings have not been applied to the context of climate-related risk. More than 30 years ago, a leading clinical epidemiologist, David Barker of Southampton University, coined the "fetal origin of adulthood disease" hypothesis, based on a series of epidemiological studies that observed a robust linkage between intrauterine growth restriction (as indexed by low birth weight) and a heightened risk for hypertension, coronary heart disease, obesity, and type 2 diabetes in adulthood [55,56]. The most prominent factor in affecting disease susceptibility later in life is maternal malnutrition.

Later, the lasting effects of this interplay between environmental factors and intrauterine development were found to also apply to brain development, cognitive functions and mental health [57–60]. A seminal study carried out in the mid-1990s investigated the lasting effects of the Dutch Winter Famine of World War II, where adults who were conceived at the height of the famine were found to be at twofold risk for schizophrenia [61]. These findings were later replicated in a Chinese cohort that experienced famine during the 1950s, which likewise showed an increased risk of schizophrenia among those exposed prenatally [62].

Following the influential work of the Dutch Winter Famine study, subsequent studies began to observe similar links for a range of different mental health disorders, in some cases depending on trimester exposure. As an example, a recent meta-analysis of famine studies showed that famine exposure during the first trimester elevated the risk for personality disorders by more than twofold, whereas exposure during the second and third trimester were at heightened risk for affective disorders (such as depression and bipolar disorder) [63]. Additionally, an increased risk of psychotic disorders was associated with prenatal famine exposure for all three trimesters. Complementary evidence from laboratory studies has shown heightened stress and cognitive deficits following prenatal malnutrition in animal models [64–66].

The converging lines of research on climate risks to agriculture production and supply chains, and the developmental origin of mental health challenges, as described above, demonstrate the risks to human health and well-being. Climate change is likely to cause severe stress for pregnant mothers, directly through exposure to climate hazards and indirectly (e.g., via food insecurity); such stresses have the potential to heighten risk for poor mental health outcomes of their children [36,37]. Evidence is also growing that early-life environmental stressors can instigate epigenetic changes with lasting effects across many generations [13,67,68].

Beyond these physiological pathways of climate change-related agricultural losses and food insecurity to mental health costs, rising food prices and struggling farms also have mental health consequences through other mechanisms. Rising food prices creates economic strains that can also harm mental health; food insecurity creates and exacerbates poor mental health, while in the UK, people living with mental health challenges are more than twice as likely to experience food insecurity [69]. Food insecure young people are more at risk of anxiety, self-harm and suicidal thoughts, with 31% of food insecure UK children feeling stressed every day – 3x the number for their food secure peers [69,70]. Farmers' mental health is also at risk from strains to food systems, with alarming suicide rates among farmers already in India, Australia and other particularly climate-vulnerable areas [71–73], though even in the UK the government is recognising the need to consider the mental health of farmers increasingly exposed to floods and droughts [74]. The strain on farming families may lead to other potentially traumatic consequences like raised rates of domestic violence and child marriage, and forced migration as farmers are forced to leave farms and homelands; creating further stressors on mental health [39,75,76]. Farmers facing severe distress or the risk of losing their livelihoods may be unable to continue farming, participate in climate adaptation efforts, or maintain their land; under mounting climate-related pressures,

many are forced to abandon farming altogether [77], which reduces food availability for their communities and fuels a vicious cycle [78].

In full, climate change related hazards, food systems and mental health are deeply interconnected in ways that can only be appreciated with a systems lens [78,79]. Yet climate-change related changes to food systems is just one set of pathways, and mental health consequences are just one set of impacts. The true set of compounding and interacting risk cascades is vast, and the implications of this are that the true cost of inaction and the economic and social damage caused by fossil fuels is likely vastly underestimated. Similarly, the benefits of actions to halt climate impacts are also likely to be underestimated. Yet cross-sectoral risk pathways such as these are often overlooked and thus unaccounted for by conventional climate risk and vulnerability assessments, which typically examine other associated economic and social costs: labour, infrastructure, and more tangible goods damaged [7,80].

A fast and fair transition away from fossil fuels, as well as investment in societal resilience, will provide cost savings that are far beyond what current models consider. At the same time, climate action can also provide significant co-benefits to boost human health above and beyond protection from the negative effects of climate change.

Building the evidence base to advance a policy approach for whole-systems resilience

Climate adaptation policies around the world have been incremental in nature, lacking a robust systemic response [7,81,82]. This is at least partly due to the institutional inertia and legacies of existing governance structures, and the sectoral siloes in which policy planning take place, as well as the broader institutional and administrative constraints of public authorities in the context of limited resources [83,84].

Other limitations, as noted above, stem from climate risk assessments, scenarios and impact models, which inadequately capture the complexity and systemic nature of climate change [85–87]: these miss spillover effects, feedback loops and the risk-multiplier effect for non-climatic threats – particularly unconsidered impacts of climate change, such as on mental health. This is no small thing; as highlighted by a recent report from actuarial scientists, which notes, “climate change drives a complex basket of interconnected risks that could threaten the basis of our society and economy”, and “failure to consider these interconnections will underestimate risk.” Therefore, “Policy- and decision-makers all around the world need to start radically rethinking their approaches to risk assessment and response” [88].

Recent technological advancements in artificial intelligence, machine learning strategies and supercomputing hold great promise for delivering step-change improvements in climate impact modelling, risk assessments and scenario analysis, not only by improving the accuracy and efficiency of climate models, scenarios and impact forecasts, but also by enabling assessments of more complex and cascading climate risks. These can be leveraged to gain a better understanding of the systemic risks from climate change to mental health and other sectors. We propose adding indices of mental health to these models. Investment in research to identify the appropriate pathways and outcomes to add to these models, and to enable the required data to be collected and indices to be developed globally is vital to better account for the impacts and target responses.

We need to broaden our understanding of the interplay between different climatic and non-climatic risk-drivers that, for instance in our illustrative example, mediate the impacts of climate change on mental health, as well as the availability and quality of the data that index these variables. Greater investments and more joined-up cross-disciplinary efforts in scientific research are therefore needed to expand our knowledge base on the many different direct and indirect risk pathways, through which climate change will converge to compromise our societal resilience and well-being.

Strategic foresight methodologies can play an important role. For instance, in examining the different ways climate change will impact mental health, these methodologies can knit quantitative data together with qualitative multidisciplinary expert viewpoints from mental healthcare researchers and practitioners, policymakers and other key stakeholders. This methodology is less tethered to the limitations of current empirical evidence and subjective biases in prioritizing specific climate change related impacts in climate models, and it is becoming increasingly used to explore systemic climate risks

and future scenarios by researchers and policy experts [89–91]. Such approaches may help to explore how many different climatic and non-climatic drivers can act in concert to shape a future of mental health in a rapidly warming world.

Addressing systemic climate risks through greater cross-sectoral policy response

The illustration above highlights just one of the many ways that climate change effects in one sector, in one part of the world and at one point in time, can have lasting ripple effects with consequences for people in another part of the world, years or even decades later, in an entirely different sector. A severe drought that causes a substantial yield decline for a staple crop in one or more breadbasket regions, e.g., rice production in Thailand or US maize production, could lead to an acute compromise in food security, both in quantity and quality, in places as diverse as Europe and Africa, with lasting mental health implications for people and even unborn generations in those regions. This cascading risk pathway transcends the agriculture, trade, food security, maternal and child health, and mental health sectors. The systemic interlinkages between different climate risks demand multiple complementary adaptation measures, acting in concert, across different sectors and policy domains. Importantly, adaptation policies should be valued and prioritised not only for their ability to reduce risks within a single sector or policy objective, but for the wider systems-level benefits they generate when viewed through a systemic lens. Too often, adaptation measures are appraised narrowly, with their cross-sectoral co-benefits overlooked in cost–benefit analyses and decision-making. Recognising and accounting for these broader benefits is essential to incentivise systemic responses.

Fig 2 illustrates some of the areas where policy interventions can help to reduce the mental health impacts of climate change – whether by reducing the risk of certain events occurring in the first place or in supporting affected communities when those events do occur. To illustrate how such systemic responses can work in practice, we highlight two examples that show the cross-sectoral benefits of adaptation policies when valued against their systems-level impacts.

One exemplar pathway lies in the sector of foreign policy, where investment in climate-resilient agriculture abroad through official development assistance can have multiple systemic benefits. Such measures not only strengthen food security and improve the physical and mental health of farming communities overseas, but also reduce volatility in international food prices, thereby alleviating the stress and anxiety experienced by households in donor countries when food costs rise [7,92,93]. These interventions can generate wider co-benefits for foreign policy and national security by reducing the social instability that can fuel forced migration or even recruitment into extremist groups [94–96]. Viewed through a systemic lens, climate adaptation investments abroad can generate co-benefits across food security, mental health, economic stability, and security, with positive implications for both donor and recipient countries.

Closer to home, adaptation policies that explicitly integrate farmer mental health support alongside investments in climate-resilient agricultural practices provide another compelling example of systemic response. Farmers are among the groups most directly exposed to climate hazards such as droughts, floods, and crop failures, and face disproportionate risks of depression, anxiety, and suicide when livelihoods are threatened [7,97,98]. By embedding mental health services within agricultural extension programs, governments can simultaneously strengthen psychological resilience of farming communities and reduce suicide rates and forced migration, improve adaptive capacity within the agricultural sector, and stabilise food production. This in turn benefits wider society: healthier and more resilient farming populations are better able to sustain agricultural output, maintain food security, and contribute to stable rural economies. Such measures demonstrate how a systemic response in one sector can create reinforcing feedbacks that extend across health, food systems, and economic resilience.

Governments increasingly recognize climate change as a systemic risk and have taken actions to mainstream climate risk considerations and adaptation needs across different sectors and policy portfolios [99–102]. In an important departure from past practices, whereby risk ownership and management for climate change was confined within a single ministry (usually ministries for the protection of the environment), more recent approaches have sought to distribute responsibility more widely [103–106]. However, these approaches have still failed to achieve a truly “systemic adaptation”; progress

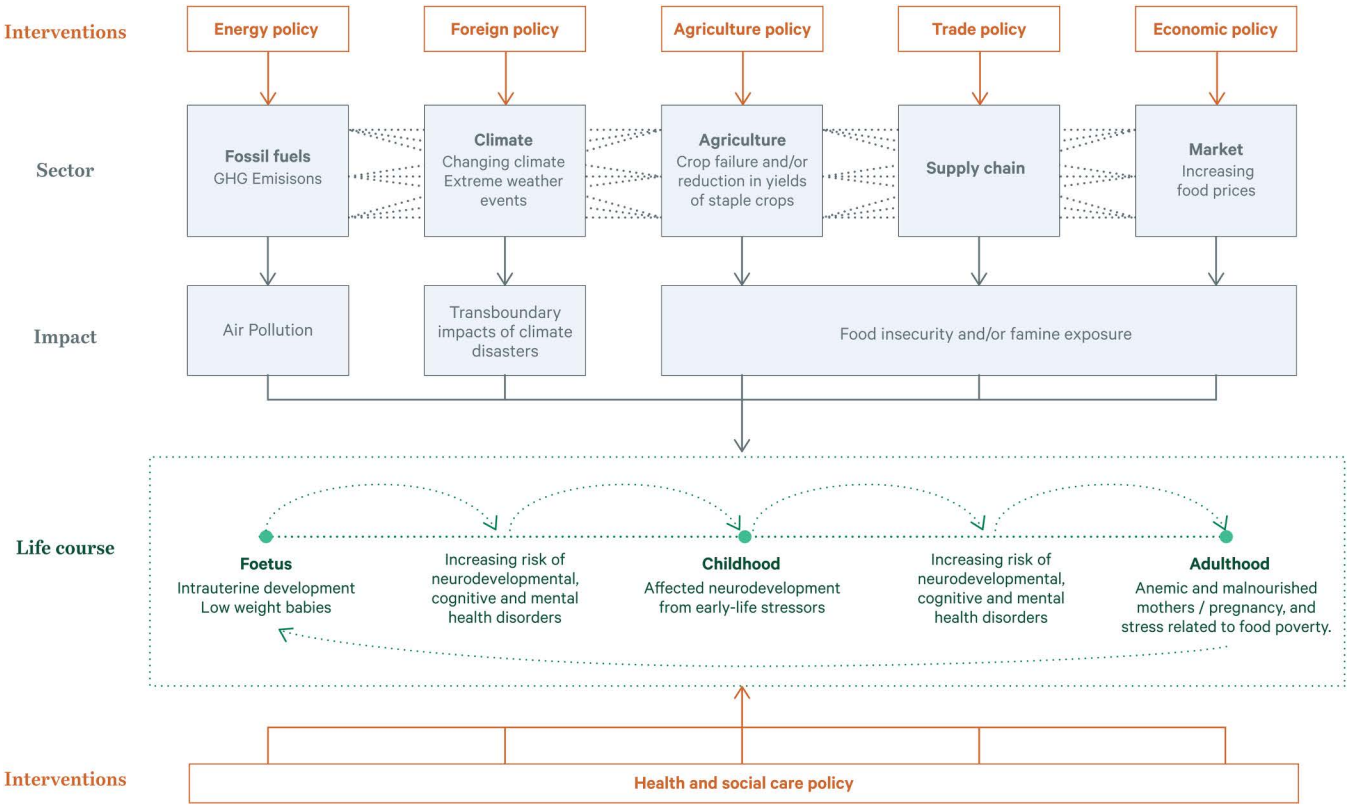

Fig 2. Illustrates areas where policy interventions (in orange) can reduce the mental health impacts of climate change, either by lowering the likelihood of certain hazards or by supporting affected communities when shocks occur. When viewed systemically, such interventions can generate benefits across sectors and scales. Example interventions include investments in climate-resilient agriculture abroad or integration of farmer mental health support into domestic adaptation policies, as discussed in the text.

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remains largely incremental and fragmented, with efforts in policy and practice largely concentrated and budgeted in sectoral silos rather than integrated across systems. This limitation is underscored by recent global and regional assessments: the UNEP Adaptation Gap Report highlights that adaptation planning and finance continue to fall far short of what is needed to address cascading and transboundary risks [107], while the European Climate Risk Assessment similarly concludes that adaptation in Europe remains insufficiently systemic, with most strategies failing to account for cross-sectoral and cascading impacts [7]. What's missing in these efforts is the recognition that any single climate risk can have serious and far-reaching cascading implications across multiple different sectors and thus may require multiple different policy levers to fully manage said climate risk, often residing across different policy portfolios. Conversely, individual policy levers can play an important role in managing multiple climate risks through often underappreciated co-benefits and cost reductions in other sectors (for instance spending on home insulation leading to reductions in fuel poverty, savings in healthcare costs and improved wellbeing) [108].

For this reason, policymakers need much better understanding of the multiple risk cascades through which climate change can exert detrimental influences on mental health, to accurately quantify the aggregated cost of climate change to mental health and to better evaluate the benefits of adaptation measures across different sectors. Current governance structures and the prevailing policy approach are unable to identify, assess and manage the compounding and cascading impacts from climate change on mental health in aggregate, nor enable an appropriate value on adaptation for mental health at a systems level.

This problem is not confined to mental health; it applies to other sectors as well. Energy policies may not take into account climate change-related water risks for water-intensive energy production (e.g., green hydrogen, bioenergy and nuclear) or growing wildfire risks from non-climate proofed electricity transmission lines, as well as changes in demand due to uncertain climate extremes. Similar lack of policy integration is observed at the intersections of climate adaptation and mitigation where different policy demands compete for the same land resource for food production, biomass production, carbon sequestration, and biodiversity conservations [83]. Yet, strategic investment in adaptation can help to align these competing demands and generate multiple co-benefits. For instance, nature-based solutions - such as restoring wetlands or forests, not only enhance biodiversity and increase carbon sequestration, but also reduce flood risk and, managed appropriately, support human health and wellbeing through improved nature connectedness and access to green and blue spaces [109,110]. Likewise, investing in resilient energy infrastructure can generate benefits across multiple sectors. For instance, climate-proofing transmission lines—through measures such as improved insulation, vegetation management along corridors, and undergrounding in high-risk areas—reduces the likelihood that extreme heat or drought conditions will spark wildfires along power lines. Such fires not only disrupt electricity supply but also damage forests, homes, and public health. By reducing this risk, the energy system is better able to maintain a stable supply of electricity, which in turn protects households from outages and ensures that critical facilities such as hospitals can continue operating during crises [111,112]. At the same time, poorly designed adaptation and mitigation measures in the energy sector can create or exacerbate risks in other domains. For example, the construction of large hydropower reservoirs can alter local ecosystems in ways that heighten the risk of vector-borne diseases such as malaria or dengue, by creating new habitats for mosquitoes [113,114]. This illustrates how actions intended to strengthen energy resilience may unintentionally undermine health outcomes if not carefully planned in a holistic manner. These examples illustrate that systemic responses carry the potential both to generate reinforcing benefits across sectors and to exacerbate risks if adaptation and mitigation measures are not designed and implemented with a holistic perspective.

In some cases, the parts of governments that deal with long-term strategies miss these systemic climate risks, for example in the context of security and defense. In other cases, government agencies provide emergency responses in context of civil protection and emergency preparedness that are transient, without that long-term view; they might miss an opportunity to respond to climate and other related shifts together. Uncertainties in climate changes and their impacts also make current preparedness, conventionally based on historic events and models that cannot accurately account for tipping points and other tail risks, largely not-fit-for-purpose.

Making clear the benefits to mental and physical health from many climate mitigation measures [26] may help to solicit greater attention from policymakers and interest from the general public; should they choose to adopt these practices, with or without climate in their thinking, they can then ultimately also reduce longer-term systems level risks. Health co-benefits of climate action include the cleaner air derived from a shift away from biomass burning or the move from petrol and diesel vehicles to 'active' travel (walking and cycling), public transport and electric vehicles. As well as reducing greenhouse gas emissions, improvements in air quality can reduce rates of mental health conditions such as depression, psychosis, anxiety, and even deaths by suicide [115]. In the housing sector, measures to improve the energy efficiency of domestic buildings can increase perceived thermal comfort, reduce anxiety and depression, and reduce demands on health systems [116,117]. Meanwhile, increasing the amount of green space in urban areas can provide short term mental health benefits from increased citizen access to nature and longer-term mental health benefits by reducing the urban heat island effect and the risk of flooding [117,118]. Of course, for the aforementioned mental health benefits of climate mitigation to influence policymaking decisions, it's essential that they are adequately quantified and that interventions are carefully monitored and evaluated to understand their impact and cost-effectiveness.

The failure to date to incorporate climate risks in policy across the board raises the question: can the systemic nature of climate change and its complicated interplay with non-climate drivers be adequately managed by existing governance structures? Or are new structures with cross-sectoral remits required at the heart of governments, possibly at the most executive level?

The role of prevention and early intervention in mitigating climate risks, including those to health

Much of the effort to manage or ameliorate the impacts of climate change on mental health to date has focused on the direct and proximate causes – immediate responses to climate catastrophes, such as floods, fires and heat domes – and centred on individual interventions, such as health advice and coping strategies [79]. However, these narrowly siloed interventions leave unaddressed the more systemic challenges of climate change's consequences for mental health and underlying socioeconomic vulnerabilities. Mental health experts have, for instance, recently argued that such an individual-centric approach fails to consider the deficiency of opportunity structures, social determinants, and lack of service access, which significantly affect peoples' capacity to benefit from such support [79]. Additionally, aside from the direct impacts of climate change on mental health mentioned earlier, it also neglects the myriad of risks that converge on a whole-population level, as well as indirect and distal influences, and life-course and future drivers.

We argue here for planning and preparedness measures for mental health that are suitable for the elevated risks under a changing climate, in addition to the "first-responder" and disaster or crisis measures that health officials are expected to provide. In the same way that the absence of flood protection measures can exacerbate the impacts of extreme rainfall and flooding, the lack of psychological preparedness and resilience of people, as individuals and as communities, will amplify the mental health consequences of climate-related disasters. As such, climate adaptation policies must include measures that enhance psychological and psychosocial resilience in advance of climate-related catastrophes and other impacts, rather than merely treating the trauma and other psychological effects once they have occurred [119].

Enhancing mental health resilience on a whole-population level is not only important for societal wellbeing, but also for our capacity to combat climate change, across adaptation and mitigation dimensions. Appropriate support for the mental health and psychological resilience of healthcare workers, fire fighters, and others working at the frontline of civil protection and emergency response is a prerequisite for society's capacity to respond to and recover from the impacts of climate change. The lack of such support came at enormous cost for healthcare workers during the Covid-19 pandemic [120]. Robust investment into mental health services and infrastructure are, for instance, essential to improve the baseline of mental wellbeing and reduce the likelihood that additional stressors would pass a certain threshold, beyond which people become overwhelmed by the effects of climate change and descend into post-traumatic stress and other psychological breakdowns. In fact, improving access to mental healthcare is considered as a form of effective adaptation by the 2022 IPCC AR6 report [121].

At the same time, failure to curb climate-related distress that can overwhelm individuals, could risk increasing cognitive dissonance, apathy and fatalistic behaviour among the population [122,123]. This could hinder the kind of public engagement and actions that are needed on a whole-population level, to transform our economies and societies to become sustainable and compatible with the constraints of our climate, biodiversity and natural resources, while growing activities that promote human flourishing within planetary boundaries, like more time with loved ones [124,125]. Adaptation policies for mental health must also focus on strengthening community ties and people's psychological and emotional capacities on a broader basis.

Indeed, the IPCC defines resilience as the capacity of social systems to cope with hazardous events while maintaining the capacity for adaptation and transformation. However, it should be clear that achieving such resilience requires not only building financial and infrastructure capacity, but mental health capacity as well.

Conclusion

It may seem remarkable that what the WHO and UN has called the greatest threat to human health, economies and even the existence of humanity [126–128], can be underestimated. But even organisations, policymakers and industries accounting for increased climate-related hazards from increasing extreme weather and climate events, are sorely underestimating the true systemic risks for our interconnected planetary and social systems, and the likelihood of cascading and compounding impacts that can set up vicious cycles, for instance between climate change and mental health. It is only by

accounting for these connections through more systemic approaches across research, policy and interventions that we can flip this vicious cycle to a virtuous one, and act with appropriate speed and scale. Climate research and risk models must endeavor to more adequately capture the cascading and compounding risks, indirect risks and risks perpetuating across geographies, throughout the life course of individuals and across generations. This will require transdisciplinary approaches and incorporations of new datasets and technological methods.

In parallel, decision-makers and governance structures must be upskilled to take systems-level perspectives on climate change, both with respect to risks and risk management. Beyond embedding climate considerations across departments, policymakers must work across departments to understand the interconnected impacts and benefits of interventions.

While relevant interventions do exist – for instance those supporting and promoting good mental health in a changing climate, they often remain in disciplinary, cultural or geographic containers, and are thus not identified, appraised and scaled up in appropriate ways, to prepare and protect humanity from escalating climate risk. However, early interventions – including in other sectors such as energy and food production - have the potential to be highly effective at saving costs, by reducing cascading impacts across the life course and generations.

Drawing on the illustrative example in this article, it is clear that our failure to adopt a more systemic approach to assessing and managing climate risks will not only risk further accelerating the current deterioration in mental health globally, but also threatens a reversal in the progress made in recent decades in maternal and reproductive health [129]. In presenting mental health as a lens through which to trace cascading and cross-sectoral impacts, this article hopes to broaden the systemic risk literature, traditionally focused on finance, infrastructure, and food systems, towards a more integrated account that includes human health and wellbeing as central to resilience. Addressing these issues systemically could also improve mental health care overall, an endeavour that remains sorely underfunded and unrecognized more generally by national governments.

Ultimately, recognising climate change as a source of systemic risk means acknowledging the feedback loops through which hazards can trigger cascading, compounding and cross-sectoral consequences for societies and mental health. Meeting this challenge requires a systemic response: coordinated action across governance levels and sectors that not only prevents vicious cycles of risk, but also creates virtuous cycles of resilience and wellbeing.

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