Climate Resilience in Special Education: Economic Perspectives on Building Inclusive and Sustainable Learning Environments in South Africa

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ABSTRACT:

Climate shocks and disability exclusion are converging on the same classrooms, yet the economics literature has kept them apart. Schools in South Africa already lose instructional time to floods, heatwaves and drought. At the same time, a large share of the estimated 3.3 million people with disabilities in the country remain shut out of schooling altogether. Global estimates put this exclusion at up to 7% of gross domestic product in low- and middle-income economies. What is missing is an economic account of what it would take to build learning environments that are both climate-resilient and genuinely inclusive. Current practice treats these as separate infrastructure problems, competing for the same scarce budget. This is the motivation for the present paper. The objective is to develop an economic framework for prioritising investment in climate-resilient special and inclusive education infrastructure in South Africa. The method is a structured desk-based review of recent high-impact literature in development economics, climate adaptation finance and disability studies, interpreted through the capability approach developed by Sen and standard investment appraisal logic. The central finding is that conventional cost-benefit analysis systematically undercounts the returns to resilient school design whenever accessibility is treated as an add-on rather than a co-benefit, understating the true rate of return on inclusive climate adaptation. The paper concludes that the climate adaptation agenda and the disability inclusion agenda in South Africa are, in economic terms, the same investment problem viewed from two different ministries. It recommends an inclusion-weighted appraisal method for school infrastructure finance, treating accessibility as a fourth dividend of climate resilience investment rather than a residual cost.

Keywords: Climate resilience, special education, disability inclusion, education economics, South Africa.

1. Introduction

Climate-related disruption to schooling is now a well-documented global phenomenon, supported by increasingly precise economic estimates. Since 2022, extreme weather has disrupted schooling for close to 400 million students worldwide, with the burden falling overwhelmingly on low-income countries. In these economies, on average, 18 instructional days are lost each year, compared with 2.4 days in the developed countries (World Bank, 2024). A modest outlay of $18.51 per child could meaningfully close much of this gap, through better infrastructure, improved classroom conditions and stronger continuity planning. Yet education still receives only around 1.5 per cent of global climate finance (World Bank, 2024).

A parallel and equally well-established literature documents a second global exclusion. People with disabilities die in natural disasters at rates up to four times higher than the general population, and disability remains almost entirely absent from climate policy and financing decisions, despite affecting well over a billion people worldwide (Stein et al., 2024). This exclusion is not confined to disaster response. Global estimates place the macroeconomic cost of disability-related exclusion from education and employment at up to 7% of gross domestic product in low- and middle-income economies (UNICEF, 2025). Two large, independently documented global problems, climate-related school disruption and disability exclusion, therefore sit alongside each other in the literature without ever being examined together.

South Africa provides a clear setting in which to examine this intersection, because it carries both burdens at a national scale. The most recent national census puts disability prevalence at six per cent under the internationally recognised United Nations measure, equivalent to roughly 3.3 million people, present from early childhood rather than accumulating only with age (Statistics South Africa, 2024). Fieldwork in rural South African schools directly describes the operational mechanics behind this figure: too few specialist facilities, unreliable scholar transport, and buildings whose physical layout outright excludes learners with mobility impairments (Chirowamhangu, 2024). These same schools are located within a climate hazard profile that is already causing direct physical damage. Basic education policy, disaster management policy and disability inclusion policy nonetheless continue to operate as three unconnected files.

This produces a clear and specific gap in the South African literature. One line of research treats disability exclusion in schooling as an established fact, independent of any external shock (Chirowamhangu, 2024; Statistics South Africa, 2024). A separate line tracks the scale of climate-related disruption to schooling without asking who within the affected population bears the heaviest cost (World Bank, 2024). Neither asks whether climate events compound pre-existing disability exclusion, and if so, through what mechanism. This paper addresses that gap directly. Its objective is to bring these two strands together within a single economic frame, and to establish what an economically coherent investment strategy for climate-resilient, inclusive school infrastructure in South Africa would require.

This paper situates the economic argument within the capability approach developed by Sen. This framework evaluates development not by income or infrastructure spending as ends in themselves, but by the real freedoms these resources allow people to exercise (Sen, 1999). A recent critical interpretive synthesis of forty-three empirical disability studies confirms that this framework remains as the dominant lens for evaluating disability-related deprivation in current research, both as a main theory and as an outcome measurement tool (Sebaggala et al., 2025). For schooling, the relevant capability is not only enrolment. It is the persistent ability to attend, learn and progress, a capability expressed by a learner. A physical barrier, such as a staircase that a wheelchair user cannot climb, can remove this capability. It may be removed by an environmental shock, such as a flooded classroom. The Sen standard framework is useful here precisely because it fails to separate these two forms of capability removal into distinct

conceptual categories. Both a disabling building and a disaster-damaged building convert the same underlying resource, a functioning school, into a non-functioning one for a specific learner or group of learners.

This theoretical position has a direct economic implication. If accessibility and resilience both operate through the same capability-removal mechanism, standard investment appraisal should evaluate them jointly rather than sequentially. Current practice does the opposite, both in South Africa and in the extant literature on infrastructure finance. Accessibility adjustments and climate upgrades are treated as competing line items, each assessed against its own narrow cost-benefit ratio. The theoretical contribution of this paper is to assert that this practice exaggerates the true return on investment in both categories. It disregards the fact that a single effective intervention can protect against two distinct sources of capability loss simultaneously. One example is a storm-resistant classroom block that is raised and ramped. Separate projects would address the needs at a higher cost.

2. Methodology

There is no primary disaggregated data on climate-related disruption to special and inclusive education infrastructure in South Africa. Given this absence, the paper adopts a structured desk-based review methodology, suited to a synthesis of economic evidence across literatures that have rarely been read together. The review draws on recent high-impact sources in four fields. The first is climate adaptation finance and investment appraisal, drawing on the World Bank Global Program for Safer Schools and the triple-dividend-of-resilience framework developed at the World Resources Institute. The second is disability-inclusive climate research, drawing principally on The Lancet Planetary Health and World Bank fieldwork in comparable developing-country contexts. The third is macroeconomic and central bank research on climate exposure in South Africa and the wider Southern African region, drawing on the South African Reserve Bank, the Organisation for Economic Co-operation and Development, and the Climate Policy Initiative. The fourth is South African disability and education policy literature, drawing on the African Journal of Disability, Frontiers in Education, the Journal of African Law and Statistics South Africa. Search terms combined climate resilience, school infrastructure, disability inclusion, cost-benefit analysis and South Africa, with priority given to material published from 2021 onward. The capability approach is retained as the sole theoretical anchor predating this window, since later economic literature on inclusive development continues to build on it directly.

The analytical method proceeds in two stages. The first stage synthesises the separate economic evidence bases on climate-resilient school infrastructure and on disability-inclusive education investment, establishing the scale and nature of each problem independently. The second stage applies standard cost-benefit logic to ask what changes when accessibility is incorporated as a co-benefit of resilient design, rather than assessed separately. This logic follows the triple dividend of the resilience framework used in recent climate adaptation finance research. This is a conceptual rather than an econometric exercise. The paper does not estimate a South Africa-specific rate of return because the underlying data are not yet available in disaggregated form, a limitation discussed further in Section 10. The contribution of this paper is to specify the framework that such an estimation would require. It also shows, using global reference figures, why the current separation of these investment categories is likely to understate the true return on both.

3. The Economic Case for Climate-Resilient School Infrastructure

The global evidence for investing in climate-resilient infrastructure is strong and increasingly well quantified, and this applies specifically to school infrastructure. A 2025 analysis of 320 adaptation investments across twelve countries used the triple dividend of resilience framework. It found that every dollar invested in climate adaptation yielded more than ten dollars in

benefits over a ten-year horizon, with average annual returns ranging from 20 to 27 per cent (Brandon et al., 2025). These returns are captured across three channels. The first is the losses avoided when infrastructure withstands a shock. The second is economic activity induced by the investment itself. The third is broader social and environmental benefits that conventional appraisal often omits entirely. The same analysis notes that only a small share of adaptation investments currently monetise all three channels, meaning published rates of return likely understate the true economic case for resilient infrastructure (Brandon et al., 2025).

For schools specifically, the World Bank Global Program for Safer Schools has supported resilience investment across thirty-five countries, benefiting more than 121 million students. Over three billion dollars in school infrastructure financing is now explicitly informed by disaster and climate risk considerations (World Bank, 2024). The scale of the underlying problem justifies this investment. Climate-related school disruption is not evenly distributed. Low-income countries lose an average of eighteen instructional days annually to extreme weather, compared with 2.4 days in high-income countries, a gap that itself represents a measurable and growing driver of global learning inequality (World Bank, 2024). Set against this, the estimated cost of protective measures is strikingly modest, at roughly $18.51 per child for a meaningful reduction in climate exposure. This raises an obvious question. Why does climate finance directed at education remain so small a share of total climate finance, at approximately 1.5 per cent (World Bank, 2024)? Part of the answer, this paper argues, lies in how narrowly the benefits of school infrastructure investment are typically defined.

The broader financing environment is, at least, moving in a favourable direction. Resilience-related investment accounted for 43 per cent of the World Bank Group's public sector development finance portfolio in the 2025 fiscal year, up from roughly one-third only two years earlier, out of a record $50.8 billion in development finance carrying climate co-benefits (World Bank Group, 2025). Multilateral development banks collectively report similar growth, with climate finance reaching $163 billion in 2025 (World Bank Group, 2025). Rising resilience budgets create a genuine window in which appraisal criteria could be revised, so that accessibility is recognised as a co-benefit of resilient design at the point where large volumes of new capital are already being allocated, rather than modified later at additional cost.

4. Climate Risk and Economic Exposure in South Africa

Exposure to climate risk in South Africa is not abstract. It is already priced into national economic projections. Without further mitigation, the country is projected to lose just over 5 per cent of gross domestic product by 2050, rising to more than 13 per cent by 2100 under a high-emissions pathway (CMCC Foundation, 2021). Flooding alone is projected to cost the economy an additional fourteen billion rand by 2050, and heat-related deaths are projected to rise to twenty-five times the 1990 level by the end of the century under the same pathway (CMCC Foundation, 2021). Schools sit within the same built environment described in this national risk profile, and a classroom is no more insulated from a flood or a heatwave than a road or a power station.

Recent central bank research adds a sectoral dimension to this picture. A 2026 spatial analysis of climate shocks across the Southern African Development Community region finds that drought, extreme temperature, floods and storms all significantly affect agricultural output, with effects propagating across borders through shared water systems and trade (Mazviona et al., 2026). Fiscal capacity to respond remains constrained. Only just over eleven per cent of tracked climate finance in South Africa currently supports adaptation, well below the continental average of close to thirty-four per cent, a gap widened further by a debt-to-gross-domestic-product ratio close to seventy-four per cent (Climate Policy Initiative, 2025). A broader assessment of the policy environment reaches a similar conclusion, noting that the carbon tax currently raises revenue equal to only a small

fraction of gross domestic product, limiting the scale of adaptation finance that carbon pricing alone could support (OECD, 2025). Education infrastructure competes for capital within this same constrained fiscal envelope, which is precisely why the appraisal method proposed later in this paper matters.

5. The Compounding Economics of Disability Exclusion in South African Schooling

The disability exclusion problem in South Africa is well documented, independently of any climate consideration. The Education White Paper 6 policy framework was adopted twenty-five years ago, yet implementation remains concentrated in better-resourced urban schools. Successive assessments have estimated that as many as seventy per cent of school-age children with disabilities are entirely out of school (Chirowamhangu, 2024). Fieldwork in the Eastern Cape identifies the specific mechanisms behind this figure: an insufficient number of specialist facilities, unreliable scholar transport, inadequate sanitation, and buildings whose physical layout, long staircases in particular, is incompatible with the needs of learners with mobility impairments (Chirowamhangu, 2024). More recent research on autism spectrum disorder in the Tzaneen Circuit reaches a similar conclusion. Mainstream teachers have gained most of their limited knowledge informally rather than through structured training, and classrooms remain overcrowded with minimal specialist support (Sepadi, 2025).

This exclusion has already been tested and found wanting during a national emergency. In Centre for Child Law v Minister of Basic Education, a South African court examined return-to-school planning during the COVID-19 pandemic, finding that the Department of Basic Education had excluded learners with disabilities from planning from the outset, and that special school hostels were closed without equivalent alternative arrangements being provided (Kamga, 2021). The associated economic disruption was severe even for mainstream learners: national assessments found significant shifts in dropout and grade-repetition rates through 2021 and into 2022, a pattern described in the literature as a generational setback to human capital accumulation (Shepherd & Mohohlwane, 2022). If disabled learners were excluded from planning during a shock that affected the entire schooling system, there is little basis for assuming they are better accounted for during smaller, localised shocks such as flooding or heat. Global estimates place the macroeconomic loss from disability-related exclusion at up to seven per cent of gross domestic product in low- and middle-income economies, driven substantially by foregone human capital formation during the school years (UNICEF, 2025).

Global education financing data reinforce the scale of what is at stake when children exit school early, whether the cause is disability exclusion, conflict or a changing climate. Governments worldwide forgo an estimated 1.1 trillion United States dollars in revenue each year because of early school leaving, and a further 3.3 trillion dollars in foregone output is linked to children who complete school without acquiring basic skills (UNESCO & World Bank, 2024). Chronic under-investment compounds this loss: the global out-of-school population fell by only one per cent over nearly a decade, a stagnation attributed in part to persistently low education financing in low-income countries (UNESCO, 2024). Targeted investment in the two problems examined in this paper, climate-resilient infrastructure and disability-inclusive design, addresses two tractable drivers of exactly this kind of foregone human capital.

6. Climate Risk and Disability: An Underdeveloped Intersection

Despite the scale of both problems, the intersection between them remains strikingly underexamined. A major 2024 synthesis in The Lancet Planetary Health draws on an interdisciplinary panel of climate and disability researchers from around the world. It concludes that disability remains largely absent from climate policy, programming and research, despite more than a billion people with disabilities facing disproportionate and differentiated climate risk

(Stein et al., 2024). Fieldwork conducted by the World Bank in Uzbekistan directly illustrates the mechanism, even outside the education sector. Persons with disabilities interviewed after flooding and mudslide events described being unable to evacuate without assistance on damaged or unpaved terrain, a vulnerability rooted entirely in the interaction between physical impairment and degraded infrastructure, rather than in either factor alone (World Bank, 2023). A qualitative study of intersectional disaster experience in Indonesia reaches a closely related conclusion, finding that disability compounds exposure to climate hazards in ways that generic disaster response planning consistently fails to anticipate (Pirmasari & McQuaid, 2023). Even in wealthier settings, the same oversight recurs: a recent case study of climate resilience planning in Massachusetts found that people with disabilities were largely overlooked in local adaptation planning processes, despite formal consultation requirements (Brown et al., 2025). The pattern, in other words, is not confined to low-income contexts.

Within the disaster risk reduction literature specifically, the same gap has been identified for schools. A 2024 study developed a disability-inclusive disaster risk reduction model. It found that accessible evacuation routes, disability-aware emergency communication and staff training were all measurable and protective where present, though these features remain inconsistently implemented (Rofiah et al., 2024). Regional analysis across Africa reaches a similar conclusion. Implementation of disability-inclusive disaster risk reduction remains slow despite growing rhetorical commitment, and comprehensive disability-disaggregated data on disaster impacts is still largely absent (UNDRR, 2024). A recent synthesis covering the Southern African Development Community region goes further. It argues that disabled children remain largely excluded from disaster preparedness education specifically, despite facing disproportionately higher climate vulnerability, and it calls for participatory research with disabled children on this question directly (Lunga et al., 2026). Taken together, this literature establishes that the mechanism linking disability and climate vulnerability is well understood in principle. What is missing, particularly in the South African schooling context, is any economic framework for acting on that understanding.

7. Towards an Inclusive Climate Resilience Investment Framework

This paper proposes an Inclusive Climate Resilience Investment framework. It builds directly on the triple dividend of resilience logic described in Section 4, but extends it to recognise accessibility as a fourth, co-produced dividend rather than a separate cost centre. Under the conventional triple dividend approach, a resilient classroom generates returns through avoided losses, induced economic activity and broader social benefits (Brandon et al., 2025). This paper argues that a fourth dividend should be recognised explicitly wherever resilient design and accessible design use the same physical interventions. This is the capability to return learners who would otherwise be excluded by ordinary physical barriers, independent of any climate shock.

Consider a concrete illustration relevant to conditions in South Africa. A raised classroom floor with a gently graded ramp, built to withstand flood inundation, serves two purposes at once. It protects the building during a flood event, generating the avoided-loss dividend, which is already recognised in the climate adaptation appraisal. It also provides step-free access for a wheelchair user on every ordinary school day, generating a capability dividend that has nothing to do with climate risk. Under current appraisal practice, a ramp commissioned as part of a flood-resilience retrofit is costed once, but the benefits are counted only against climate outcomes. A ramp commissioned separately as a disability access measure is costed again from a different budget line, and the climate co-benefit, where the design also happens to be flood-resistant, goes unrecorded. Neither appraisal captures the joint return, and both therefore understate the true value of resilient, accessible design relative to cost.

Formally, the Inclusive Climate Resilience Investment framework treats the net present value of a school infrastructure project as the sum of four dividends. These are avoided climate losses, induced economic development, broader social and environmental benefits, and an inclusion dividend. The inclusion dividend captures the capability gains to learners with disabilities who gain reliable access as a direct consequence of resilient design choices. Design decisions should be made jointly, as this paper argues they should be. Where this happens, the marginal cost of adding the inclusion dividend is close to zero. This is not merely theoretical. A context-dependent costing study covering twelve building cases, including secondary schools, found that incorporating universal design from the outset of construction was consistently cheaper than retrofitting it later, precisely because the structural features involved overlap substantially with standard building requirements (Ielegems & Vanrie, 2024). The structural features required for flood or heat resilience, elevated flooring, wide and stable circulation routes, and robust ventilation are often the same as those required for physical accessibility. The economic implication is clear. Jointly appraised projects should show a materially higher benefit-cost ratio than either accessibility retrofits or resilience retrofits assessed in isolation, because the fixed costs of structural intervention are shared across both objectives rather than duplicated.

8. Policy Implications for South Africa

Applying this framework to South Africa points towards three concrete policy shifts. First, infrastructure planning processes at the Department of Basic Education should require joint appraisal of accessibility and climate resilience for any new construction or major retrofit, rather than routing these considerations through separate approval processes as currently occurs. Second, disaster response and recovery financing following events such as the floods in KwaZulu-Natal should build in universal design features as a condition of funding, converting reconstruction, which is unavoidable after a flood, into an opportunity to correct pre-existing accessibility deficits at a marginal rather than a full cost. Third, given how thin the underlying data remain, provincial education departments should begin recording disability status alongside climate exposure in routine school infrastructure audits, generating the disaggregated evidence base that this framework will ultimately require. None of these recommendations requires new institutional architecture. They require an amendment to existing appraisal criteria, so that accessibility and climate resilience are scored as complementary rather than competing objectives within the same capital budgeting process. Global evidence already shows returns to climate adaptation investment in the range of twenty to twenty-seven per cent (Brandon et al., 2025), and disability exclusion alone is estimated to cost up to seven per cent of gross domestic product annually (UNICEF, 2025). The fiscal case for this shift does not depend on speculative assumptions. It depends only on recognising that two large, independently documented economic problems share a common physical solution, at a time when the fiscal space available to address either problem separately is already limited (Climate Policy Initiative, 2025). A practical financing mechanism follows from this logic. Provincial education infrastructure grants in South Africa could be restructured to offer a co-financing premium for projects that document joint accessibility and resilience specifications at the design stage, rather than as an afterthought during construction or a costly retrofit later. This would mirror the shared multilateral development bank practice of tracking climate co-benefits within broader development finance, an approach that has already increased resilience to 43% of the World Bank Group's public sector portfolio (World Bank Group, 2025). A similar co-benefit accounting convention, applied domestically and specific to accessibility, would make the fiscal case for joint investment visible to budget authorities, using a form they already apply to climate finance.

9. Limitations

This paper is conceptual rather than empirical, and the principal limitation follows directly from that choice. No South African dataset currently

links school-level climate exposure to disability-inclusive infrastructure features. This means the Inclusive Climate Resilience Investment framework proposed here cannot yet be parameterised with local data, nor tested against an observed benefit-cost ratio. The figures cited from global adaptation finance research illustrate the scale of returns available in principle, not predictions of what an application in South Africa would yield specifically. The central claim of the framework, that joint appraisal dominates separate appraisal whenever structural interventions overlap, is a theoretical proposition grounded in engineering logic and capability theory rather than an estimated parameter and should be treated accordingly until the necessary data collection, recommended in Section 9, has taken place.

10. Conclusion

Climate resilience and disability inclusion in South African schooling have developed as separate policy conversations, each evaluated through separate appraisal methods and funded from separate budget lines. This paper has argued that this separation is not economically justified. Both climate shocks and physical barriers remove the same underlying capability: the sustained ability of a learner to attend school. The global evidence on climate adaptation returns and disability exclusion costs suggests that the combined economic stakes are substantial. This conclusion is reinforced by national evidence on the fiscal constraints already facing climate adaptation spending in South Africa (Climate Policy Initiative, 2025; OECD, 2025). The Inclusive Climate Resilience Investment framework proposed in this paper makes that shared logic explicit within standard cost-benefit analysis. It treats accessibility as a fourth dividend of resilient design, rather than a competing cost. The immediate recommendation is not a specific spending figure, as the data do not yet support one. It is a change in appraisal method. School infrastructure planning in South Africa should jointly evaluate climate resilience and accessibility, and begin collecting disaggregated data to rigorously test this framework in future research.

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