K4D | Knowledge, evidence and learning for development

Improving resilience, adaptation and mitigation to climate change through education in low- and lower-middle income countries

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Question

What evidence is available from low- and lower middle- income contexts on approaches to improve resilience, adaptation and mitigation to climate change and associated environmental degradation in and through education?

Contents

Introduction

The Intergovernmental Panel on Climate Change (IPCC) warned, in their latest report, that global surface temperatures will continue to increase until 2050 (IPCC, 2021, p. 17). This will take place regardless of human intervention to reduce greenhouse gas emissions. The report also warns that the traditional technocratic approaches are insufficient to tackle the challenge of climate change, and that greater focus on the structural causes is needed. High- and upper-middle-income countries have been persistently shown to be the biggest contributors to the global carbon dioxide emissions, with lower income countries facing the most disruptive climate hazards, with Africa countries particularly vulnerable (CDP, 2020; IPCC, 2021). The vulnerability of low-income contexts exacerbates this risk, as there is often insufficient infrastructure and resources to ensure resilience to climate hazards (IPCC, 2021).

For decades, advocates of climate change education have been highlighting the potential of education to help mitigate against climate change, and support adaptation efforts. However, implementation has been patchy, with inconsistent approaches and a lack of evidence to help determine the most effective way forward. This paper is divided into three sections, drawing together evidence on the following key aspects:

1. System reform
2. Green and resilient infrastructure
3. Curriculum, pedagogy, assessment and teacher development

Key definitions

Climate resilience is the ability to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to climate (C2ES, 2022). Mitigation focuses on reducing the human impacts contributing to climate change (Burton, 2007, cited in Rousell & Cutter-Mackenzie-Knowles, 2020). Adaptation is about increasing people's adaptive capacity, reducing the vulnerability of communities and managing risks (Anderson, 2012). Anderson further defines adaptation as not just being able to adapt from one stable climate to another but having the skills to adapt to uncertainty and make informed decisions in a changing environment.

While 'climate change' is the term used throughout these briefs, it should be read as a shorthand for a more inclusive approach, which also captures associated environmental degradation.

Section A: Green/resilient system reform

1. What is needed for green and resilient education system reform?

Education systems need to strengthen their capacity to respond to the impacts of climate change on national and sub-national levels, with cross-sectoral collaboration an essential component. UNICEF (2019b, pp. 43–44) developed three core recommendations for cross-sectoral working to strengthen education system response to climate change:

- Strengthen the education sector's leadership in climate change policies, finance and actions (ministries of education collaborate further with ministries of environment).
- Improve cross-sectoral collaboration and programming (e.g. with ministries of health, agriculture and environment).
- Incorporate climate change in education planning and financing.

Mundy (2022) identified core goals to ensure all education sector policies, strategies and plans address climate change. This includes:

- Ministries of education have access to education and non-education data (such as climate and environmental change models and population movements) to inform planning and decision making to ensure education continuity, especially for those most affected.
- Ministries of education have stronger individual, organisational and institutional capacity to undertake climate risk analysis, plan for preparedness and develop mitigation strategies, and for addressing needs of displaced learners and teachers.
- Education sector plans include greater attention to school infrastructure and ensure that schools are safe and climate resilient through relocation, retrofitting, replacement and construction.
- Sector strategies aim to transform teaching and learning so that schools can help children and youth to make informed decisions and take bold actions—to limit carbon emissions and develop and use new energy-efficient technologies.

Using Education Development Trust's (Ndaruhutse et al., 2019) six considerations for education system reform, the below diagram maps out the different ways in which cross-sectoral working may take place with the shared goal of responding to climate change.

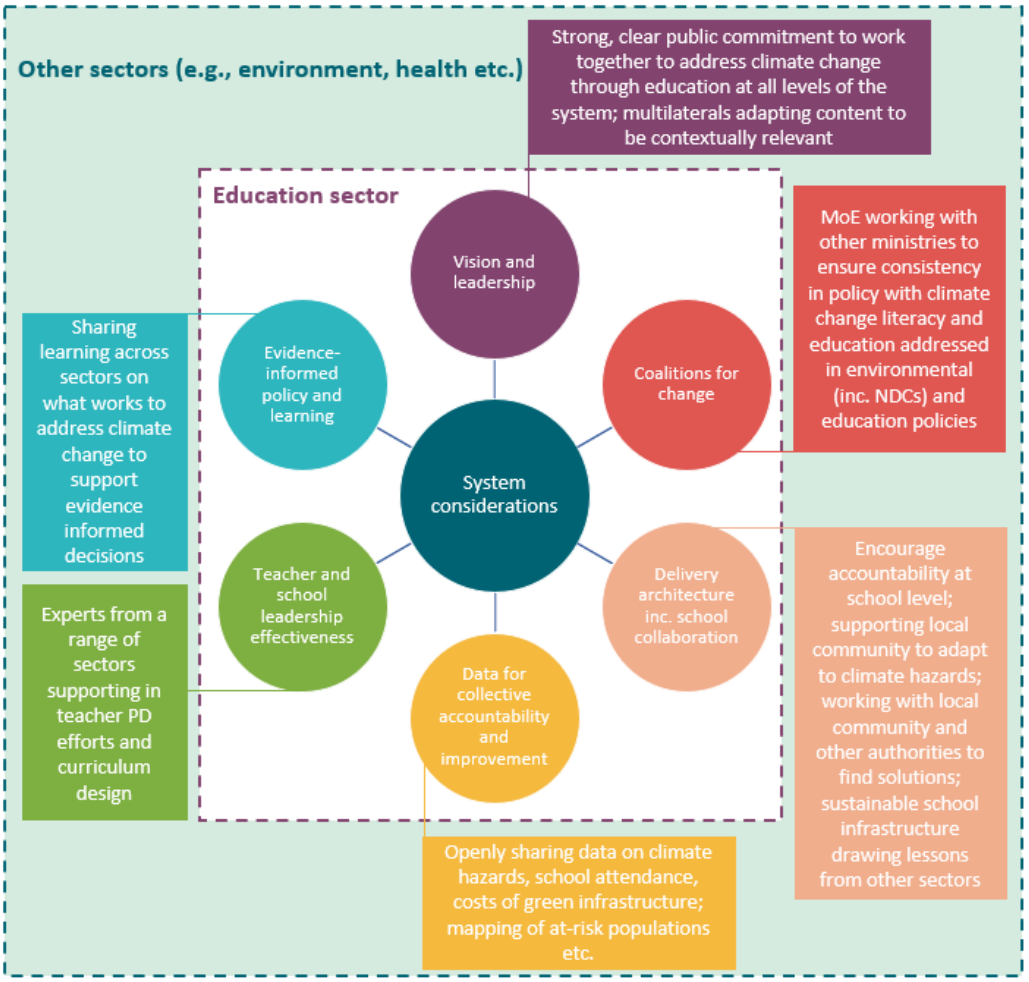


Figure 1: system considerations for green/resilient reform.

1.1 Policy coordination

Integrating climate change into education policies/strategies, and education into climate change policies/strategies, requires coordination between ministries. Country mapping exercises that explore the extent to which this has already been achieved, and how consistently, will help determine the starting point in each country. The below table outlines policies and strategies to be considered as a minimum, though there will likely be more policies, strategies and resolutions that are relevant to different country contexts.

Table 1: education and environmental policies to consider in coordination efforts.

Education sector policies, strategies and plans to integrate climate change	Climate change policies, strategies and plans to integrate education	Other
Education policies (e.g., National Education Policy, policies on inclusion etc.) Education sector development plans National curriculum	Climate change policies National Climate Change Learning Strategy Nationally Determined Contributions (NDCs) National Adaptation Plans (NAPs) Regulatory frameworks	Sustainable Development Goals (e.g., SDG4 Strategic Frameworks) Regulatory frameworks

1.1.1 Education sector policies integrating climate change

There is inconsistency in the extent to which climate change is considered in Education Sector Development Plans and National Education Policies. Most make some reference to climate change, but often without specific objectives or targets that can be meaningfully measured. For example, in the National Education Policy (2020) for India, there are five references to climate change; none of these references relate to the curriculum, teaching, learning or resilience measures. Instead, climate change features as part of a longer list of challenges potentially faced by the education sector. Others, however, have clearer strategies for resilience measures to school infrastructure and integration into the curriculum that are built into the ESDPs (see box below on Bangladesh's ESDP).

Example: Bangladesh Education Sector Development Plan 2020-2025

The ESDP of Bangladesh includes both response to climate hazards in relation to emergency planning, and relevant curricular content. The overall objectives of the plan in relation to climate change are (pg. 111):

- Developing and applying a workable approach to reforming curricular content for promoting sustainable development and related aspects of climate change and coping with emergencies. Special attention given to appropriate teaching learning practices, teacher support and skills, and assessment of student learning outcomes.
- Developing and planning necessary links, assessing current provisions and practices, between school education system responses in emergencies and national emergency preparedness and responses (including for COVID-19 pandemic response) with special attention to budgets, development investments and plans for school operations – recognising patterns of vulnerabilities and hazards, decentralized decision-making, and community involvement.
- Promoting appreciation of and behaviour reflecting resilience and adaptability to challenges arising from the effects of climate change through activities in schools.
- Development of ethics and values among young people appropriate for sustainable living, living in harmony with nature through curriculum, teacher performance, school and classroom practices, assessment and school-community-parents cooperation.
- Capacity development and enhancing awareness among stakeholders for facing challenges related to climate change and disaster risk reduction in schools and

communities. Addressing the psychological impacts during and after disasters would be integral part of strategic educational planning for continuing learning.

Specific targets to meet these objectives include review of current plans, curriculum content and strategies, with adaptations to meet the above objectives.
(Government of Bangladesh, 2020)

Other education sector policies place accountability on the schools rather than adopting top-down approaches. Although this has the benefit of ensuring that learning content is contextually relevant, it raises questions around teacher capacity to be able to implement climate initiatives at the classroom level, and school leadership at the wider school level, without sufficient training or a systematic approach to doing so. (See box below for an example of this approach in Indonesia's Adiwiyata Schools Programme).

Example: Indonesia's Adiwiyata Schools Programme

In 2006, the Ministry of Environment and the Ministry of Education of Indonesia worked together to implement environmental education through an eco-schools programme. The objective is to encourage a whole-school approach to environmental education through eco-friendly behaviours. The program involves a multitude of different stakeholders (government agencies, universities and NGOs) involved in the environmental education sector, to evaluate and give awards to schools who participate. The programme encourages a whole-school approach, with schools awarded a 'status' if they meet the following requirements:

- Schools must have an environmental policy with a clear mission that sets out the ways in which the school considers sustainability and cares for the environment. The policy must cover how the school plans to increase staff capacity in environmental education, saving natural resources, creating and maintaining a healthy and clean school environment, and how funds will be allocated to activities
- Schools must implement an environmental-based curriculum which covers multiple subjects, including elements of problem solving relating to the surrounding environment and community. This must adopt pedagogical approaches that include activities that develop student knowledge and awareness about the environment
- Schools must engage in participatory-based environmental activities. These are considered extra-curricular activities that engage stakeholders from outside the school setting
- Schools must develop environmentally friendly management of school support facilities, including saving natural resources and improving the quality of healthy food services and waste management systems.

(One Planet Network, 2015)

Schools can achieve different levels of Adiwiyata status, these awards are designed as an incentive for schools to be recognised.

Astitu and Aminatun (2020) sampled 1568 students from nine senior high schools in Indonesia and found that students in Adiwiyata schools had significantly higher levels of environmental competency compared to students in non-Adiwiyata schools. Nurwidodo et al (2020) assessed the impact of Adiwiyata schools on environmental literacy. They surveyed 275 students from

grades 10 and 11 in Malang City. They found that students in Adiwiyata schools achieved higher scores in ecological knowledge, pro-environmental behaviours and cognitive skills.

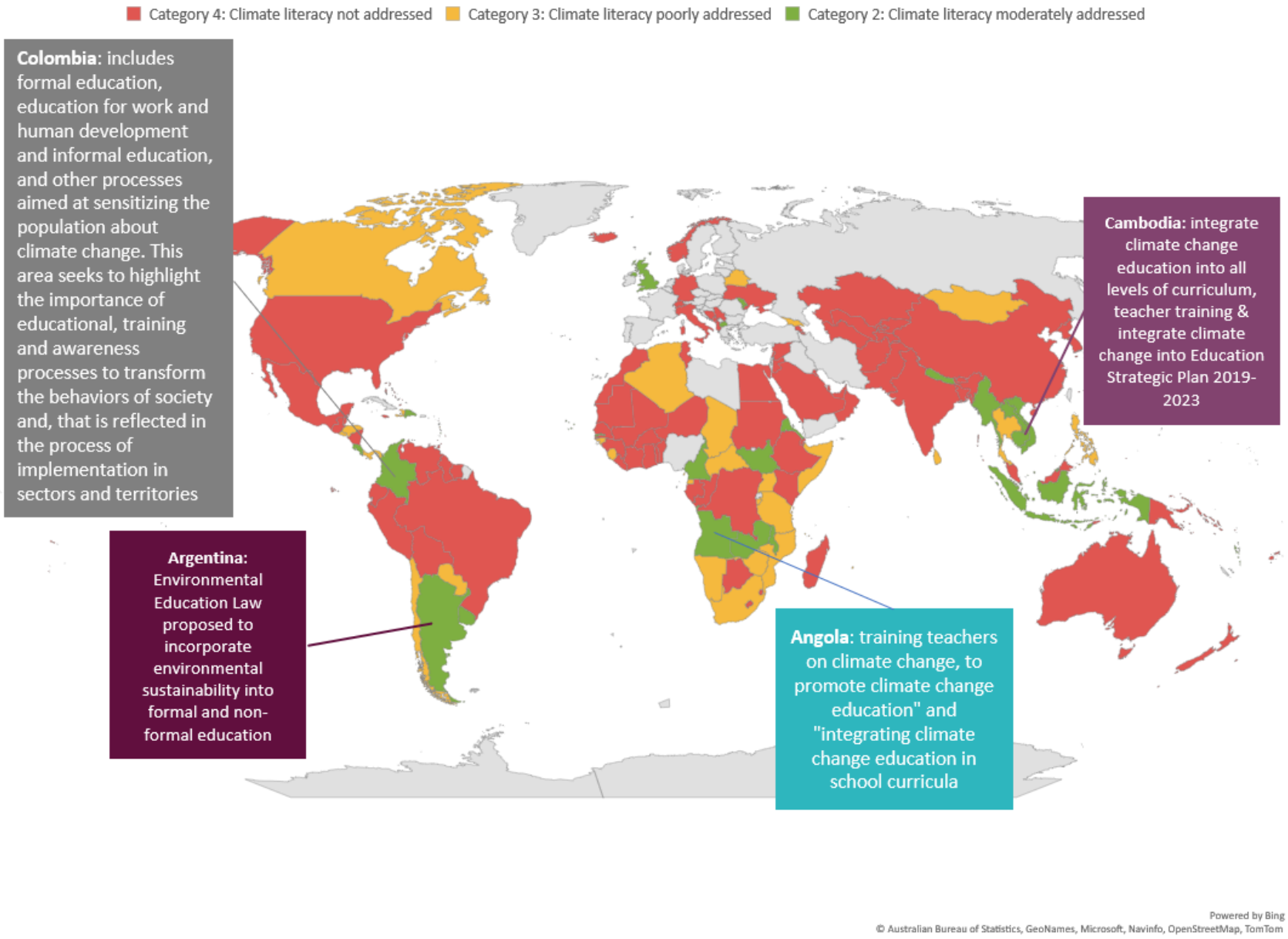
1.1.2 Education integrated into climate change policies and strategies

As with education policies, when education is referenced in climate change policies it is typically a cursory mention or references the need to "raise awareness" or statements related to general learning. In 2014, the UNFCCC:Learn released a guidance note for developing national Climate Change Learning Strategies. This was the product of a three year pilot with Benin, the Dominican Republic, Indonesia, Malawi and Uganda (UNITAR, 2014). The strategies typically reference intentions to integrate climate change into the curriculum, in addition to highlighting capacity gaps for teachers and other education stakeholders in effective implementation. For example, Uganda's Climate Change Learning Strategy (2013, pg.11) lists "integrate climate change learning in the education curricula (primary, secondary and tertiary education)" as the second activity in their action plan, with a recommendation to "strengthen capacity to integrate climate change in the various levels of education" (pg. 12). There are also multi-country climate change policies that include education, or learning, as key components of action plans and capacity building. The East African Climate Change Policy lists education, training and learning as key areas for capacity development.

Nationally Determined Contributions (NDCs, country action plans to respond to the climate crisis) do not typically include substantial reference to education. Where they do, reference is often linked to awareness raising, without consideration for the education sector's urgent needs to adapt to the climate crisis (UNICEF, 2019b, p. 43), or the foundational importance of learning to facilitate resilience, adaptation and mitigation.

The UK Government hosted the 26th Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC), or COP 26, in November 2021. Analysis of 165 NDCs submitted found that all countries failed to "make strong commitments to climate education" (EarthDay, 2021). 29 NDCs included plans for implementing climate education, including using education to promote climate awareness and climate literacy (Argentina and Colombia), and integrating climate change across curricula (Cambodia). 32 countries referenced the importance of climate education but did not provide information on policy initiatives nor plans to implement climate education. The remaining NDCs did not address climate education.

The below heat map visualises the countries meeting the different categories of climate literacy inclusion in their NDCs (EarthDay, 2021). No countries met 'Category 1: Climate Literacy Strongly Addressed'.


Category 4: Climate literacy not addressed
Category 3: Climate literacy poorly addressed
Category 2: Climate literacy moderately addressed
Colombia: includes formal education, education for work and human development and informal education, and other processes aimed at sensitizing the population about climate change. This area seeks to highlight the importance of educational, training and awareness processes to transform the behaviors of society and, that is reflected in the process of implementation in sectors and territories
Cambodia: integrate climate change education into all levels of curriculum, teacher training & integrate climate change into Education Strategic Plan 2019-2023
Argentina: Environmental Education Law proposed to incorporate environmental sustainability into formal and non-formal education
Angola: training teachers on climate change, to promote climate change education" and "integrating climate change education in school curricula
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Source;Earth Day (2021)

Point for consideration

Despite an abundance of policies, strategies and political mandates/statements, there is limited evidence of enactment. One consideration is whether current strategies are too ambitious or complex for the current funding available, or whether there is limited capacity within systems to deliver. This is applicable to all contexts. More research is needed on enactment of policies, including enablers and barriers.

1.2 Ensuring approaches are inclusive

A recent blog by the Population Council emphasized the need to ensure countries embed gender equality into emerging green policies (Pinchoff et al., 2022). Including disability, ethnicity and other protected characteristics should also be considered when developing green policies. Pinchoff et al. (2022), for example, identified a Kenyan government initiative that sought to prepare students for work with green skills. However, the programme was found to "lack a gender focus" and did "not address the negative norms, biases, and stereotypes that result in the "leaky pipeline"—the drop off of girls pursuing STEM as they progress from secondary school, higher education, and into the workforce" (Ibid).

1.2.1 Disaster Risk Reduction and contingency planning

Potentially one of the most established and integrated aspects of climate change adaptation resilience being built into education systems is around Disaster Risk Reduction (DRR). DRR strategies can encompass school infrastructure, curriculum development and teaching approaches. The Comprehensive School Safety framework (CSS) was designed to be integrated into education frameworks from 2012 onwards to support sustainable development, risk reduction and resilience. The below table outlines the three pillars of the framework and the different system stakeholders who should play a role in each.

Table 2: Three pillars of comprehensive school safety (UNISDR, 2017, pp. 4–5)

Pillar	Stakeholders
Safe learning facilities	Education and planning authorities, architects, engineers, builders, and school community members who make decisions about safe site selection, design, construction and maintenance (including safe and continuous access to the facility)
School disaster management	Education sector administrators at national and sub-national education authorities, and local school communities who collaborate with their disaster management counterparts in each jurisdiction. At the school level, the staff, students and parents who are all involved in maintaining safe learning environments. They may do this by assessing and reducing structural, non-structural, infrastructural, environmental and social risks, and by developing response capacity and planning for educational continuity.
Risk reduction and resilience education	Curriculum and educational materials developers, faculty of pedagogic institutes, teacher trainers, teachers, youth movements, activity

	leaders, and students, working to develop and strengthen a culture of safety, resilience and social cohesion.

In 2017, a baseline survey of national policies was conducted in 68 countries in the Asia-Pacific, Africa and Latin America and the Caribbean (Paci-Green et al., 2020). The baseline found that countries, on average, adopted approximately 48% of CSS policies assessed in the baseline survey. Of the three surveyed regions, African countries scored lower than average. The below table outlines the proportion of countries by region and globally that had Pillar 1, 2 and 3 policies.

Table 3: Proportion of countries globally and by region with pillar 1,2 or 3 policies

	Global (N=68) % (n)	Africa (N=25) % (n)	Asia Pacific (N=24) % (n)	LAC (N=18) % (n)
Pillar 1: Safe school facilities				
Safe site selection	66 (45)	56 (14)	63 (15)	83 (15)
School construction monitoring	66 (45)	60 (15)	58 (14)	83 (15)
Funding for school retrofit/ replacement	19 (13)	8 (2)	17 (4)	39 (7)
Policies limiting use of school as shelters	37 (25)	12 (3)	38 (9)	67 (12)
Pillar 2: school disaster management				
National risk reduction or disaster management plan	75 (51)	64 (16)	88 (21)	72 (13)
Mandated fire drills	46 (31)	8 (2)	58 (14)	78 (14)
Teacher training for school disaster management	25 (17)	12 (3)	25 (6)	39 (7)
Pillar 3: risk reduction and resilience education				
Included in national curriculum	65 (44)	48 (12)	75 (18)	72 (13)
Included in teacher training	35 (24)	20 (5)	50 (12)	39 (7)
Public awareness campaigns	68 (46)	48 (12)	88 (21)	67 (12)

Source: Paci-Green et al, 2020

Nepal is cited as an example that has comprehensively addressed school safety (Ibid). Official guidelines for Nepal were created after the Ghorka earthquake in 2015. Guidelines offer tailored school designs for different contexts. The guidelines incorporate a multi-hazard approach to safe school site selection, design, construction and monitoring of construction.

2. Considerations around data and financing for green/resilient system reform

2.1 What data is needed for decision making?

Access to timely data is an important component of decision making for any ministry. The data needed for effective education planning includes climate and environmental change models, population movements, and other contextually relevant data to help with decision making.

For example, Sakti et al (2021) developed a model for land suitability for educational facilities based on hazards in Indonesia. The model included analysis based on the economic value of the land, and on the integration of parameters across three main aspects: accessibility, comfort and a multi-natural/biohazard (disaster) risk index. Using maps of disaster hazards, the authors identified flood-prone areas, and were able to map schools considered to be very high vulnerability to hazards.

Other relevant data will be dependent upon the nature of climate hazards schools are exposed to. For example, in Turkana, Kenya, the National Drought Management Authority monitors climatic data to try and predict when prolonged droughts are likely to occur, enabling them to send out early warning systems to communities (Education Development Trust, 2022). This can help schools prepare for closure, as warnings of drought are typically followed by periods of conflict in the region.

The below table outlines the potential areas where data collection could be beneficial for education sector planning.

Table 4: examples of the types of data needed and potential uses

Type of data	Potential use
Teacher knowledge and understanding of curriculum content	Identify where capacity building efforts are required as part of teacher development planning
Land suitability models	Identify appropriate locations for building new schools or relocating schools that are not in flood zones or likely to face other climate hazards
Monitoring data as part of early warning systems, including risk maps to identify populations at risk of climate hazards	To warn schools in advance where they may need to close due to extreme weather or other social impacts of climate hazards
Health and nutrition	In prolonged periods of drought or flooding, food sources can be disrupted leading to hunger and malnutrition, which impacts school attendance and learning. Monitoring learner and community health is an important component of monitoring the impact on learners and in providing targeted support (e.g., through school feeding programmes)

Socio-economic indicators that help determine poverty levels	Poverty levels impact household ability to pay for school fees and other associated costs. Understanding socioeconomic impacts on households can help with education sector planning.
Education (e.g., enrolment, dropout, gender gaps, disability data etc.)	Strengthening existing data and sharing with other sectors can support effective planning and help determine the impact of climate change on learners

2.2 Financing climate change system reform in education

The information about potential avenues for financing climate change system reform in education is currently limited. The main area funding appears to have been directed is in disaster risk reduction, with a combination of investment from donors and governments. For example, Nepal's Disaster Risk Resilience in schools project was funded jointly by the government and a combination of different donors (ADB, 2018; Save the Children, 2016; and see mapping of donors for Nepal by UNISDR, N.D.).

In addition to country-specific approaches to funding through typical donor channels, there are potential opportunities to tap into funds that are not specific to the education sector. The below table outlines climate change funds that are not specific to education, but could potentially be drawn upon for adaptation, resilience and mitigation measures. It is likely that the requirement for adequate data to support investment in education will be a necessary prerequisite for securing funding.

Table 5: global climate change funds

Fund	Description
The Adaptation Fund	The Adaptation Fund has committed US$850 million to projects and programmes in 100 countries since 2010 (Adaptation Fund, 2022). The fund is committed to supporting the most vulnerable communities, acknowledging the significant resources required to adapt to the changing climate. However, the fund has not yet funded education specific adaptation programmes.
Climate Resilience Fund (part of Climate Investment Funds)	The Climate Resilience Fund does not cite education programmes in their latest annual report. However, the report does indicate where other funding for climate resilience has the potential to positively impact education. The report suggests that by supporting communities to engage in sustainable livelihoods, households have funds that can support education and healthcare (see example on Burkina Faso, (CIF, 2021, p. 27)).
Pilot Program for Climate Resilience	This is a $1.2 billion pilot program for climate resilience to support developing countries and regions in building their adaptation and resilience to the impacts of climate change (CIF, 2017).

Asian Development Bank Climate Change Fund	The Climate Change Fund was established in 2008 to facilitate greater investments in developing member countries to address the causes and consequences of climate change. The fund provides financing through: grant component of investments, technical assistance (standalone and piggy-back or linked to loan) and direct charge. There are three components: (i) adaptation, (ii) clean energy development, (iii) reduced emissions from deforestation and forest degradation and improved land use management (REDD+ and land use) (ADB, 2021).
Green Climate Fund	The Green Climate Fund is mandated to support low- and lower-middle income countries raise and realise their NDC ambitions. The Fund invests in four areas: built environment, energy and industry, human security, and livelihoods and wellbeing (Green Climate Fund, 2021).
Least Developed Countries Fund	The Least Developed Countries Fund aims to support countries to implement their National Adaptation Programs of Action (NAPAs). Priority areas include agriculture and food security; natural resource management; water resources; disaster risk management and prevention; coastal zone management; climate information services; infrastructure; and climate change induced health risks (LDCF, 2022).
Special Climate Change Fund	The Special Climate Change Fund was established under the Convention in 2001 to finance projects relating to: adaptation; technology transfer and capacity building; energy, transport, industry, agriculture, forestry and waste management; and economic diversification (UNFCCC, N.D).

In addition to these global funds, there are also more localised funds that are typically smaller in scale (see example box below of ADA in Kenya). Overall, however, it is evident that education does not feature as a top priority for the largest climate change funds currently active. Benefits to education are perceived as a positive indirect consequence of other interventions that seek to build resilience in communities, by removing some of the barriers to attending school.

Example: The ADA Consortium County Climate Change Fund, Kenya

One example of promising practice is the ADA's County Climate Change Fund (CCCF). The ADA is a consortium of partners led by the National Drought Management Authority. They

work directly with the National Treasury, Climate Change Directorate, National Environment Management Authority, Ministry of Devolution and ASALs and the Council of Governors to align work with national policies and processes and to upscale approaches nationally. The CCCF was successfully piloted in five counties (Isiolo, Garissa, Kitui and Makueni) and is currently being rolled out to Kisumu, Vihiga, Nandi, Bomet, Kisii, Kakamega, Narok and Siaya. The Consortium is funded by a large range of different actors including the Swedish Embassy, the World Bank, UKAid, WomanKind Kenya, amongst others. The CCCF is a mechanism whereby counties can create, access and use climate finance from different sources to build community resilience and reduce vulnerabilities to a changing climate in a more coordinated way. Although not specific to education, this mechanism offers insight into one model for funding climate initiatives with a focus on resilience. The fund has five guiding principles: (1) Community driven, bottom-up planning (2) anchored within supportive devolution, (3) flexible learning approach, (4) focus on public goods investment, (5) inclusion.
(ADA consortium, 2022)

Section B: green/resilient school infrastructure

3. Summary of current evidence and resources on infrastructure

3.1 Why school infrastructure matters

School infrastructure is important for climate resilience, adaptation and mitigation. We know that the condition, location and nature of school infrastructure can affect both access to and impact of education. When schools are well maintained and closer to home, students are more likely to attend (UNICEF, N.D.). Climate hazards negatively impact on attendance due to damage to school infrastructure or the school building not being conducive to effective learning. In 2019, Cyclone Idai damaged or destroyed 3,400 classrooms in Mozambique (UNICEF, 2019a). In 2009 in Yemen, floods caused disruptions to electricity which in turn led to school closures (World Bank, 2013). In a forthcoming study by Education Development Trust (Amenya & Fitzpatrick, 2022), damage to school kitchens in Kenya during high winds and flooding prevented the school feeding programme from being implemented, which led to student absences. Students were forced to learn outdoors in harsh conditions when classrooms were damaged during flooding and high winds. These are a small number of many examples of how infrastructure damage from climate hazards can impede education.

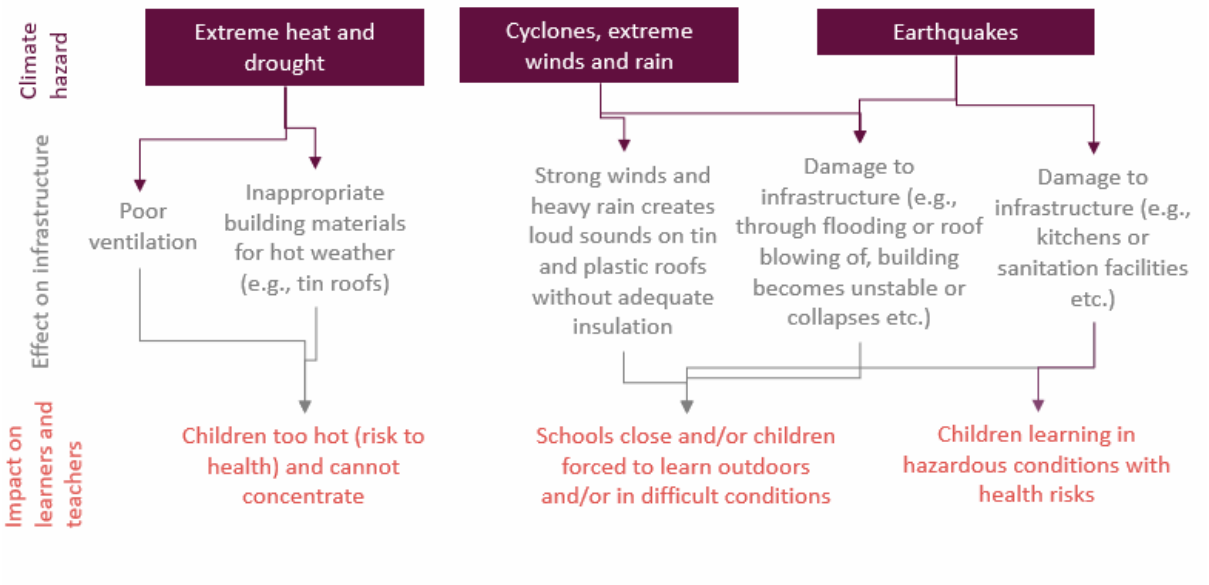

Figure 2: examples of the links between climate hazards, infrastructure and learning

In workshops held as part of the Global Program for Safer Schools, the following factors were considered necessary for success in disaster-proofing schools (World Bank, 2015):

- Developing a national school infrastructure inventory for any long-term strategy for infrastructure safety. This involves the creation of a school infrastructure census that provides insights into the scale of rehabilitation needed to reduce existing risk.
- A physical risk assessment of school infrastructure to help prioritise investments to strengthen school infrastructure.

- Strategies for new construction to build on an institutional and technical assessment of the current school construction environment.

In addition to the importance of infrastructure being resilient to climate hazards to ensure continuity of learning, it also plays a role in teaching learners about sustainability and in supporting climate change mitigation efforts. As noted in the third brief in this series about pedagogy and teaching, sustainable school infrastructure such as school gardens, water conservation systems and solar energy can all play a role in active learning approaches. Schools can also play a role in becoming examples for the wider community in how to live more sustainably.

3.2 Capacities of the education system to respond to climate threats and hazards

Resilient school infrastructure can go hand in hand with sustainable school infrastructure. Many of the techniques that can be used to adapt existing schools, or build new ones, to make them resilient to climate hazards, also involve elements of mitigation and thinking around sustainability. For example, The Ministry of Education of Peru, in 2008, published *A Guide to the Application of Bioclimatic Architecture in Educational Centers*. The guide covers recommendations for schools to adapt their infrastructure that is specific to the climates around the country (Robles et al., 2015). Bioclimatic architecture[1] reduces environmental impacts by considering the environmental conditions of the building's specific location (Robles et al., 2015). The aim of bioclimatic architecture is to ensure optimum comfort levels whilst avoiding air conditioning or heating systems that use energy. Natural heat, light and ventilation are optimised through strategic design such as the position of the building or insulating walls (Ibid). This could also include roof overhangs in warmer climates to support ventilation and allow a natural breeze for cooling. Paci-Green and Pandey (2015) also suggest using coconut tree fibres (or other indigenous materials) underneath tin or corrugated iron roofs as insulation against heat and also sound.

UNICEF, UNESCO, VSO and others have advocated for participatory approaches to risk assessment and the development of action plans in the school environment. Although these action plans go beyond infrastructure considerations, infrastructure is a key component. In Chapter 5 of UNICEF's *Child Friendly Schools Manual*, there is guidance for 'preventive maintenance' of schools that involves teachers and learners (UNICEF, N.D.). This involves teachers working with children to develop plans for monitoring and maintaining school facilities. The plan also considers ways in which children can keep themselves clean and healthy. Preventive maintenance includes: patching minor cracks in slabs before they become big faults in the wall; fixing leaking taps to avoid waste; repairing water pumps before the whole system fails; painting regularly to protect buildings; maintaining safe, clean, separate sanitation facilities for girls and boys; scrubbing and cleaning regularly to prevent grime; planting indigenous trees to provide shade and soil security; maintaining school gardens; and reusing and recycling waste through activities such as composting (UNICEF, N.D., p. Chapter 5, pg. 5). Paci-Green and

[1] Bioclimatic architecture is an approach to designing buildings that is based on the local climate, with the aim of ensuring comfort using environmental resources.

Pandey (2015) suggests that some of these activities, for example landscaping and planting, can be carried out as a local community engagement activity.

Multiple organisations have identified features of sustainable and resilient schools. The below table outlines the ways in which schools can adapt based within key thematic areas relating to infrastructure. Examples of these features being used in practice are outlined in Annex A.

Table 6: Diagnostics and points to consider for sustainable school infrastructure.

Theme	Description/considerations
Location	Predominant climate Proximity to water Location on inclines or slopes Wind direction Shady areas Staff/children proximity to school Located in flood zone Accessible to children with disabilities
Functionality of school spaces	Existing spaces are in good condition Facilities support children with disabilities WaSH facilities Separate toilets for girls and boys
Comfort	Classroom temperature Air circulation Natural lighting Physical condition
Health hazards	Materials inside and outside the school prevent mould spreading Hygienic restrooms Ventilation Acoustic levels Outdoor space
Water consumption and supply	Safe and sustainable water source consumed at school Adequate water supply Guttering for rainwater Rainwater harvesting Sanitary facilities Systems in sinks/toilets to conserve water Water reduction methods Recycling of ‘grey’ and ‘black’ water[2]

[2] Blackwater can be recycled into biogas to provide clean energy for cooking. This contributes to human health by significantly reducing pathogen-polluted water released into the environment. Greywater from showers and kitchens can be treated using reed-bed technology and septic tanks. Although it cannot be used for drinking and food crop irrigation, reed-bed treated water is safe to use for general irrigation and cleaning purposes as well as flushing toilets (UNESCO and UNESCO Bangkok, 2021, p. 9).

Theme	Description/considerations
	Water usage audits
Waste management	School uses recycling Composting in school gardens using food and other organic waste
Safety	Near hillside or slope Located away from flood zone Early warning systems Contingency plans for assessing school vulnerability School system such as electrical and plumbing safety Constructed to resist earthquakes, hurricanes and other natural phenomena likely to take place in context
Energy efficiency	School produces own electricity (e.g. solar panels) Energy conservation measures or initiatives
Environmental impact	School generates a positive impact on surrounding area
Design and materials	School is built using materials appropriate to the region
Leadership and institutional arrangements	Building regulations take into consideration environmental factors School has environmental management policies, environmental committees, or other approaches to managing environmental matters such as strategies, visions, missions or action plans
Participation	Needs of teachers and students and how they are met Students and teachers involved in environmental risk assessment
Techniques used in the community	Whether there are buildings in the local area that have survived diverse range of weather events over many years that could be emulated

Source: (Bizcommunity, 2017; Bonner et al., N.D; Robles et al., 2015; UNICEF, 2012, 2019b, N.D.)

Example of innovation: Solar-powered floating schools in Bangladesh

Extreme floods affect up to two-thirds of Bangladesh each year. Flooding can lead to absenteeism and dropouts from school, in addition to causing unsafe conditions for walking to school. In response to these hazards, Shidhulai Swanirvar Sangstha (an NGO in Bangladesh) began operating floating schools (in addition to other public service buildings such as health clinics and training centres) year-round, with additional boats during periods of flooding. The project has been operational since 2002. The schools collect children from different riverside villages. Once all the children have been collected, classes begin. Boats have classrooms with capacity for 30 students and include resources such as books and laptops with internet connection. They provide basic primary education for up to fourth grade.

(Shidhulai Swanirvar Sangstha, 2022)

3.3 Potential challenges to implementation

Despite there being a multitude of diagnostic tools that can be used to find solutions to build sustainable schools, and to improve existing schools, there are challenges that may prevent these goals being met. The below table combines insights from Cilliers (2019) and Zuniga-Teran et al (2020) on the potential challenges that might be encountered when attempting to implement green infrastructure initiatives.

Table 7: potential challenges in implementing green infrastructure initiatives

Challenge	Description	What is needed?
Design standards	This relates to uncertainty in how best to plan, design, implement and maintain green infrastructure-based approaches. Example of a limitation could be around lack of data relating to performance or value for money of different approaches, or lack of technical knowledge of different contexts	Design guidelines that are specific to local contexts and respond to the specific hazards that may be faced and the availability of natural and sustainable resources. Upskilling of building and design sectors to develop capacity in the different elements of green infrastructure.
Regulatory pathways	Few jurisdictions globally have clear regulatory guidelines for green infrastructure and its potential benefits	Legal arrangements need to have clarity in the distribution of responsibilities and the sustained maintenance commitment in the long-term
Socio-economic	Although promoting social equity is present in most resilience initiatives, in practice, it is often not effectively achieved. For example, vulnerability to floods is typically greater in low-lying regions, but this does not necessarily determine the risk. The areas in cities, for example, that are low-income, typically have less access to green space and vegetation compared to wealthy neighbourhoods, which can counteract any locational advantages	Public participation has been identified as a critical component in implementing decisions that could affect disadvantaged populations
Financing	The cost of not investing in resilience initiatives – or the cost of no action – is increasing as climate change unfolds. However, there are currently insufficient mechanisms to reliably estimate the potential costs and benefits of green infrastructure technology. Green infrastructure can also be viewed as a luxury good rather than a necessity. This was found to be particularly true in rural African contexts where budgets were allocated for basic needs.	Cost-benefit analyses to be conducted and shared to help identify the most cost-beneficial solutions to green infrastructure and responding to different climate hazards

4. Considerations around data and financing green/resilient infrastructure

4.1 Data

This section outlines considerations for the types of data needed to support decision making on green and resilient infrastructure. The level of data included in the literature is variable, and there is arguably a need for greater transparency in sharing data to support evidence-informed decision making. The below table outlines the different types of data that would be beneficial in decision making around green and resilient infrastructure.

Table 8: examples of types of data needed to make decisions about green/resilient infrastructure

Data required	Description	Example (where available)
Data on the impact of learners	• Data on the negative impacts to provide rationale for investing in resilient infrastructure: children missing school as a result of climate hazards closing school or affecting safety travelling to school. This should include information about the type of hazard, duration and any lasting impact on learners. • Data on adaptive strategies with positive impact: connecting developments in resilient infrastructure initiatives to learner outcomes, such as school attendance. Data should be disaggregated by gender and disability at a minimum, to help determine disproportionate impact to support more targeted interventions. Additional disaggregation based on vulnerability will be required based on local relevance.	There is overall more evidence on the negative impacts than the positive. Data on positive impacts of infrastructure interventions rarely disaggregate by gender or disability. Positive example: the implementation of rainwater harvesting in Nandi County in Kenya was found to increase school attendance in the 21 participating schools from an average of 70% to 100% (Camellia PLC, 2018). The project reported a particularly large increase in girls attending due to improved WASH facilities.
Data to support the selection of green infrastructure approaches	Data about specific approaches that can be adopted for specific problems, with data on the context to support considerations on suitability in different contexts. Data on the durability of different approaches (i.e., if recycled plastic bottles were used to build a school, did the building withstand climate hazards).	UN Habitat (2012) have produced resources with examples from different contexts on green infrastructure using locally sourced materials and building techniques, including cost-benefit analyses.

Data required	Description	Example (where available)
	Technical capacity needed to implement approach Level of effort to implement Typical cost of intervention relative to local average income	Overall weak evidence in this area, though potentially more learning from other sectors.

4.2 Financing

Example: School Rainwater Harvesting Project in the Seychelles
The School Rainwater Harvesting Projects in the Seychelles, funded by local and international donors, was launched in 2009 in 10 schools, and has since expanded. It is jointly coordinated by the Environmental Education Unit in the department of Environment and the Public Education and Community Outreach in the Environment Department. Schools reportedly store 2000 litres of extra water per month, with schools also reportedly reducing their water bills. One school in the project reported a saving of R13,423 per month (approx. £800). (Seychelles Nation, 2012)

There is limited literature on overarching financing options for resilient infrastructure. The majority of the projects reviewed for this paper were funded by local NGOs, private corporations or UN programmes such as UN Habitat. For example, rainwater harvesting in Kenya was funded by a private limited company, Eastern Produce Kenya (Camellia PLC, 2018). Even when funding channels are disclosed, there is rarely a clear breakdown of project cost, return on investment or value for money.

A UN-Habitat handbook on “going green” outlines the cost-effectiveness of various sustainable housing practices that can also be used in school settings (UN-Habitat, 2012). However, as this publication is now ten years old, the figures included are likely no longer accurate. The level of detail included demonstrates the type of financial data that would be beneficial for decision makers. For example, the report outlines a project building affordable, durable, and culturally, ecologically and economically sustainable building stock in Papua New Guinea, outlining the cost per m2 of construction in the report (Ibid, pg. 84). The report also indicates average annual income to place these figures in local perspective. There are also models available for supporting the costing of resilient schooling, such as the The Education Policy and Strategy Simulation Model (EPSSim) that has a supporting module for costing child-friendly schools (UNICEF, N.D.).

Overall, however, greater transparency is required in the funding and reporting of resilient infrastructure, with learning required from outside the education sector. It was not within the scope of this review to determine what can be learned from other sectors, but it is likely that there are more advanced models and approaches outside of education that should be consulted.

5. Identification of gaps in green/resilient infrastructure literature

The below table outlines the thematic areas where more research and/or robust data is required to facilitate decision making. Some of these points have been outlined in the text above.

Table 9: gaps to be addressed in green/resilient education infrastructure

Thematic area	Gaps
Financing	• Typical cost of each type of intervention • ROI and VfM for each type of intervention
Technical capacity	• Technical capacity required to implement • Level of effort required for different interventions
Data	• Impact data that is disaggregated by gender and disability – exists to some extent but inconsistent, particularly for disability • Positive impact of interventions on education (i.e. improved school attendance as a result of improved infrastructure) • Long-term data on whether interventions have continued to work

Section C: curricula, pedagogy, assessment and teacher development

6. Summary of current evidence and resources on curricula

For the purpose of this brief, it is important to note that UNESCO and UNFCCC distinguish between education and training (UNESCO and UNFCCC, 2016, p. 3, based on UNFCCC, 2005, Article 6, in Reid, 2019). Although both are categorised as having the same objective; 'to foster a better understanding of, and ability to address climate change and its effects' the aim of training is said to be to develop practical skills, whereas education is to change habits in the long term (Reid, 2019). To align with this, green skills training has not been included in this brief.

6.1 Challenges of 'climate change education'

Defining climate change education itself has been identified as a challenge in several literature reviews (see Monroe et al., 2019 and Rousell & Cutter-Mackenzie-Knowles, 2020). There are continued contentions about what constitutes climate change education as distinct from environmental education, science education or education for sustainable development (ESD). This has led Rousell & Cutter-Mackenzie-Knowles (2020) to report climate change education as an independent subject, a 'relatively nascent and under-theorised area of inquiry' with limited literature available. They also distinguish between views of climate change education as formal curricula, behaviour change, or adaptation/mitigation, although for this brief all three have been addressed as interlinked.

People's understanding of climate change education is intrinsically linked to their beliefs about the aim of such an education, which impacts on how it is taught. Those focused on addressing scientific misconceptions see climate change education as conveying factual knowledge (as noted by Monroe et al., 2019), whereas for those who equate climate change education with eco-justice, the goal is to give youth agency and address global inequities that have led to the lowest polluters experiencing the worst impacts (Kruger et al., 2020). Such differing interpretations makes the available literature itself a challenge to review, particularly when areas of dissent are the result of a differing understanding of the essence and goals captured under the broad banner of climate change education.

Vongalis-Macrow (2010) refers to the tension around socio-scientific research, that is, research which 'aims to investigate the way that scientific propositions are incorporated into opinion making about a particular social problem which has a scientific dilemma at its core' (Sadler, 2005 referenced in Vongalis-Macrow, 2010). She highlights the challenge of using facts as a basis for action and social change in climate change education, and cites studies which have identified issues with students' ability to evaluate and draw upon scientific evidence when justifying their views (e.g. Levinson, 2006). These challenges also arise when interpreting the

aims of climate change education for the purpose of improving resilience, adaptation and mitigation to climate change, because such a goal necessitates action as a result of learning.

Pruneau et al. (2010) further identifies three challenges around climate change education:

- First, cognitive challenges around misconceptions, an awareness of climate change that was not part of 'everyday priorities', confusion around mitigation versus adaptation and differences around who was responsible (p.16). Forming links between the 'interdependent components that mutually affect each other' was a further cognitive challenge, particularly when they are challenging to perceive or happen in remote areas, thereby limiting experiential learning.
- Second, social/psychological challenges arise in terms of people's reactions when faced with anxiety, with focus on meeting immediate needs leading people to busy themselves with day-to-day problems at the expense of potential future events.
- Third, behavioural challenges because mitigating and adaptation require individual and collective behavioural change, which takes time and can require shorter term sacrifices.

This brief focuses on curriculum, student learning and assessment for the purposes of improving resilience, adaptation and mitigation to climate change and associated environmental degradation.

Point for consideration

The majority of children in schools in low- and middle-income countries are learning very little. Since COVID-19, it is now estimated that over three quarters (76%) of children in low- and middle- income countries will not learn to read adequately by the end of primary school, a 20% increase to pre-pandemic levels (World Bank, forthcoming). This report should be read with this context in mind, calling into question whether climate change education is a luxury in low- and middle-income contexts. As Newman (2021) pointed out, there is a danger that in trying to tackle the learning crisis and climate change education at the same time, neither goal will be achieved. A key question to consider is therefore 'what is it essential for learners to know, and how can this be determined on a context-by-context basis?'. There is a strong argument for solving the learning crisis through ensuring all learners have strong foundational skills, which will be an essential prerequisite for learners engaging with climate change content. It is also arguable that the responsibility for climate change education should lie with high-income countries, who are responsible for a significant proportion of global emissions.

The below table outlines potential characteristics of effective climate curricula, as identified in the literature. It is important to note, however, that what is considered 'effective' is inconsistent and often not defined at all. Approaches draw on beliefs about effective practice in curriculum development more broadly, adding in specific insights relevant to climate change education. There also appears to be limited assessment of capacity constraints within the education system when considering curriculum design (e.g. resource constraints and teacher capacity to deliver content).

Table 10: approaches to integrating climate change into curricula

Approach	Description
Teaching at the right level	Although not specifically mentioned in much of the climate change literature, Teaching at the Right Level has been included as an arguably important component in ensuring learners have the appropriate foundational skills to interact with information on climate change (see website for details on approach TaRL, 2022)
A contextualised, place-based approach to climate change curricula	One of the critiques of current curriculum content in lower- and middle-income contexts is the limited relevance of what is being taught to learners (see Amenya & Fitzpatrick, 2022 in Turkana, Kenya; Ghosn-Chelala & Akar, 2021 in Lebanon). Monroe et al (2019) in their systematic review of the evidence identified localised and relevant information as one of the most common themes across approaches to the curriculum in all contexts. This does not necessarily mean that global concepts of climate change cannot be taught, but that they are taught in a way that connects to the learner. This needs to be considered on a context-by-context basis for what is most relevant and appropriate for learners.
Cross-curricular approach	The majority of the literature (*Climate Generation*, n.d.; Schreiner et al., 2005; UNESCO, 2016) suggests that a cross-curricular approach is best, being one that seeks to develop scientific understanding whilst also teaching about the social, political and economic structures. "Real-world environmental problems do not easily map onto curriculum subject areas, and it is increasingly evident that no academic discipline or field of practice can address environmental challenges alone" (Alonso-Yanez, 2017, p. 99).
Support a basic understanding of scientific concepts	According to Anderson (2010), an understanding of the scientific concepts, along with a knowledge of the history and causes of climate change, are needed. This should be combined with the skills to distinguish between 'certainties, uncertainties, risks and consequences of environmental degradation, disasters and climate change; knowledge of mitigation and adaptation practices that can contribute to building resilience and sustainability; understanding of different interests that shape different responses to climate change and ability to critically judge the validity of these interests in relation to the public good' (p.10). This is supported by Rousell & Cutter-Mackenzie-Knowles (2019), who in their systematic review reported that a number of studies between 1993-2014 indicated that 'young people's understandings of climate change are generally limited, erroneous and highly influenced by mass media' (p.191). Monroe et al (2019) also identify that, particularly when teaching more controversial topics within climate

Approach	Description
	change education, content should be designed to 'uncover and address misconceptions about climate change' (p.801).
Experiential and active	Anderson (2012) recommends that the curriculum be sustained and active, providing continuity to students and anchored in a practical curriculum focused on application. This is supported by Monroe et al's 2019 review, in which it was concluded that effective climate change education is personally relevant and meaningful, engaging for learners, enables learners to experience the scientific process and uses personal, school, and community projects to build skills. Rousell & Cutter-Mackenzie-Knowles (2019) further add that studies have found that scientific-based didactic approaches towards climate change education alone have not been effective in transforming the attitudes or behaviour of young people. It should be noted though that the literature shows dissent between knowledge-based (as covered in the previous point) and interdisciplinary experiential approaches to climate change education, particularly at the primary and secondary level. More detail about how such a curriculum could be delivered is covered under the pedagogy section below.
In contexts where there is a risk of climate hazards, disaster risk reduction strategies should be integrated	Disaster risk reduction (DRR) education is one of the most established approaches to taking adaptive action at a local level in response to climate hazards. Countries such as Nepal, Vietnam and the Philippines have developed cross-sectoral approaches, with curriculum integration being a core component. DRR education must be situated within wider policy frameworks and strategies that address contextually relevant risks. Providing children and young people with the skills to respond to disasters is arguably an essential component of education in contexts prone to risk. Nepal promotes resilience teaching and learning, whereby students learn new knowledge and skills about how to prepare for and respond to disasters to change behaviour, manage risk and reduce vulnerability to hazards such as floods, earthquakes and violence, thereby building adaptive capacity.

7. Summary of pedagogical approaches

Pedagogy includes teachers' knowledge, beliefs and attitudes, and so is broader than teaching practice alone (Westbrook et al., 2013). This is particularly relevant to climate change education, where, as already noted, teacher beliefs about the goals climate change education affect what and how they teach. For example, Monroe et al. (2019) highlight how 'the distinction between 'just the facts' and 'also the actions' may separate some science educators from environmental educators, but also may highlight the point at which educators believe a fundamental science

topic becomes political, and therefore too close to advocacy for classroom educators to address' (p.792). Further examples are given about those who may focus on practical problem-solving skills to adapt or those who prioritise the ethical side of climate change education. Vongalis-Macrow (2010) also raises the challenge of socio-scientific teaching about climate change where there is so much political rhetoric and varied solutions.

The argument has been put forward that the 'distinct qualities' of climate change necessitates a rethink of traditional pedagogies (see Vongalis-Macrow, 2010, p.238). The education outcomes of climate change education are, for many, much broader than understanding scientific principles. Vongalis-Macrow, for example, defines climate change as a public health issue, impacting all of humanity and compares it to public campaigns about healthy lifestyles and active citizenship. Pruneau et al (2010) promotes a version of Fraser and Greenhalgh's pedagogy of complexity to climate change education, which necessitates the development of capabilities ('the extent to which individuals can adapt to change, generate new knowledge, and continue to improve their performance') rather than mere competence ('what individuals know or are able to do in terms of knowledge, skills, attitude') (Fraser & Greenhalgh, 2001).

One of the challenges in selecting appropriate and relevant pedagogical approaches to include in this brief is that there is scant evidence available to justify the use of commonly cited approaches. Again, much of the literature also comes from higher income contexts and advocates for learner-centred pedagogies which are more widely implemented in these contexts. The pedagogical approaches recommended often include assumptions about minimum resources available to teachers, making them difficult to apply to many low-income contexts. One of the key challenges with lower-income evidence noted by researchers such as Monroe et al (2017) is that the evaluation of projects is not often published or even made public, making it difficult to both identify and evaluate the evidence.

7.1 An overarching constructivist learning theory

Constructivist learning theory underlines many of the pedagogical approaches adopted in the literature. Constructivist learning implies that students build knowledge rather than passively receive it. The approach is by no means new, with Monroe et al (2019, pg. 804) referring to results which showed higher learning from resources using Aebli's 1983 criteria.

Based on the evidence from the selected articles, together with their relevance to mitigation, adaptation and resilience, the below table outlines the pedagogical approaches that have been shown to be effective when teaching climate change education. In reality, there is often significant overlap between these approaches, particularly when implemented in the classroom (e.g., experiential learning through group work which is focused on future education and concludes by engaging the local community). However, they are also approaches in their own right and so addressed individually below.

Table 11: overview of frequently cited pedagogical approaches in the literature

Approach	Description
Experiential learning	McLeod (2017) outlines the steps of an experiential learning cycle: Concrete experience (having the actual experience). Reflective observation (reflecting on the experience). Abstract conceptualisation (learning from the experience). Active experimentation (trying out what you have learned)
Futures education	Futures education is defined by Vongalis-Macrow (2010) as education which 'specifically focuses on immanent perspectives and problematizing about the future' (p.243). The uncertainty and intangibleness of climate change makes the ability to predict impact and imagine scenarios affecting student lives key to bringing the future into the present. With the notion of time being a 'critical factor in moral reasoning and decision making' (p.243), this approach can help students to understand and accept that climate change will impact on their lives. The effectiveness of the Futures approach is echoed by Pruneau et al (2003), who reported that such an approach encouraged students to feel empowered by realising that they were able to affect their future.
Inquiry and problem-based approaches	According to Monroe et al (2019), literature shows that the effectiveness of inquiry-based approaches lies in how such activities enable students to a) develop their own knowledge and b) use this knowledge to generate conclusions. They refer to research by McNeal et al (2014), who found that inquiry-based activities improved students' understanding of how complex systems interact as well as increasing conceptual knowledge. Pruneau et al (2010) explains an environmental problem approach as 'determining each of the problem's traits (causes, location, actors, local vulnerability, impacts, and so on) as well as stating the problem many times, to properly define the initial situation and the goals to be reached' (p.22).
Group work and deliberative discussion	According to Monroe et al (2019), student engagement without interaction does not lead to learning gains. Holthuis et al. (2014) suggested that, although they found that interaction is key to learning, it is epistemic discussions, or 'how do we know talk' (i.e. talking about how we arrived at our current understandings of climate change) which requires students to justify and support their claims with evidence, which is particularly effective. Monroe et al (2019) also found deliberative discussion to be an effective approach to address misconceptions amongst students. The deliberative element refers to 'nudging' from the teacher through dialogic interactions to enable students to express, compare and critique ideas through group discussion. An example was given of how students were able to address misconceptions about the relationship

Approach	Description
	between the ozone layer and climate change because of their own discussion, supported by their teachers.
Engaging the community	According to Pruneau et al (2010), the community is central when focusing on climate change and adaptation. They stress that action must come from members of the community, who would need to work together and use community resources to predict future impacts and adapt accordingly. Therefore, climate change education with the goal of adaptation should be embedded in a wider community process. Monroe et al (2019) also highlighted the behaviour change which can come about when students learn through community action projects, with the sharing of information with the local community being a way of increasing student engagement.
Use of visual imagery	The use of visual imagery has been recommended by Monroe et al (2019), who cited several studies showing that learning increased amongst those who watched videos or, for those without access to technology, had access to drawings or cartoons. Note though that 'increased knowledge' does not necessarily equate to behaviour change. Pruneau (2010) also refers to research which found that using visual representation tools can enable people to formulate local environmental problems.

7.2 Children as agents for change

One of the core aims of these approaches is to instil hope in students, and to help students become agents for change. Mitchell et al (2009) explored the role of children as agents for change in disaster risk reduction in the Philippines and El Salvador. In both contexts, children were encouraged to raise awareness of disaster risk in their local communities. It was found that children were able to influence their communities to act upon identified risks such as landslide risk threatening to destroy the school. The study identified the following key takeaways from both contexts in adopting a child-centred approach to risk reduction (Mitchell et al., 2009, pp. 38–39):

- Children's families are crucial actors in implementing child-centred DRR as households have the same political dynamics as wider society.
- Experience from El Salvador suggests that making progress with addressing low magnitude, high frequency events give children's groups confidence, cements their position and agency within their community and provides a launch pad to stronger relationships with other bodies.
- Children's voices on DRR in wider policy spaces, both within the community, regionally and nationally, is dependent on the existence of functioning institutions on DRR and the willingness of key actors within these institutions to value the voice of children and willingness to give them a platform to participate.

Other studies have demonstrated the ability of children to influence their households in practices such as effective water management. Okyere et al (2017) investigated an intervention where Ghanaian youth aged 12-16 were trained in school on using water testing equipment to assess

the quality of water in their households. Results showed that children equipped this way educated other household members on hygiene problems and on how to keep drinking water clean at home and in the field.

A forthcoming study from Education Development Trust (Amenya & Fitzpatrick, 2022) reinforces the points identified by Mitchell et al (2009) in considering children as agents for change. There is a need for advocacy work and sensitisation to take place at a household level and beyond to change perceptions of the value of children's inputs and knowledge on DRR and wider environmental issues. The Education Development Trust study identified a gendered lens to this, where boys were considered to have more knowledge on climate change than girls, despite this not being evident in the data collected. This suggests a need to embed gender sensitisation training with any strategies aimed at disseminating important information to communities through learners.

Example: Beekeeping to foster resilience

"Forests act as carbon sinks and play a major role in stabilizing the climate. Deforestation has posed a major threat to forests, resulting in ecosystem and biodiversity loss as well as ecosystem services. Recognizing that forest restoration has vast potential to contribute towards reducing the impacts of climate change, a beekeeping initiative was initiated by Kanga Hill School students, located beside the Kanga Forest reserve in Tanzania's Nguru Mountains. The school identified critical issues pertaining to low income, unsustainable use of forest products, biodiversity loss, and water scarcity through participatory environmental assessment, conducted by students with community support. The project showcased a successful model of community-based adaptation through initial installation of 41 beehives adjacent to the forest reserve, jointly managed by students, teachers, and community members. The students worked with the community from the design stage to planning and preparation of beehives. The apiaries helped protect vegetation by discouraging people from entering the forests. The harvested honey is used for food, medicinal, and commercial purposes. The overall initiative led to better management of forests and biodiversity as well as increase of income for the school and resident groups. The school believes this has potential to further increase forest cover and water security. The initiative also served as a learning hub for the students and demonstrated a partnership model for forest conservation. The project is now being adopted by other Tanzanian schools, as well as families, community members and active youth groups."
(Singh & Shah, 2022, p. 17)

7.3 Whole school approaches

Within the above pedagogical approaches are opportunities to learn in a broad range of environments beyond the classroom. Whole-school approaches tie in with infrastructure, as approaches to learning often draw on the school environment (e.g. using data from solar panels in maths lessons). Holistic approaches to climate change education argue that best practice should encompass the whole school environment in addition to the wider community (Bieler et al., 2017; Hargis et al., 2021; Henderson, 2019; UNESCO, 2016). Multiple models of whole

institution approaches have since been developed that seek to identify the core areas where climate change education can be integrated.

Example: FEE Eco-schools
'Eco-schools' is an approach that encourages learners to engage in real-world learning opportunities. Eco-schools is operated by the Foundation for Environmental Education, and there are an estimated 56,000 eco-schools across 70 countries globally (Eco-schools, 2022). The approach of eco-schools typically involves practical, outdoor and community-oriented learning with the aim of developing skills that can benefit both students and the wider community. Activities can include:

- Poultry keeping
- Gardening
- Growing vegetables
- Water conservation (typically rainwater harvesting)
- Skills related to sustainably manufacturing household products such as soaps and paper bags
- Beekeeping
- Tree planting

Eco-schools, in their community outreach approaches, often include changing local attitudes towards both education and the environment. Linking to learner agency, eco-schools often have elements that encourage learners to become involved in the development of school environmental action plans and risk assessments. This is in itself an educational act to help learners engage in identifying proactive environmental behaviours in their school, but also in ensuring accountability.

Source;Eco-schools, (2022)

Part of the whole-school approach includes linkages with the local community. This also ties in with agency. In Adams et al. 's (2020) study on the non-formal sector eco-programme, the programme was found to foster a positive relationship with the local community, where parents trusted knowledge gained by their children in the clubs and positively adapted their behaviour. Other studies however, such as Eilam and Trop (2013), found that community relationships between the school and local community were often not sustained due to conflicting, changing and entrenched values systems across generations.

Example: Vegetable cultivation to meet the need for fresh farm produce as part of FEE eco-schools project
The school, 'Every Child Counts,' is located on Abaco Island in the Bahamas. The Abaco Island was badly impacted by Hurricane Dorian in 2019, with the school building destroyed. Local farms were also destroyed, affecting the ability of locals to acquire local produce, particularly vegetables. In this school, students started growing their own vegetables from table scraps, providing families with fresh local produce. The initiative initially started with one class and has since spread to all classes involving 82 students and their families.

(Singh and Shah, 2019, pg.33)

8. Summary of professional development: the skills, knowledge, attitudes, beliefs and behaviours to effectively implement climate change education

There are a range of challenges cited in the literature regarding teachers' readiness to effectively implement climate change education. These are summarised in the table below.

Table 12: challenges in teacher professional development for climate change education

Issue	Description
Widespread teacher misconceptions	The largest body of literature relating to teacher capacity and development needs for environmental education in low- and middle-income contexts typically focuses on the expanse of teachers' knowledge and teacher misconceptions about climate change. Multiple studies in a range of contexts have tested the knowledge of teacher trainees and existing teachers, often finding teachers hold common misconceptions or have limited knowledge of climate change.
A lack of training on how to teach climate change	A recent study by UNESCO (2021) found that although most teachers surveyed believed that teaching about climate change was important, only 42% believed they were "very ready" to teach ESD and Global Citizenship Education themes. Cross (2019) found that teachers report not having received any training in integrating education for sustainable development into their subjects, with the approach to implementation coming down to teachers' own beliefs. A forthcoming study by Education Development Trust (Amenya & Fitzpatrick, 2022) in Turkana, Kenya, found teachers and headteachers felt they needed more training on the components of the curriculum that related to climate change, particularly in how to make the content more relatable and relevant to learners.
Limited confidence to effect change	Teacher beliefs about the limitations of their ability to effect change, or the structural challenges faced in tackling climate change, can also inhibit adoption of effective climate change education. Darmawan and Dagamac (2021) interviewed teachers in Indonesia on the enablers and barriers to teaching climate change education. They found that teachers believed student attitudes, societal apathy and ignorance and the ecological damage caused by government implementations were amongst the greatest challenges. A study by Cross (2019) in Trinidad and Tobago on primary school teacher perspectives on education for sustainable development found that teachers felt that "postcolonial residue" impeded the nation's efforts for sustainable development, which carried through into the curriculum.

Issue	Description
Unclear linkages between teacher characteristics and knowledge about climate change	Much of the research attempts to find linkages between teacher characteristics and knowledge and beliefs in relation to climate change and wider sustainability issues, with often mixed results. Whereas some research identified that teacher gender may impact knowledge and understanding (for example, McCright (2010) found women were more likely to be concerned about climate change than men), other studies (for example Olatumile (2013)) observed no difference in knowledge and understanding by gender. Similar opposing findings have been found in relation to age and teacher qualification levels (for example, Bozdogan (2011) and Hegde et al (2012) observed that level of qualification had no influence on teachers' knowledge and understanding about climate change, whereas Baker and Loxton (2013) found the opposite to be true for the same variable). Anyanwu and Le Grange's (2017) study in South Africa found that gender, age, teaching experience and teaching grade all significantly influence Geography teachers' literacy about climate change science, but qualification level and specialisation did not.
Impact of teacher training	Teacher training in the literature for lower income and middle-income countries is typically cited as through individual workshops or other 'one-off' events that are not conducive to what is known about effective teacher continuing professional development. Some studies do indicate positive results from such training events, though evaluation methods are often limited and do not follow up what takes place in the classroom. Mickelsson's (2020) qualitative exploration of a Re-Solve participatory workshop with teachers in Tanzania found that teachers sharing their own experiences of integrating education for sustainable development supported contextually relevant scaling with teachers showing willingness to adopt new ideas. However, there was no long-term follow up of participating teachers to determine whether the model resulted in any differences in teacher practices.

8.1 Areas for more research and development on teacher training

Much of the evidence found on effective strategies for climate change education equates to effective teaching in general. Engaging learners, personalising, contextualising and making learning relevant, active, inquiry-based and experiential learning and groupwork are all strategies applicable across subjects. One key area, for lower- and middle-income countries, would be the provision of effective teacher professional development to encourage student-centred active learning.

To enable teachers to address misconceptions held by students they themselves need to have a robust scientific knowledge of climate change. As well as an accurate knowledge of concepts, teachers need critical thinking skills to be able to identify authoritative information and guide

students to develop such skills. This is particularly important where areas of contention around climate change persist.
According to Vongalis-Macrow (2010), pedagogical strategies which promote systemic awareness and systemic change are necessary to enable students to construct more tangible ideas about the future (p.243).

Vongalis-Macrow (2010) points out that teachers need to know what causes behaviour change and how to incorporate this into teaching and learning. She also highlights the usefulness of agency and social action theories; which focus on the individual within a social context (p.245). This links to both the role of the community in mitigation and adaptation, and the possible influence that students may have on their communities, along with the role of positive and empowering communication about climate change.

Pruneau et al. (2010) draw out explicit skills necessary to improve adaptation change. As well as concepts related to climate change itself, they add 'the scientific knowledge that is endogenous to local ecological and social problems, knowledge of community resources that can facilitate adaptation, as well as the knowing adaptation means. In addition, if citizens are to succeed in implanting efficient adaptation measures, it is insufficient to only reinforce their knowledge' (p.21). They also highlight skills needed to manage adaptation measures, such as technical, mathematical and analysis skills along with the ability to forecast risks and undertake vulnerability analyses and sustainable decision making. For sustainable long-term adaptation strengthening it appears that the remit goes far beyond generic teacher training.

9. Student learning and assessment

The core competencies and knowledge students should learn and how this learning should be assessed is directly linked to the overall purpose of climate change education. If the goal of climate change education is to improve resilience, adaptation and mitigation to climate change and associated environmental degradation, it can be assumed that a successful outcome is behaviour change. This is supported by UNESCO (UNESCO and UNFCCC, 2016, p. 3 based on UNFCCC, 2005, Article 6) which articulates the goal of climate education as the 'change [of] habits in the long term'. Knowledge assessed through a traditional assessment cannot guarantee improved capacity to be resilient against, adapt to and mitigate climate change, with multiple studies having found that knowledge about climate change alone does not lead to adaptive or mitigating behaviours (for example, Plutzer et al., 2016 in the US). Anderson (2012) found a lack of evidence-based research into behaviour change, particularly longitudinal studies to demonstrate the impact of longer-term behavioural change because of climate change education. This makes assessing student learning in terms of behavioural change more complex than through a traditional school-based written assessment. Overall, there is a lack of robust evidence on the effect of a curriculum on longer term student learning as translated into behavioural change (rather than short term knowledge gain).

A further point to consider for evidence from low-income countries is how climate change education has been delivered and who by. Much of the evidence found (and included as case studies throughout this brief) is from project-based interventions implemented by NGOs in the non-formal education sector rather than state-led education fully integrated into a national

curriculum. Project outcomes include keeping drinking water clean (Okyere et al 2017) or learners taking home key skills to caregivers (Copsey, 2019). Whilst the strength of these outcomes is that they do focus on behaviour change (albeit short term), there is no evidence of these outcomes being scaled up and integrated into a national school curriculum, making it unclear how they could be realistically assessed by teachers rather than outside agencies.

Although disaster risk reduction is an example of an area which has been more fully integrated into the curriculum, particularly in countries such as the Philippines and Nepal, it is much more established than climate change education. Assessments are typically focussed on whether learners absorbed the knowledge that can help them mitigate against risk and are less focussed on learning levels.

10. Considerations around data and financing

Information on financing is particularly limited for this topic. The below table outlines considerations for leveraging off existing funding in the areas of curriculum and teacher training.

Table 13: considerations around funding

Thematic area	Considerations for funding
Curriculum	Curriculum reform can be costly and time consuming given the wider cost implications beyond changing the actual curriculum (e.g., changing textbooks, training teachers on curriculum content etc.). There is no evidence that adopting a curriculum solely for climate change will produce the best outcomes (though there is also no evidence against this). Climate change education could be considered during existing reforms, or through supplementary resources that complement opposed to adding to the curriculum. The most appropriate approach will need to be decided on a context-by-context basis.
Teacher training on pedagogical approaches	The majority of pedagogical approaches referenced in this report are those that are already advocated for in other subject areas/disciplines. Climate change advocates could leverage existing programmes at both pre- and in-service level that are focussed on student-centred learning, by infusing training programmes with examples and content about climate change.

Collecting more data, and sharing that data, will arguably support efforts around financing. If certain approaches are proven to be effective, this will support rationales for financing climate education initiatives.

Example: SROI data for effective decision making

In Copsey's (2019) report on the Social Return on Investment (SROI) of Eco-schools in Africa, funded by the Danish Outdoor Council, multiple case study schools identified improved attitudes towards education, learners taking skills home to caregivers etc. as being key programme outcomes. By learners bringing home practical skills around agriculture, water harvesting, and other similar actions, it was believed that parents could see wider value in education due to what children were learning in school being useful to the household.

The author calculates SROI using information about investment through recurring and non-recurring costs, against identified project returns. Returns are identified as micro-projects initiated from the initial investment (over 3 years) and extra time accrued to the project implementation. For example, the author identified that in Queen of Peace boarding primary school in Kampala, there were less absences per term, additional teachers and teachers volunteered additional time at the school. In St Kagwa boarding primary school in Bushenyi, fewer learner absences were also identified, in addition to improved teacher attendance and greater community cooperation. The author was able to calculate cost savings and returns for the schools using these and other metrics.
Source;Copsey (2019)

11. Gaps and limitations

This section of the brief focused on curriculum, student learning and assessment to improve resilience, adaptation and mitigation to climate change and associated environmental degradation in and through education. There are also other purposes of climate change education which can be considered, such as climate justice and education for sustainable development, but these were out of the scope of this brief.

In producing this brief, the following gaps were identified in the area of curricula, pedagogy, assessment and teacher development:

- Most of the available literature on climate change education focuses on high income countries and only a minority of this literature focuses on assessing climate change education interventions (in Monroe et al's (2019) systematic review of the climate change education literature, only 5% of citation records on a selected academic database addressed the assessment of climate change education interventions). The majority narrate the methodologies used, without clear metrics for determining success.
- Anderson (2012) highlights a lack of evidence-based research into how climate change education impacts on behaviour change, particularly longitudinal studies.
- There was no robust evidence found about which areas of content should be included in climate change curricula for differing contexts.
- There was little evidence found on student learning and assessment in climate change education.
- Due to the overall limited evidence on 'what works', there is also limited evidence on what does not work.

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Annex A: examples of green/resilient infrastructure

The examples below have been selected to demonstrate the variety of contextually-relevant approaches to green and climate resilient education infrastructure. Many other approaches are available within the literature referenced within this guide, and beyond.

Thematic area	Description	Source
Flood resilient school	UN-Habitat in Mozambique used mixed local materials, with local skills, to build schools resilient to flooding. Local community was also trained in resilient construction techniques.	UN-Habitat, 2021
Flood and earthquake resilience	The Pacific Region of Colombia is characterized by heavy flooding and a high risk of seismic activity. Its structures are made of reinforced concrete on stilts, which avoid flood damage and are resistant to earthquakes. The front exterior wall is made of plastic wood, inspired by a typical instrument of the region, the marimba. This design provides the school with good ventilation and lighting.	Robles et al, 2015, pg. 25
Temperature control and acoustic insulation	Preschool in Morales, Mexico. The project used bales of straw, layers of mud, plaster, whitewash, and earth for construction. The space was designed to be a preschool, and built with the support of the school community. The design included thick walls for excellent temperature and acoustic insulation. The project was completed in very little time due to the low cost of materials and voluntary labour.	Robles et al, 2015, pg. 26
Rainwater harvesting	St Michael's Holy Unit Academy, Nairobi. The water harvesting project showcases a successful model of locally-led resilience and adaptation action by installing water tanks and sanitation infrastructure on building rooftops to harvest water during the rainy season. This activity involved 24 teachers and 730 students between the ages of 16-21 who were further supported by families and community members. For water scarce Nairobi, this project has helped establish access to water for many people living in the Kibera slums. It has given them the confidence to explore further opportunities such as water harvesting using local workmanship and sustainable farming practices using sacks within their residential areas. The project has been recognized by the area's government officials and NGOs working within the slums. Additional funding is required to make this project a permanent feature in the slums and	Singh and Shah, 2022, pg.11

	establish water security among the residents in the long run.	
	The School Rainwater Harvesting Projects in the Seychelles, funded by local and international donors, was launched in 2009 in 10 schools, and has since expanded. It is jointly coordinated by the Environmental Education Unit in the department of Environment and the Public Education and Community Outreach in the Environment Department. Schools reportedly store 2000 litres of extra water per month, with schools also reportedly reducing their water bills. One school in the project reported a saving of R13,423 per month (approx. £800).	Seychelles Nation, 2012
	Rainwater harvesting in Nandi County in Kenya was found to increase school attendance in the 21 participating schools from an average of 70% to 100%. Each school was provided with two water tanks with a capacity of 5,000 litres each, gutters, fascia boards and piping to dormitories or science labs.	Camellia PLC, 2018
Wastewater management	Loreto College, Mauritius. Students at Loreto College are involved in building an aquaponic system to support nearby communities, which is a combination of aquaculture (raising fish) and hydroponics (soil-less growing of plants). The integrated system reflects the symbiotic relationship between fish and plants, where the fish waste acts as an organic food source for the plants, and the plants naturally filter the water for the fish. Students are trained to manage the system without the use of artificial chemicals. All the produce from the system is donated to local communities and needy families of some of the students, demonstrating a sustainable food production as well as resilience model. Aquaponics established by the students represents an effective way to provide healthy food to local communities and contributes to the economic growth, while reducing the ecological footprint. The school also ensures eco-friendly options for pumping and recirculation of water.	Singh and Shah, 2022, pg.15
	In Togo, child friendly schools in the state of Dapaong engaged teachers and students in projects to promote sustainable hygiene, water and ecological sanitation practices. They began using the by-products (water and organic waste) to fertilize	UNICEF, 2012, pg.153

	school gardens, with the aim of increasing access to locally grown food in a drought-prone environment.	
Eco-friendly infrastructure	Ecologically friendly schools were built in Myanmar with compressed earth blocks. This technology has reduced the carbon footprint of a traditional reinforced concrete structure by more than 300 per cent. These schools have rainwater collection systems, access to safe drinking water, vegetable gardens, central courtyards and play areas. Some roofs are sloped properly to receive solar panels. Substantial community participation went into both design and construction. This process allowed for the transfer of technology to the local community and created much-needed work and cash transfers to households. All schools have covered outdoor areas, which are elevated a minimum of 3 feet (1 metre) and are fully accessible (ramps and handicap toilets). The multipurpose space can be used and shared by the community (library, clinic, food storage, etc.). The schools were successfully used for refuge during the cyclone season in 2009. There were no casualties, and the structures survived the intensive consequences of climatic changes.	UNICEF, 2012, pg.151

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This report is based on six days of desk-based research. The K4D research helpdesk provides rapid syntheses of a selection of recent relevant literature and international expert thinking in response to specific questions relating to international development. For any enquiries, contact helpdesk@k4d.info.

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