

1 Introduction and Overview

Climate change poses an existential threat to children unlike any that previous generations have had to face. Wars, economic depressions, and pandemics may have terrible impacts on children but they do not risk the total collapse of civilisation and biodiversity. This Element seeks to review and discuss the implications of the climate crisis for the development of children today and in the future.

1.1 The Climate Crisis

There is now no reasonable doubt that climate change is happening, is caused by human behaviour, and will have catastrophic consequences without urgent action. The latest report from the Intergovernmental Panel on Climate Change (IPCC, 2021) provides the clearest picture yet of the past, present, and future climate and documents how global temperatures have risen in response to rising greenhouse gas concentrations. Levels of carbon dioxide (CO₂) are now higher than they have been for four to five million years, at which time sea levels were 10–20 metres higher than currently and trees were growing in Antarctica (Steffen et al., 2016).

The IPCC (2021) report reflects major advances in the science of attribution¹ and concludes that climate change is now a causal factor in most extreme weather events. At the time of writing, the global temperature rise is about 1.1 degrees Celsius (°C) above pre-industrial levels (Steffen et al., 2016). Even this level of warming has made the world too hot, as shown by the record-breaking heatwaves, wildfires, hurricanes, droughts, flooding, and coastal inundation that have become commonplace. Some coastal and island populations have been forced to relocate, and extreme temperatures, droughts, reduced crop yields, and water shortages are leading to mass migrations and contributing to intrastate and interstate conflict and refugee crises. Climate scientists are also increasing their understanding of complex feedback loops and chains of events causing further climate disruption. For example, melting of the permafrost in the Arctic releases large amounts of methane, a potent greenhouse gas (Gray, 2018), and Arctic warming is likely to start a chain of processes that will ultimately result in periods of extreme cold in northern mid-latitudes such as the USA (Cohen et al., 2021).

The United Nations (UN) Secretary-General António Guterres described the IPCC report as nothing less than ‘a code red for humanity – the alarm bells are deafening, and the evidence is irrefutable’ (UN, 2021a, para. 2). The report warns that, unless there are immediate, rapid, and large-scale reductions in greenhouse gas emissions, limiting warming to close to 1.5°C or even 2°C will

¹ Attribution science addresses the role of climate change in specific weather and climate events.

be beyond reach. To have a chance to avoid worse impacts, global greenhouse gas emissions need to be halved by 2030, and cut to zero by 2050, at the same time as drawing down excess gases already present in the atmosphere. Furthermore, climate scientists warn that the Earth is close to irreversible tipping points; for example, changes in ocean currents, which would have catastrophic impacts (Steffen et al., 2018). However, as of early 2022, most countries are not on track to meet these targets (UN, 2021b).

Even with the transformative action that is needed to stay within safe limits, it could take twenty to thirty years for global temperatures to stabilise. In the 2020s and beyond, increasing climate impacts are predicted across the world, including more intense rainfall and associated flooding as well as more intense droughts in many regions; continued sea-level rises; amplified permafrost thawing, loss of seasonal snow cover, melting of glaciers and ice sheets, and loss of summer Arctic sea ice; and ocean warming, with more frequent marine heatwaves, ocean acidification, and reduced oxygen levels (IPCC, 2021). In addition, climate change is contributing to the threatened extinction of around one million species of animals and plants (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2019).

Climate change is a global phenomenon, but it is important to recognise significant disparities in the scale of its impacts. Despite greenhouse gases being emitted predominantly in the Global North,² their impacts are and will continue to be felt most severely in the Global South.³ However, the capacity to prevent, prepare for, adapt to, and respond to these impacts is typically weaker in countries in the Global South (Hanna & Oliva, 2016). Climate change also has direct detrimental and inequitable impacts on Indigenous peoples around the world, disproportionately threatening their self-determination and their human rights to land, health, water, food, housing, and life itself.

An even starker inequity is that current and future generations of children will suffer disproportionately, even though they are not responsible for the emissions. As discussed in more detail in Section 2, the World Health Organization estimates that over 80 per cent of the physical health impacts of climate change will be experienced by children (McMichael, 2014). Roughly 85 per cent of the world's children live in the Global South, and the combination of age and location makes these children doubly vulnerable (United Nations Children's Fund (UNICEF), 2014). Climate change can thus be considered an issue of

² Also referred to as high-income countries, the developed world, the minority world, or the WEIRD (Western, educated, industrialized, rich democracies) world, comprising approximately 12 per cent of the world's population.

³ Also referred to as low- and middle-income countries, the developing world, or the majority world.

structural violence, intergenerational injustice, and a violation of children's rights (Sanson & Burke, 2019; UNICEF, 2021a), with profound developmental implications.

The consequences of climate change for today's generation of children were clearly demonstrated by Thiery and colleagues (2021). Based on careful modelling, they showed how children born in 2020 will fare in comparison to people born in 1960 under three scenarios: (a) if climate action is limited to global pledges made in 2021; (b) if action is taken to limit warming to 2°C; and (c) if action is taken to limit warming to 1.5°C. They estimated that, under scenarios a, b, and c, respectively, today's children will experience seven, six, or four times as many heatwaves in their lives than children born in 1960. Similar or stronger results were found for six other types of extreme climate-related events (wildfires, crop failures, droughts, river floods, heatwaves, and tropical cyclones). There were strong variations by region (with the Middle East and North Africa worst impacted) and by income category (with greatest effects in low-income countries, which also have the most children). Thiery and colleagues (2021) noted that their results likely underestimated the intergenerational inequities because they did not consider compound (co-occurring) events, some types of climate-induced events such as coastal flooding, and indirect effects such as destruction of schooling infrastructure and forced migration that may have lifelong impacts. They concluded that while limiting warming to 1.5°C would substantially reduce the burden on children, it would still leave the next generation with unprecedented exposure to extreme weather events.

In the face of this existential crisis, why is humanity so slow to act? While the exploitative patterns of behaviour that have led to the crisis and the lack of action to address it often have their roots in philosophical, religious, political, and economic belief systems (see Newell et al., 2022; Wiseman, 2021), there are also many psychological factors that inhibit action on climate change (Australian Psychological Society (APS), 2017; Gifford, 2011). Some people still perceive climate change as something happening 'elsewhere' or 'in the future', not here and now, despite the ubiquitous evidence of its impacts. Some people wish to maintain the status quo, believing that things can continue to be as they are now (termed 'system justification') – these include those with vested interests in 'business as usual' and short-term profits, such as those involved in the fossil fuel industry. A small but influential number of people, some of whom are influenced and/or funded by the fossil fuel industry, still claim to deny the reality of climate change. Many others are resistant to change and experience discomfort and fear when contemplating the changes in lifestyles that might be involved in transitioning to a zero-carbon economy. For many, the natural desire to avoid emotional distress leads to avoidance of contemplating the reality of

climate change and the havoc it threatens to wreak on human life, which inevitably arouses distressing feelings. Finally, many people may understand the threat of climate change but feel powerless to do anything about it. When exploring how climate change impacts the development of the next generation, and how young people can best be supported in this context, it is important to consider how factors such as these – perceived distance in time and space, resistance to change, reluctance to confront uncomfortable feelings, and a sense of helplessness – may affect the responses of both children and those adults with responsibility for their care and development.

As this summary of the stark reality of the climate crisis implies, reviewing and discussing its implications for the children of today and tomorrow is no simple undertaking. First, the range of climate impacts is large and diverse, varies across contexts, and plays out over time. Second, we do not yet know if the world's governments will rise to the challenge and commit to the urgent, whole-of-economy large-scale transformative actions that are needed to limit global warming to 1.5°C. As a result, the extent of future impacts is currently unknowable – they could theoretically be minimal (although no current modelling predicts this) or involve widespread upheaval and suffering in the context of an unstable climate and rapid societal change, or billions of deaths, ecosystem collapse, and even the collapse of human civilisation. Third, climate change affects all aspects of children's development – physical, cognitive, social, behavioural, and emotional. Fourth and critically, despite the seriousness of the issues involved, researchers have been very slow to address climate impacts on children's development, especially for children aged from birth to twelve years who are the focus of this Element. This is even more true of children from the Global South. The body of research specifically addressing climate change and children's development is thus small and incomplete. We therefore rely on research on particular slow-moving climate-related changes and more sudden extreme weather events, reports from governmental, intergovernmental, and non-governmental organisations (NGOs), and on developmental theory, to draw together existing knowledge and develop recommendations for future directions.

Overview of Subsequent Sections

In the following sections, we review the research evidence on how children's development and well-being are affected by climate change and what is needed to protect them. We adopt a broad bioecological model of development (informed by Bronfenbrenner & Morris, 2006; Tudge, 2008), recognising that children's development occurs, over time, through interactions between themselves and their environmental contexts – in contrast with the view of children

as passive ‘one-way’ recipients of the actions and influences of others. Tudge (2008) captured these interdependent interactions with the phrase ‘synergetic interplay’, taking into account these interactive processes, the child, the context, and time – because climate change is explicitly about change over time.

Throughout this Element, we draw on the bioecological model to discuss the implications of climate change for children. We therefore consider children’s own individual characteristics and direct interactions with microsystems such as family, friends, and school, and the interactions between these microsystems (mesosystems) and the other systems external to these proximal systems. The latter include their parents’ workplaces and the community in which they live (exosystem) and the large, distal macrosystems (such as the physical environment, cultural factors, and government policies) that influence children and their microsystems indirectly. Because human development cannot be separated from the physical environmental contexts in which it takes place, we view climate change as a macrosystem phenomenon that is occurring over time and examine how it is manifested at different levels of the child’s ecology, with direct and indirect impacts on children’s well-being, and their physical, emotional, social, and cognitive development. Figure 1 shows the bioecological model we adopt, as developed by Tudge (2008).

Our focus is on childhood (ages zero to twelve years), but we also look back to the prenatal period and forward to adolescence and adulthood. This broader time frame allows us to gain a fuller picture of the impacts of climate change on

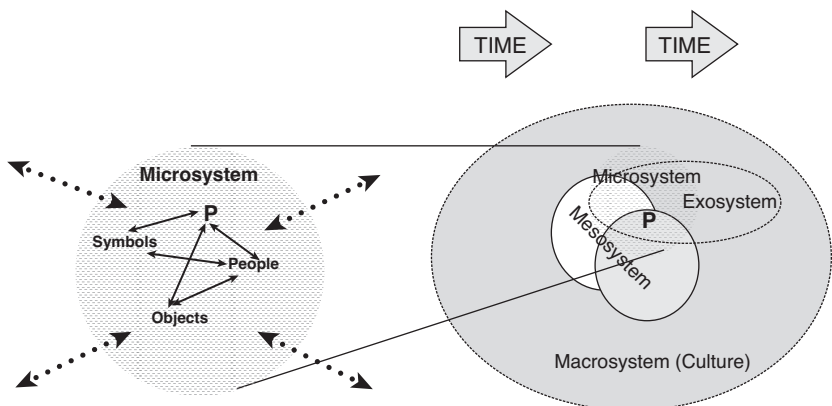


Figure 1 Visual representation of the PPCT model of Urie Bronfenbrenner’s bioecological theory, showing the active Person (P) engaging in proximal Processes (P) with people, symbols, and objects in a microsystem in interaction with other Contexts (C) involving both change and continuity over Time (T) (from Tudge, 2008; used with permission from Cambridge University Press)

the growing individual and to consider the ways in which children’s experiences early in life may affect their future development. Furthermore, it allows us to consider how children can be supported now to enable them to thrive in the future that awaits them.

We start by reviewing how exposure to gradual climate changes, such as changes in rainfall patterns, sea-level rise, and droughts, and to the sudden extreme weather events that are becoming more frequent and intense as a result of climate change (e.g., floods, hurricanes, wildfires) are related to children’s health, development, and well-being (Section 2). We then turn to how children’s awareness of the threat posed by climate change affects their emotional well-being, with evidence that many children globally are expressing fear and anxiety about their perceived future lives (Section 3). Section 4 provides a discussion of effective coping strategies for children, where senses of self-efficacy and agency emerge as important protective factors. Sections 5 and 6 then explore the roles of parents and educational settings, respectively, in supporting children. We next consider the skills and attributes that the next generation of children will need in the longer term to cope with the climate-induced changes that they are going to experience in the world they will inherit (Section 7). Finally, Section 8 draws these learnings together, identifies the many gaps in current knowledge, and examines the implications for professionals with responsibilities for this and future generations of children, ending with a call to action for all of us.

2 Impacts of Exposure to Climate-Related Events on Children’s Health, Development, and Well-Being

This section discusses the impacts of climate change on the well-being of children, applying the bioecological model (see Figure 1) to understand how the interactions of children with their families, communities, and societies create and reinforce challenges for their physical, psychological, and social development.

Children are more vulnerable to climate change impacts than adolescents and adults but have received much less research focus (Burke et al., 2018). The first comprehensive report on children’s exposure and vulnerability to the impacts of climate change was developed by UNICEF (2021a) through the Children’s Climate Risk Index (CCRI). The CCRI is based on a multi-layered analysis of children’s vulnerabilities – at the individual, community, national, and institutional levels – to the impacts of shocks and stresses, combined with the hazards of experiencing multiple, overlapping climate and environmental risks.⁴

⁴ The risk index calculation is based on two factors: (1) children’s exposure to climate and environmental shocks and stresses (e.g., water scarcity, floods, cyclones, heatwaves, air pollution) and (2) children’s vulnerability (e.g., health and nutrition, education, poverty, communication, and social protection).

The risks of children's exposure to the impacts of climate change for 163 countries are calculated, ranging from 8.7 for children in the Central African Republic to 1.0 for children in Iceland. The index documents that almost all countries in Africa and Asia have very high CCRI scores, almost every child is exposed to at least one serious climate and environmental hazard, and 850 million children – approximately one-third of all children globally – are exposed to four or more stresses, leading to the conclusion that the climate crisis 'is already having a devastating impact on the well-being of children globally' (UNICEF, 2021a, p. 9).

Children are the most vulnerable to climate change because of their level of physical and cognitive development (e.g., immature neural and immune systems, less capacity to detect danger) and due to common age-specific behaviours (American Public Health Association (APHA), 2019; UNICEF, 2021a). Compared to adults, children breathe more air and drink more fluid for their body weight, and they are shorter, spend more time on the ground, and engage in more hand-to-mouth activities (APHA, 2019). All these factors increase their vulnerability to air, water, and soil pollutant exposures and disease vectors. Older children engage in more outdoor activities, resulting in greater exposure to heat and outdoor air pollution, which is exacerbated by climate change (APHA, 2019). Children are also vulnerable because of their dependency on adults. As discussed in subsection 2.2, in disaster situations, parents and other carers are likely to be stressed and preoccupied, and at worst, unavailable (e.g., through death, injury, separation), resulting in suboptimal care and protection of children. Furthermore, as discussed in Section 1, today's children are likely to experience multiple climate-related stressors whose impacts will accumulate over their lives.

Here we provide an overview of the known impacts on children's well-being of exposure to slower-onset changes caused by climate change, more sudden-onset events, and the more general environmental degradation and stresses that both cause. It is important to note that the literature tends to focus more on the impacts of sudden climate-related disasters than slower climate events like sea-level rise and increasing temperatures. Furthermore, the existing literature on disasters has paid more attention to physical health impacts than to psychosocial consequences.

Because climate change is an overarching factor in the macrosystem of children's lives, over time its impacts filter through other systems, including children's individual health, their interpersonal relationships, and the living conditions in their communities (Sanson, Wachs, et al., 2018; Sanson et al., 2022). Using the bioecological model (Figure 1), we present impacts at the individual level, including the physical and psychosocial impacts on

children. Then we discuss the available literature on the impacts at the micro- and mesosystem levels, that is, impacts on the settings closest to children such as family and neighbourhood. Then we explore the impacts at societal and institutional levels. This framework helps to emphasise that no child lives in a silo, but that the dynamics occurring within their families and societies can exacerbate or ameliorate the extent to which children are impacted by climate change.

2.1 Individual Impacts

Climate change exacerbates existing health threats and creates new ones. Individual impacts not only affect children's current health conditions, but the harm can last for many years resulting in a lifetime of lost opportunity (UNICEF, 2021a) and even be passed down from generation to generation. Climate change disrupts basic amenities, creating water crises, food insecurity, biodiversity loss, and increasing levels of pollution in the air and soil. Climate change therefore has myriad physical health impacts including respiratory infections and illnesses, malnutrition, and vector- and water-borne infectious diseases (Fuller et al., 2021; Milman, 2021).

The prevalence of vector-borne diseases, such as malaria, dengue, Lyme disease, and Zika, is likely to increase with increasing temperatures and changing climatic conditions that lead to the proliferation of mosquitoes and other vectors (Blakstad & Smith, 2020). Over one in four children globally (600 million children) are currently exposed to vector-borne diseases (UNICEF, 2021a), which have potentially lasting health impacts such as neurological damage, malnutrition, and developmental impairment (Anderko et al., 2020; Blakstad & Smith, 2020). Zika, in particular, has adverse effects on children's physical, cognitive, and mental well-being, intensifying social and economic inequalities (Blakstad & Smith, 2020). Salinity from seawater intrusion is another consequence of climate change that potentially creates public health hazards through its impacts on freshwater availability for households, commercial use, agriculture, and coastal ecosystems. For example, recent literature has shown that high salt intake related to increasing water salinity increases the risks of miscarriage and pre-eclampsia in pregnant women (Hossain, 2020).

Prenatal and early years exposure to climate shocks undermines children's health by causing low birth weight and short height for age (Anderko et al., 2020; Molina & Saldarriaga, 2017; Pacheco, 2020). For example, Kumar and colleagues (2016) found that in utero exposure to droughts in India had detrimental impacts on children's nutritional status, with the impacts on child health being mediated through financial duress in drought years.

Turning from slower-acting climate effects to more immediate ones, exposure to climate shocks and disasters that are increasing in frequency and ferocity (e.g., hurricanes, cyclones, wildfires, heatwaves, and floods) can have devastating physical impacts on children, ranging from illnesses to injuries and even death. Children are more likely than adults to suffer injuries and other physical afflictions during disasters (Biswas et al., 2010), which can lead to increased incidence of permanent disabilities, and disasters also disproportionately affect children with pre-existing disabilities (Stough et al., 2017). Disruptions to the basic necessities of life such as clean water, adequate food, and shelter result in health problems including respiratory conditions, stomach diseases, and malnutrition (Naylor, 2021; Peek et al., 2018).

The devastating shocks and continuous threats caused by climate change damage not only children's physical well-being but also their mental health. High levels of post-traumatic stress disorder (PTSD) have been reported in various humanitarian settings worldwide, with long-term effects on the lives of children (Kulig & Dabravolskaj, 2020; Leppold et al., 2022). For example, after the 2010 floods in Pakistan, 73 per cent of children aged ten to nineteen years displayed high levels of PTSD, with displaced girls more affected (Gibbons, 2014). Research analysing the psychosocial impacts of wildfires on children and their families showed that younger children who experienced significant exposure to the fire were more likely to experience PTSD than older children (Kulig et al., 2018; Kulig & Dabravolskaj, 2020). As another example, a study of 159 students aged eight to eighteen years after the 2005 bushfires in Australia found that, while most students reported having mild PTSD symptoms, substantial proportions reported moderate (17 per cent) or severe/very severe (10 per cent) symptoms, with younger children reporting more severe symptoms than older youth (Yelland et al., 2010).

The literature also documents the high risk of developing other mental health problems including depression, anxiety, substance abuse, phobias, sleep disorders, attachment disorders, regressive behaviours, and somatic complaints as a result of exposure to climate-related disasters (Anderko et al., 2020; Burke, et al., 2018). For children who experience multiple climate-related disasters, there can be cumulative mental health impacts, especially if they do not receive adequate support (Leppold et al., 2022; Sanson, Burke & Van Hoorn, 2018).

Most of the literature on the impacts of climate change on children's mental health focuses on climate-related disasters, but some literature provides evidence of links between slower environmental changes and poorer mental health (Burke et al., 2018; Clayton, 2020). For example, researchers in Canada and South Korea found associations between exposure to air pollution (known to be exacerbated by climate change) and symptoms of depression and suicide

attempts (Trombly et al., 2017). Psychological impacts can also contribute to other developmental complications like problems with emotion regulation, behavioural issues, impaired language development, and impaired learning (Anderko et al., 2020; Burke et al., 2018).

2.2 Interpersonal Impacts

When looking at interpersonal impacts, climate stressors impact the physical and mental health of caregivers, thereby limiting their capacity to provide care and protection for children. For example, Biswas and colleagues (2010) found a high prevalence of unintentional injuries to children after floods in Bangladesh. They explained that, when caregivers were preoccupied with post-flood cleaning and reconstruction activities, children spent more time without adult supervision which increased the risks for them. Another study in Puerto Rico exploring the impacts on women and their children after Hurricane Maria showed that higher stress and depression scores among mothers were associated with higher negative affect and lower self-regulation in infants (Martinez, 2020). An increase of domestic violence after Hurricane Katrina in the USA was also reported by participants in a study by Harville et al. (2011).

Pressures on caregivers arise not only because of exposure to extreme weather events but also due to gradually unfolding environmental changes combined with existing economic and social challenges, resulting in anxiety about future loss and the well-being of future generations. A study conducted in Tuvalu found that the impacts of climate change (e.g., drought, more variable weather, and extreme temperatures) were predominant matters of concern in the community and that such concerns had increased since Tropical Cyclone Pam in 2015 (Gibson et al., 2019). A fifty-year-old participant said: ‘I worry about my grandchildren, my children. I always tell them, “if something happens, or before the thing happens, you should migrate. Go to some place higher than Tuvalu”’ (p. 679).

Environmental shocks produced by climate change increase household vulnerability, resulting in economic hardship, food and water insecurity, and, with extreme events, uninhabitable living conditions. The actions that families may take to try to face challenging circumstances can create harmful situations for children such as migration (Earle, 2021; Kielland & Kebede, 2020), child labour, and child marriage (Dewi & Dartanto, 2019; Guarcello et al., 2010). These practices affect adolescents more than children, but even young children become involved in child labour to support their families, which places them at higher risk of suffering violence and other threats as well as disrupting their education. Pereznieto and colleagues (2020) found