Policy Brief

# Effects of early life exposure to climate shocks on education outcomes

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## Key Messages

In utero and post-natal exposure to climate hazards impacts learning outcomes and education attainment.

Socioeconomic vulnerabilities such as income and seasonal dependencies increase the likelihood of negative foetal and post-natal health impacts, as well as long-term learning and earning potential.

Children can recover from climate shocks experienced in early developmental stages. Investing in maternal health, early childhood care and household capacity to adapt to climate shocks is key to resilience.

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# 1 Overview

Human-induced climate change is increasing the frequency and intensity of extreme weather events, leading to widespread adverse impacts on humans and nature, well beyond natural climate variability. On current trajectories, the world is on track to experience 2.7°C warming above pre-industrial levels within the next century, far above the global goal of 1.5°C (Climate Action Tracker, 2024). Climate change is not only an environmental challenge – it is an intergenerational threat to human capital. Extreme weather events linked to climate change lead to substantial damage to life and infrastructure, and have severe negative impacts on nutrition, education and human health. The most vulnerable individuals and systems are also the ones most impacted by these extreme events (IPCC, 2022).

Education is critical for human development. Beyond playing a role in improving understanding of climate change (Fagan and Huang, 2019; Simpson et al., 2021), education helps individuals develop skills and knowledge and increases their productivity and earning potential, thereby increasing human capital. Human capital is critical for improved adaptive capacity and resilience to climate-linked events (Ara Begum et al., 2022; Birkmann et al., 2022). Education can empower individuals to make choices that can influence consumption patterns (Cordero et al., 2020; Yao et al., 2020; Acharibasam and McVittie, 2023) and policy decisions and has been associated with pro-climate beliefs (Angrist et al., 2024). Education can therefore define long-term impacts on climate change mitigation efforts.

Increasing evidence shows that shocks experienced prenatally – before a child is even born – can undermine long-term development outcomes by impairing health, cognition, schooling and, ultimately, earning potential. A large body of literature examines the early life health and education relationship. In this policy brief, we hone in on the impacts of climate hazards on education outcomes via effects on pre- and post-natal stages of child development. Based on a systematic review outlining the impacts of climate hazards on learning outcomes conducted between April 2024 and June 2025, and using data from 14 geographically diverse quantitative studies,[1] the brief shows that exposure to climate shocks *in utero* has distinct and often persistent effects on educational outcomes and earnings (summarised in Table 1). It then outlines the mechanisms of impact, and implications for policy action.

1 Quantitative studies were only selected if they used at least a quasi-experimental methodology. Perception surveys, for example, were not included in the study set.

# 2 What is the link between climate change, early life exposure and education?

Across all major climate hazards – rainfall, floods, cyclones and hurricanes, temperature shocks, landslides and wildfires – pre- and post-natal exposure has demonstrated impacts on learning outcomes, education attainment (graduation rates and years of schooling) as well as lifetime earnings. These impacts arise via several interconnected pathways that impair foetal development and disrupt caregiving environments.

Pre- and post-natal climate shocks can have direct impacts on child health and cognition. Leight et al. (2015), using data from rural China, found that children exposed *in utero* to rainfall shocks during harvest seasons had significantly lower height-for-age Z-scores (–0.15 SD), reflecting stunted foetal growth linked to reduced food intake as a result of decreasing household income. In Ecuador, Rosales-Rueda (2018) found that a one-month flood exposure during pregnancy reduced household income by 1.9%, total consumption by 1.8% and food consumption by 1.75% the following year. The study further reported that each month of *in utero* flood exposure increased the probability of low birth weight and anaemia, and reduced height-for-age scores by 0.031 SD. These outcomes were linked with lower cognitive test performance, particularly vocabulary acquisition in early childhood (Rosales-Rueda, 2018).

Even in high-income contexts such as the US, prenatal exposure of students from low-income backgrounds to hurricanes, on average, led to 9.9% lower high school graduation rates and 3.8% fewer years of schooling. For those exposed during infancy but before the age of nine months, the decrease in graduation rates was lower but still significant, at 4.7% (Karbownik and Wray, 2019).

Climate shocks, particularly floods and droughts, diminish household income, especially in agrarian contexts, limiting investments in maternal nutrition and early child development. Climate variability also correlates with the physical workload of pregnant women in these contexts. For example, in rural China, Leight et al. (2015) found a 16% increase in maternal labour supply during planting seasons following positive rainfall shocks, and a 22% decline during harvest-related rainfall failures. Increased workload during pregnancy may reduce maternal rest and caregiving, with hypothesised implications for birth outcomes.

**Table 1** Summary of effects of climate hazards on education outcomes arising via pre-natal and post-natal impacts

| No. | Study | Country / Geography | Climate Hazard | *In Utero* Impact | Postnatal Impact (0-5) |
|---|---|---|---|---|---|
| 1. | Abiona (2017) | Malawi | Drought & Floods | Drought exposure ↑ delayed entry (0.159 SD, males); no effect from floods | Postnatal effects not assessed |
| 2. | Akresh et al. (2012) | Burkina Faso | Drought (Rainfall Deficit) | ↓ Cognitive ability (–0.23 SD); ↑ late school entry (+113%), ↓ enrolment (–32%), ↑ child labour (+0.8 hrs/day) | Similar to *in utero* impacts |
| 3. | Brando & Santos (2015) | Colombia | Excess Rainfall (La Niña) | ↓ PPVT scores (–0.10 SD) | ↑ risk of socioemotional problems (Ages and Stages) |
| 4. | Carrillo (2020) | Colombia | Floods | ↑ Illiteracy (1.7%); ↓ year of schooling (0.21%); ↓ adult likelihood of working (0.36%) | Postnatal effects not assessed |
| 5. | Caruso (2017) | Latin America (11 countries) | Floods | ↓ Schooling (–0.472 years); most severe with high-intensity floods | Exposure at ages 5–10 had weaker effects |
| 6. | Chang et al. (2022) | Peru | Rainfall Variability | ↓ Vocabulary (at age 5); ↓ Math (~~ 2% at age 15) | Postnatal effects not assessed |
| 7. | Karbownik & Wray (2019) | United States | Hurricanes | ↓ Income in adulthood (–5.7%); ↓ High school graduation (–9.9%); ↓ years of schooling (–3.8%) | Infancy exposure led to –4.7% income; no effect beyond infancy |
| 8. | Leight et al. (2015) | China | Rainfall Shocks | ↓ Test scores (–0.1 to –0.2 SD); ↓ height-for-age z-score (–0.15 SD) | 1st-year effects present but attenuated over time; year 2+ effects minimal |
| 9. | Lin et al. (2021) | China | Typhoons | ↓ Schooling (–1.38 years); ↓ income (up to –40% for strongest typhoons); due to fetal exposure and sibling competition | No significant postnatal effects |
| 10. | Pazos et al. (2024) | Ethiopia | Drought (Rainfall Deficit) | ↓ PPVT scores; ↓ executive function (working memory); strongest in gestation and early infancy | Early postnatal effects faded by age 12; evidence of recovery |

**Table 1** Summary of effects of climate hazards on education outcomes arising via pre-natal and post-natal impacts (continued)

| No. | Study | Country / Geography | Climate Hazard | *In Utero* Impact | Postnatal Impact (0-5) |
|---|---|---|---|---|---|
| 11. | Paudel (2023) | Nepal | Wildfire | | ↓ Middle school completion rates (1.1- 1.7 pp) |
| 12. | Randell & Gray (2019) | 29 tropical countries | Heat (High Temperature) | ↓ Schooling (–1.5 years); stronger among wealthier households | Postnatal effects not assessed |
| 13. | Rosales-Rueda (2018) | Ecuador | Floods | ↑ Anaemia and low birth weight; ↓ PPVT (–0.034 SD/ month exposure) | Postnatal effects not assessed |
| 14. | Shah & Steinberg (2017) | India | Rainfall Variability | ↑ Test scores (+1.3% SD/year), enrolment, and progression under positive shocks | Postnatal shocks (ages 5–16) ↓ school access |
| 15. | Wilde, Apouey & Jung (2017) | Africa (6 countries) | Heat (High Temperature) | Slight ↑ in schooling (+0.024 years); ↑ literacy; positive effect due to foetal selection | Postnatal effects not assessed |

## 2.1 Impacts on learning outcomes

Pre- and post-natal climate shocks have direct impacts on learning outcomes, including literacy and numeracy, in addition to increasing the risk of socioemotional problems. In China, Leight et al. (2015) found that exposure to rainfall shocks *in utero* had persistent effects on the child's physical and cognitive development. These shocks were particularly significant when experienced in the harvest season. Further, rainfall shocks during the first year of life had a statistically significant negative effect on cognitive scores (Leight et al., 2015). In Colombia, Carrillo (2020) showed that *in utero* flood exposure was associated with a 1.7% increase in illiteracy rates, and in Peru Chang et al. (2022) found that *in utero* exposure to rainfall shocks led to declines in vocabulary and maths scores between ages five and 15, respectively. Pazos et al. (2024) found that children in Ethiopia exposed to reduced rainfall in early life scored lower on vocabulary tests at ages five and eight.

In Colombia, Brando and Santos (2015), examining the impact of exposure to landslides and floods (from the *in utero* period to age five) caused by La Niña in 2010–2011, found that exposure to one flood or landslide in the second year after birth is linked to a statistically significant reduction in vocabulary scores. They also found that the prevalence of socio-emotional problems increases by 7.6% when exposure during the second year of life increases by one standard deviation. In Burkina Faso, Akresh et al. (2012) found that prenatal drought exposure reduced a child's cognitive test scores by 0.23 standard deviations, and increased child labour hours by 0.8 per day. These children

were more than twice as likely to start school late. Children with higher cognitive scores (who had not faced shocks prenatally) were better protected from early labour and school dropout. They find similar results for children exposed in the first year of life (Akresh et al., 2012).

## 2.2 Impacts on education access and attainment

Exposure to climate shocks like floods, storms and elevated temperatures during prenatal and early childhood stages affect educational attainment and years of schooling. Randell and Gray (2019) examined the effects of periods of raised temperatures *in utero* and during early childhood to understand the impacts on educational attainment at ages 12 to 16. In a study across 29 countries in the global tropics, they found that a student in South-east Asia experiencing temperatures of two standard deviations above average prenatally or in early life was predicted to attain 1.5 fewer years of schooling than one who experienced average temperatures. They also found that early-life rainfall is positively correlated with attainment in both West and Central Africa and South-east Asia, and negatively associated with attainment in Central America and the Caribbean (Randell and Gray, 2019). Caruso (2017) found that, while *in utero* exposure to floods and cyclones is associated with a decrease in educational attainment across several countries in Latin America, the impact decreases when the individual is exposed to floods later in life, reaching least impact when exposed at the age of eight. After this age, the impact of the hazard starts increasing again. Shah and Steinberg (2017) also find that exposure during school-going years (ages 5–16) was linked to declines in educational access and performance, probably due to school disruptions and income losses that diverted children into labour. In Malawi, Abiona (2017) found a 9.3% and 7.5% increase in delayed entry to school for males for drought shocks *in utero* and in the second year after birth.

These findings highlight that climate hazards experienced pre- and post-natally impact educational attainment, and that these impacts are both time-sensitive and context-dependent. Wilde et al. (2017) found that children in six African countries conceived during hotter months had slightly higher educational attainment, possibly due to improved food supply. A one standard deviation increase in average monthly temperature[2] nine months before birth was associated with a mean increase of 0.024 years of schooling, and the probability of being literate increased by 0.37% (Wilde et al., 2017).

Not all studies find impacts across all education outcomes. Lo Bue (2019) finds that poor prenatal and health conditions and those in the first six months significantly and negatively influence years of education and readiness to enter school, but there is a weak relationship with cognitive test scores. Paudel (2023), examining long-term effects of *in utero* exposure to wildfire, shows that the impact on middle school completion is negative and statistically significant only among individuals that experienced forest fires when they were 0–5 years old.

2 In this case, 1 SD increase was equivalent to a 1-degree increase.

# 3 Policy implications

Beyond learning outcomes and educational attainment, longitudinal studies show that *in utero* and postnatal exposure to climate shocks affects lifetime earnings and economic productivity in adulthood. In the US, Karbownik and Wray (2019) found that individuals exposed to hurricanes *in utero* had 5.7% lower adult incomes. In China, Lin et al. (2021) showed that typhoon exposure during gestation reduced schooling by up to 1.38 years, and annual income by up to 40% for the strongest typhoons.

Climate shocks experienced during gestation and postnatally result in profound and persistent developmental losses. These effects are seen in cognitive development, education and adult earnings, particularly among vulnerable populations with limited income buffers. **A cross-sectoral approach including coordination between Ministries of Education, Health, Climate, Finance and others, and integration of data systems combining health, education and income indicators, will support timely interventions to mitigate the negative impacts of climate shocks.**

Cash transfers, in particular during a child's gestation or early in their life, have been shown to offset the long-term impacts of climate hazards (Duque et al., 2018). Pazos et al. (2024) find that financial support to poorer families might partially remediate for the negative effects of rainfall shocks on learning outcomes especially before the age of five. They find that early growth stunting due to malnutrition can be reversed over a much longer period than previously thought, and that **social protection measures such as cash transfers can mitigate climate shocks on early life through reduction of maternal labour, and other health stressors. In our own systematic review, four out of six studies found evidence of the protective power of cash transfers.**

The impacts of climate hazards are highly contextual. For example, examining the impact of exposure to floods and droughts *in utero* and in infancy on delays in school enrolment in rural communities in Malawi, Abiona (2017) found no impact of floods but negative impacts of droughts. In India, Shah and Steinberg (2017) found that increased rainfall during gestation and early childhood (up to age two) was associated with higher school enrolment and test scores, which in turn was driven by increased income and food availability. Thus, **the impacts of climate hazards are highly context- and hazard-specific, and policy considerations need take these contextual and geographic variations into account**.

Maternal stressors and income shocks that drive women into the labour force during gestation and post birth need to be mitigated through investments in maternal health and antenatal and postnatal care, as well as the provision of food security and social protection. **Investments in maternal health are essential not only for immediate well-being but also for safeguarding long-term economic productivity and reducing inequality in light of climate change.**

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