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RESEARCH ARTICLE

INTERNATIONAL COOPERATION AND CLIMATE-RESPONSIVE EDUCATIONAL INFRASTRUCTURE IN AFRICA: EXAMINING THE ROLE OF PASSIVE ARCHITECTURE IN NIGERIA

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ABSTRACT

Nigeria's educational infrastructure crisis exists at the intersection of two converging failures: the global governance gap in climate-responsive building policy, and a domestic tradition of imported architectural solutions that were never designed for the African context. This article examines how passive architectural strategies specifically designed to reduce reliance on mechanical cooling and artificial ventilation offer a structurally sound, contextually appropriate response to the thermal stress increasingly experienced by Nigerian schoolchildren and educators. The analysis situates this design discourse within the broader framework of international cooperation, arguing that bilateral aid frameworks, multilateral development finance, and global climate agreements have, paradoxically, both enabled and constrained the adoption of locally responsive infrastructure solutions. Drawing on the political ecology of development assistance, post-colonial critiques of technology transfer, and the policy architecture of global climate governance, the article makes the case that Nigeria's passive architecture potential cannot be fully realized without structural reforms to how international cooperation is designed, conditioned, and delivered. Particular attention is paid to the role of sovereignty, knowledge politics, and institutional incentive structures in shaping infrastructure outcomes across Nigeria's six geopolitical zones.

Keywords: Passive architecture, climate-responsive design, educational infrastructure, international cooperation, Development Aid, Post-colonial Governance, Thermal Comfort, green building, political ecology

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1.0. INTRODUCTION

There is a school in Kano. Forty-seven children share a room built for thirty. The roof is corrugated iron. The walls are sandcrete. It is March. The harmattan is done, and the heat has arrived. By ten in the morning, the inside temperature exceeds forty degrees Celsius. The teacher is still talking. The children are still sitting but nothing is being learned. This is not a story about poverty. It is a story about design. That school was built it did not collapse, it was not bombed, it did not flood. It was constructed, funded, and handed over. Someone signed off on it. Someone decided that the roof would be corrugated iron, that there would be no cross-ventilation, that shade trees were not part of the budget. That decision had a name. It had a donor. It had a policy behind it.

Across Nigeria's 36 states and the Federal Capital Territory, an estimated 65,000 public primary and secondary schools serve close to 40 million students (Federal Ministry of Education, 2022; Universal Basic Education Commission [UBEC], 2023). A significant proportion of those structures are thermally hostile. They trap heat. They block airflow. They perform, architecturally, in direct opposition to the learning environment they were designed to enable. The problem is systemic. It is also, in large part, inherited.

Nigeria's school infrastructure landscape bears the marks of decades of externally driven development assistance, colonial building standards, and structural adjustment-induced disinvestment (Uduku, 2022; Adeyemi & Olusegun, 2023). The design choices embedded in existing stock were rarely made by Nigerian architects with Nigerian climates in mind. They were frequently made by procurement officers in Washington, London, or Brussels working from standard templates. The result is a built environment that produces heat stress, reduces concentration, increases absenteeism, and deepens educational inequality.

Passive architecture offers a response. It is not a new concept. Vernacular Nigerian building traditions the compound courtyard of the Yoruba, the earthen construction of the Hausa-Fulani, the elevated pile structures of Niger Delta communities all demonstrate sophisticated thermal management without mechanical intervention (Elleh, 1997; Ajayi, Oyelaran, & Taiwo, 2022). These traditions encode climate knowledge accumulated over generations. They are also largely neglected by formal development infrastructure financing.

This article asks why. The answer, it argues, is not primarily technical. It is political. It lives in the spaces between donor conditionality and recipient sovereignty. It lives in the preference for replicable, auditable, standardised solutions over locally adapted, knowledge-intensive ones. It lives in the gap between what international cooperation promises and what its institutional architecture actually delivers.

This paper consists of seven parts. This introduction is followed by the building of the climate-infrastructure nexus for the educational sector in Nigeria in Section 2. Section 3 examines the tool kit of passive architecture and its implementation in the conditions of the tropics of West Africa. Section 4 looks at the architecture of international cooperation frameworks on educational infrastructure investment. Section 5 questions the political economics of technology transfer and the politics of knowledge of design sovereignty. Section 6 offers a plan for reform. Section 7 concludes.

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2.0. CONCEPTUALIZATION AND LITERATURE REVIEW

2.1. CONCEPTUALIZATION

Nigeria's Educational Infrastructure under Climate Stress

The Thermal Reality of Learning

Heat is not a metaphor in Nigerian classrooms. It is a physical state which has measurable cognitive effects. Numerous studies in the field of environmental psychology and educational neuroscience have shown that thermal discomfort has a direct impact on working memory, concentration span, reading comprehension and math processing (Havenith & Fiala, 2022; Bates, Primack & Lee, 2021; Heal & Park, 2023). Kids are more susceptible than adults. Research on paediatric thermoregulation has demonstrated that children have a faster increase in core temperature than adults under heat load conditions and hence may perform less effectively than adults at cooler ambient temperatures than those recommended by the ambient temperature guidelines (Nerbass, Gouveia, Clark, Matzarakis, & de Freitas, 2021). A child's built environment can negatively impact their cognitive ability, and children in poorly ventilated, high radiant heat environments may be among the most cognitively disadvantaged children in the world, not because they are unable, but because their built environment is against them.

Nigeria's climate presents a demanding range of conditions. The temperature range in the Guinea Coast is between 25°C and 35°C, while the relative humidity is always above 70%, making even moderate temperatures in the region feel oppressive (Nigerian Meteorological Agency [NiMet], 2023; IPCC, 2022). The weather is wet and dry in the Middle Belt, with temperatures ranging from 38°C in the dry season. In the far north, the local environment is semi-arid, with Sahelian conditions in which temperatures regularly climb over 42°C in the afternoon, during a period of direct sunlight, which will increase by 1.5–2°C by mid-century with current emissions scenarios (IPCC, 2022; World Meteorological Organization [WMO], 2023). These are not “edge cases.” They are the conditions of operation of most of the public school estate in Nigeria.

In this context, the common form of public schools in Nigeria is shallow-pitch corrugated iron roofs, single skin sand Crete block walls, little or no window openings and no overhangs act as a solar heat collector. Metal roofs absorb the sun's energy and emit it in its longwave form downward. Dense block walls have thermal storage capacity but dissipate their stored thermal mass to the interior at night resulting in higher morning temperatures prior to the sunrise (Oyelaran, Balogun, & Akinyemi, 2021; Aliyu & Sani, 2023). Cross-ventilation is lost with improper sizing of windows and when the security grilles do not allow full opening of the window. The net result is an indoor climate which enhances, not moderate, the outdoor heat.

Oyelaran et al. (2021) reported that the mean air temperature recorded in schools in the Southwest of Nigeria was also found high (more than 32°C) for over 70% of instructional hours during the dry season months. In a study that documented the standardised test of thermal comfort (Predicted Mean Vote - PMV) scores in sampled Lagos State schools, all the schools in the study were found to be operating in the 'hot' to 'very hot' range of thermal comfort index per ISO 7730 (Ogbonna and Ekechukwu 2018). Aliyu and Sani (2023) surveyed 120 classrooms in Kano and Kaduna states in 2023 and discovered that more than 83% of the classrooms surveyed had operative temperatures

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higher than the upper comfort level of 28°C during the peak teaching learning hours. Teachers reported reductions in lesson time. There was an inverse relationship between the peak-heat months and enrolments of students in affected areas as per data from the Universal Basic Education Commission (UBEC, 2023).

The crisis is exacerbated by the distributional dimension. The private schools in the topmost end of Abuja's Maitama or Abuja's Lagos Island, install air conditioning. Parents are charged for the costs. Well-to-do children get to learn in comfort. Poor children sweat between curriculum. A 2022 study in Nigeria of learning outcome differentials by type of school showed a 19-percentile difference in end-of-term assessments between air-conditioned private and non-mechanically cooled public schools, even after adjusting for the quality of the teacher and availability of textbooks (Oluwafemi, Daramola, & Medupin, 2022). In this context, climate stress isn't just a problem of the environment. It is a distributive justice issue. It's a governance issue.

Infrastructure Investment and the Gap

In the last 20 years, the Nigerian government has made huge investments in school construction and rehabilitation through its Universal Basic Education programme, Safe Schools programme and the various versions of the Tertiary Education Trust Fund. Between 2011 and 2023, the Tertiary Education Trust Fund (TETFund) disbursed more than ₦2.3 trillion, and it has pledged to release approximately ₦450 billion for the 2024-2026 cycle (TETFund, 2023). These investments have been complemented with grants, concessional loans and technical assistance programmes from international partners like UNICEF, the World Bank, USAID, the European Union, the Islamic Development Bank, JICA, etc. The World Bank's Nigeria Education Crisis Response project alone provided $125 million from 2016 to 2022, and additional $500 million Nigeria COVID-19 Action Recovery and Economic Stimulus operation provided some school rehabilitation support (World Bank, 2023a).

What emerges is a paradox of investing without change. Buildings go up. The basic design approach remains the same. When climate responsiveness makes an appearance, it often takes the form of retrofitting a painted white roof here and a planted shade tree there. It is not systemic. Not required by code. An audit carried out by the Nigerian Institute of Architects in 2023 identified only less than 4% of the school construction projects that were completed between 2018 and 2022 that featured any formal specification of passive cooling strategy other than minimum window sizing. Climate responsiveness is rarely the priority of the international procurement frameworks that govern how those buildings are designed and built. And this is the structural problem. Not the absence of money, but the presence of money governed by the wrong institutional logic.

2.2. Passive Architecture: Principles and African Precedents

Passive architecture is architecture in which the building design is used to create comfortable indoor environment conditions by controlling form, orientation, material and spatial structure without consuming energy from mechanical systems like air conditioning or powered ventilation. Architecture of Climate Intelligence (Olgyay, 1963; Szokolay, 2004; Adekunle & Nikolopoulou, 2016). It relies on the basic variables that are related to solar geometry, prevailing wind, thermal mass, evaporative cooling, natural ventilation, and shading. Passive design is the one most effective strategy identified

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by the United Nations Environment Programme's 2022 Global Status Report for Buildings and Construction for energy savings in the building sector in tropical countries that can save up to 70% of cooling load before the use of any active mechanical system (UNEP, 2022).

Heat and humidity are the major issues in the design in hot and humid climates like coastal Nigeria. The strategies that can be adopted include; maximising cross ventilation by careful orientation and positioning of windows, use of raised floor structures to capture cooler sub floor air streams, specification of deep veranda and roof overhangs (1.2-1.5 m) to block direct solar gains while maintaining daylight, use of light colored or cool roof coatings with solar reflectance index greater than 75% and selection of local materials such as laterite brick, rammed earth, compressed earth blocks with thermal transmittance index of 30-40% lower than sandcrete blocks (Adekunle & Nikolopoulou, 2016; Obi, Abugu, & Emenike, 2023).

In the hot and dry environment of northern Nigeria, the design problem becomes one of diurnal temperature moderation controlling the day to night temperature difference. Thick earthen walls are needed to store heat during the day and release it slowly after the sun sets to moderate both extremes: this is called "high thermal mass. The courtyard configurations generate shaded microclimates, which significantly reduce the internal mean radiant temperature (MRT) by 4-8°C compared with their open-plan counterparts (Aliyu & Sani, 2023; Adekunle, 2021). In Persian windcatcher adaptations recorded in the construction manuals of the Sahel, hot air is carried upward and outwards due to pressure gradients in the tower. In Nigeria, near zero operational cost additional natural cooling is obtained using underground cisterns and evaporative techniques (Adekunle, 2021)

These are not cutting edge technologies. For school buildings, a 2022 meta-analysis of 47 passive cooling interventions, implemented in Sub-Saharan Africa, reported an average indoor temperature reduction of 5.2°C which led to an increase in the measured PMV score of 61% at an average cost premium of 8–12% of the building costs as this cost is fully recovered within three years through electricity savings (Mensah, Antwi-Boasiako & Opoku, 2022). They need design intelligence, context and institutional will. They don't need to purchase materials out of the country, have any special systems, or have to keep paying for maintenance agreements.

3.2. Nigeria's Vernacular Legacy

Prior to the advent of imported building typologies from the colonial era, the Nigerian building traditions showed advanced solutions to climatic demands. The Hausa compound with thick mud walls (450–600 mm), narrow shaded corridors, and open central courtyard provided conditions of comfort on the interior of the building in a temperature range that would make modern sandcrete buildings no longer habitable without air conditioning (Elleh, 1997; Ajayi et al., 2022). In the forest zone the Yoruba employed deep eaves, ventilated sleeping rooms and shaded outdoor assembly areas to control heat and humidity. The traditions of the Nupe and Kanuri communities of the northern riverine communities had elevated granaries and sleeping platforms taking advantage of the principles of convective cooling, which are now confirmed through computational fluid dynamics modeling (Obi et al., 2023; Abubakar & Mohammed, 2024).

The solutions were not primitive. They were solutions that were optimized to the climate. The issue is that colonial building codes made them illegitimate. It is important to note that the preference for

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imported cement, corrugated iron and glass products, for which locally accumulated knowledge was not required, took over and dislodged locally accumulated knowledge (Uduku, 2022; Rodney, 1972). This colonial mentality was largely sustained in post-independence Nigeria where the aim was to modernise quickly. This led to a fracture in the flow of climate knowledge from informal, traditional practice to formal architectural education.

This rupture and its technical implications have been documented by scholars such as Ola Uduku (2022), Nnamdi Elleh (1997) and Ajayi et al. (2022). Over the last decades the Newcastle University's African Architecture programme and other universities like the University of Lagos and Ahmadu Bello University have been at the effort of recovering and formalizing this knowledge base. The review of architectural curricula in 2024 in 18 Nigerian universities revealed that less than 30% of the universities offer formal study of VCAM in their degree programs accredited by the National Universities Commission [NUC] (2024). The problem has not existed for lack of thinking work. Policy adoption and financing alignment have been missing.

Contemporary Applications

Schools in Nigeria and similar West Africa settings are now being designed in a climate responsive manner, evidenced by feasibility and scalability. The WASH-in-Schools programme, supported by UNICEF, piloted the use of roof overhangs, cross-ventilation configurations and cool-roof coatings in the classroom, in Kano and Jigawa states, from 2019 to 2022. Post-occupancy evaluation carried out recorded temperature reduction of 4 – 7°C in the classrooms compared to control classrooms with the same footprints and standard construction specifications (UNICEF Nigeria, 2022).

The Designs are pilot school design prototypes developed by the Development Bank of Nigeria (DBN) in partnership with the Nigerian Institute of Architects (NIA) and the design firm, NCA+D based in Abuja, for three climatic zones, including the use of Compressed Earth Block (CEB), photovoltaic roofing which serves as reflective shading, and rain-harvesting technology integrated into gutter design. The prototypes have been assessed independently in the humid south and the northern semi-arid zone, with reductions in operative temperature of 6.3°C in the humid south and 5.8°C in the northern semi-arid zone, respectively (DBN, 2022; NIA, 2023). The prototypes still have prototypes. No scaling has been done.

Scaling requires standardisation. For standardisation, code changes are needed. There is a need for co-ordinated institutionalization with regard to code revision across the Federal Ministry of Education, Ministry of Works and Housing, state governments and the private construction sector. It also needs the buy-in of international financiers whose procurement processes this article contends are structurally unsusceptible to locally designed alternatives.It also calls for the active support of international financiers whose procurement processes, this article argues, are structurally resistant to the development of locally designed alternatives.

The Architecture of International Cooperation
Who Builds Nigeria's Schools?

The Universal Basic Education Commission (UBEC) and the Tertiary Education Trust Fund (TETfund) are two Government bodies that contribute the highest funding amount directly to the construction of schools in Nigeria. Under the federal-state cost-sharing model of the UBE scheme,

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state governments contribute varying amounts, while fiduciary audits regularly report delays, leakages and lack of capacity at the state level (UBEC, 2023; Transparency International Nigeria, 2023). However, the federal revenue centralisation that has been ongoing for decades has gradually reduced the fiscal capacity of local governments in the country, the responsibility for which is constitutionally vested in them as the agents of primary school management, thus leaving them chronically underfunded (Nwafor, Ezeh, & Eze, 2022).

There is a large investment presence from international partners. Between 2016 and 2022, the World Bank Education Crisis Response project allocated $125 million, mainly to the conflict-affected school estate in the northeast region of Nigeria (World Bank, 2023a). UNICEF Nigeria, has school construction and rehabilitation programmes in at least 12 states. USAID's Education Support Activity provided the funding for more than 400 classroom constructions in the northern states from 2020 to 2023 (USAID, 2023). The Islamic Development Bank has allocated USD 150 million for school construction in mainly Muslim majority states within its country programme for the period 2022-2025 (IsDB, 2022). JICA, GIZ, and the FCDO of the United Kingdom have continued to have ongoing education programmes. In total, donor-funded construction projects represent an estimated 23% of new school infrastructure built each year, and more than 50 percent in conflict-affected states and climate vulnerable states (OECD Development Assistance Committee, 2023).

All of these actors have their own procurement needs, design specifications, performance measures, and reporting requirements. It is not a coherent system. It is a landscape of parallel interventions that are internally coherent, but rarely coordinated to enable design intelligence to build or be assessed and to be scaled across programmes or investment cycles (Bertrand, 2021; Mbeki, Camara, & Nkosi, 2023).

3.0. RESEARCH METHODOLOGY

This study adopts a qualitative design. It systematically draws from the perspective of international cooperation and climate-responsive educational infrastructure in Africa to elucidate the role of passive architecture in Nigeria using content analysis from exiting secondary literature. The critical contents on infrastructural gap, climate agreement, and knowledge are presented in the discourses that follow.

4.1. CONTENT ANALSES AND DISCOURCES

Conditionality and Design Sovereignty

International donors have long attached policy and procedural requirements to infrastructure financing, which is referred to as ‘conditionality' (Mkandawire, 1999, Siddiqui & Christiansen, 2022). In the educational infrastructure segment, it is applied at a level of procurement requirements, building codes, materials specification and engineering validation requirements.

World Bank financed projects are subject to the World Bank's Procurement Regulations for IPF Borrowers (2020), which call for competitive international bidding of contracts, and technical compliance to internationally recognised building standards. It is also commonly used by large international construction companies which are more efficient at working with imported materials, as well as replicable building systems that do not need local knowledge to put into practice, compared to local construction firms and locally produced materials and designs that can adapt to the local climate

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(World Bank, 2023b; Acheampong & Boateng, 2022). According to the review of the World Bank education portfolio projects in 12 SSA countries (Siddiqui & Christiansen, 2022), less than 8% of the school construction contracts were accompanied by explicit thermal performance specifications.

This isn't a conspiracy. This is an institutional logic. To the accountability mechanisms of donors, value for money, auditability and replicability need to be demonstrated. They require results frameworks that are measurable and reportable to parliaments, boards of directors and governments that support them. The advantages of passive architecture lessened heat stress, better cognition, lower operational energy costs are real but are diffuse, medium-term and challenging to quantify in the traditional framework of aid reporting (Bertrand, 2021; Gulbrandsen & Andresen, 2022). When you build a classroom, you build a classroom! It's a tough argument to make in a half-year project report that a classroom with cross-ventilation will measurably improve dropout rates so kids can concentrate.

The consequences of design sovereignty are enormous. By accepting the loan, Nigeria's government in effect adopts the design and procurement processes that come with the loan. The room for locally responsive architectural decision-making is reduced. This is not an exclusively Nigerian issue. It is a structural feature of the international development architecture that has been documented in Sub-Saharan Africa, South Asia and Latin America (Acheampong & Boateng, 2022; Mbeki et al., 2023; Rahman & Islam, 2023).

The structural conditionality of this approach has been noted by scholars working in the developing discourse of post-colonial development studies from Escobar's 1995 critique of development as discourse, to Mkandawire's 1999 analysis of 'choiceless democracies' below the realm of explicit policy negotiation. More recent scholarship has further developed this argument with an eye specifically to outcomes in the built environment. As shown by Rodríguez-Pose and Wilkie (2022), donor procurement systems systematically limit the development of nationally embedded building knowledge systems in 34 countries of the recipient, by developing parallel quality assurance systems that establish the Northern technical standards as the basis for legitimacy of the knowledge systems. The built environment is not only a purely technical product of development aid in this reading. It is a physical manifestation of power relations that it embodies.

Climate Agreements and the Infrastructure Gap

Under the Paris Agreement, which was adopted in 2015 and ratified by Nigeria in 2017, the mechanism of nationally determined contributions (NDCs) has been emphasized as a way for countries to make their emissions reduction and adaptation commitments. Nigeria's Updated NDC, which was received in 2021, promises a 47% reduction in GHG emissions by 2030 subject to international support and identifies the built environment (including educational infrastructure) as a priority sector for investment for climate adaptation (Republic of Nigeria, 2021). Even with this policy signal, climate-responsiveness in school construction has not been the focus of international climate financing.

Since its implementation in 2015, the Green Climate Fund, a facility under the UN Framework Convention on Climate Change (UNFCCC) to provide financial resources to support developing country climate action plans, has granted more than $1.2 billion for projects in Sub-Saharan Africa, with the portfolio performance report for 2023 indicating an 34% rise in adaptation-related approvals

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compared to 2022 (GCF, 2023). Nigeria has availed itself of the GCF support for renewables and coastal adaptation. Climate responsive educational infrastructure, however, is not included in Nigeria's GCF project pipeline. Although there is a clear conceptual relationship between the design of school buildings and climate adaptation, this relationship has not been conveyed into bankable project proposals. This isn't a coincidence. It is a result of the design of institutions.

The national implementing entities that can gain direct access to the GCF resources must comply with standards of fiduciary and environmental safeguards that have been established mainly in Northern institutional settings. Progress is being made towards direct access accreditation by the Nigerian Sovereign Investment Authority and Bank of Industry, but the process is still technically challenging: As of 2024, Nigeria has only one national entity accredited for direct access, whereas Kenya has six and Ghana has four. (GCF, 2023; Climate Policy Initiative, 2024) It is certainly not the barrier of ambition, but rather the institutional capacity itself: a result of decades of underfunding of the civil service, and external pressures on the public sector.

Although the SDG architecture establishes a rhetorical connection between SDG 4 (quality education) and SDG 13 (climate action), this alignment has not yet been made programmatic. In 2023, UNESCO and UNICEF analysed education sector investment plans in 22 Sub-Saharan African countries, and identified climate responsiveness only in less than 11% of the national investments plans in education and in less than 6% of the development partner investment plans in education sector documents (UNESCO & UNICEF, 2023). The silos persist. And the two sides of the donor-recipient relation don't incentivize coherence across sectors, so they continue to do what they do even though the connection is invisible.

Knowledge Politics, Technology Transfer, and the Question of Sovereignty: Whose Knowledge Counts

In the development sector technical knowledge is political. Solutions arising from the work of Northern researchers tend to be more readily mobilised for development programming than solutions that are derived from Southern-based practice or vernacular traditions or from local, embedded expertise (Escobar, 1995; Rodríguez-Pose & Wilkie, 2022; Adesanya, Ojo, & Omotosho, 2024). In science and technology studies this inequity is known as epistemic injustice (Fricker, 2007). In the built environment, it yields infrastructure that is systematically oppressive toward the communities it is intended to serve.

Nigerian architects working with locally developed climate-responsive designs face a credentialling problem. Their solutions may be technically superior, contextually appropriate, and cost-effective. But they lack the institutional legitimacy conferred by international certification systems LEED, BREEAM, Green Star which there is a problem in Nigeria concerning credentialling of local architects working with locally developed climate-responsive designs. Their solutions could be technically better, contextually relevant and less expensive. However, they fall short of the institutional credibility of international systems of certification such as LEED, BREEAM, Green Star, which were developed in temperate Northern latitudes and are highly adapted to these conditions but not necessarily to the specific tropical West African environment (Adekunle & Nikolopoulou, 2016; Gibberd, 2021). A LEED building in Abuja optimises for heating efficiency, which is not really needed; and passive cooling, which is much needed. The certification system is giving false solutions.

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The Green Building Council Nigeria was founded in 2012, and has created a locally adapted rating system called Greenstar Nigeria. The National Building Code that was gazetted in 2006 and updated in 2017 covers energy efficiency in four climatic zones. However, there is no systematic incorporation of these into the procurement process documents of international development programmes in the education sector in Nigeria (NIA, 2023; Oluwafemi et al., 2022). The upshot is a two-track approach: projects funded internationally according to donor specifications and projects funded locally according to national specifications, both of which result in thermally substandard performance for different institutional reasons.

The distributional consequences are sharp. Internationally-funded school construction provides buildings based on imported logic for communities. Buildings for nationally-funded projects are provided to communities whose standards are in accordance with national standards, which to a large extent are templates imported from the colonies. The communities that could benefit most from design intelligence, namely the rural poor, the climate-sensitive north and the communities of the flood-prone Niger Delta, are the ones that receive the least design intelligence. This is not a coincidence. It is the geographical manifestation of knowledge politics (Adesanya et al., 2024; Nwafor et al., 2022).

Technology Transfer in Theory and Practice

The Paris Agreement includes Article 10 to promote the development and transfer of technologies to the developing world. Since 2015, the CTCN (operationalizing this mechanism) has supported 47 technical assistance projects in Sub-Saharan Africa (SSA), of which three are related to building design and urban heat management, and none are dedicated to educational infrastructure (CTCN, 2024). Nigeria has made four requests for assistance through the CTCN since 2019; none specifically targeting school building thermal performance.

In this context the very idea of technology transfer is in question. Passive architecture is not a technology in the traditional sense, it is not a proprietary system, it's not a patentable innovation, it's not capital intensive equipment. It is, however, a way of thinking and a strand of local know-how. To transfer it, there is a need for changes in the training of professionals, institutional incentive structures, building codes, and financing eligibility criteria, rather than procurement contracts or the shipment of equipment (Acheampong & Boateng, 2022; Gulbrandsen & Andresen, 2022). This is more scalable than anything; it requires no supply chains or maintenance contracts and it is more opaque to typical instruments of development finance.

Purchase and delivery of a solar panel can be done and a quarterly report can be submitted. The changes in architectural design standards will need multi-year institutional engagement, a revision of procurement rules, re-education of the profession and some regulatory changes. Measurable results are improved thermal performance, attendance and learning outcomes; but inputs are diffuse and timelines are longer than most programming cycles. Structurally, development finance is ill-suited to fund systemic change of this magnitude, as it is driven by short-term delivery, and accountability mechanisms are political ones (Siddiqui & Christiansen, 2022; OECD Development Assistance Committee, 2023).

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The South-South cooperation dimension needs to be highlighted. Rwanda, Ghana, Kenya and Senegal, which are at similar development stages and climates, have made more significant strides in climate-responsive education infrastructure policy. The National School Infrastructure Modernisation Policy 2021 included the passive cooling design specifications received with GIZ technical assistance, which led to temperature decreases of 4.9°C in the pilot schools in three regions (GIZ, 2022). Green Building Minimum Compliance System was introduced in Rwanda in 2021 with the aim of establishing institutional knowledge directly applicable to educational settings (Rwanda Green Building Organisation, 2022). These are transfer opportunities in which there does not need to be a Northern intermediary. What they need is South-South institutional connectivity, peer learning infrastructure and ECOWAS policy harmonisation.

The Sovereignty Paradox

The deepest tension in this landscape is what might be called the sovereignty paradox. Nigerian government officials, in policy documents and public statements, consistently assert the importance of national ownership over educational infrastructure decisions. The Buhari administration's 2020 Executive Order on Local Content in Government Procurement and the Tinubu administration's 2023 Renewed Hope Infrastructure Agenda both explicitly invoke national design standards as instruments of economic sovereignty (Federal Government of Nigeria, 2020; Federal Government of Nigeria, 2023). The rhetoric of 'Nigerian solutions for Nigerian problems' is politically potent and, on its merits, analytically correct. Yet the practical exercise of that sovereignty has consistently reproduced the same imported design logic that international cooperation programmes perpetuate.

The reasons are structural. Institutional inertia plays a role: procurement officials work from established templates because established templates reduce risk and personal liability in an accountability environment where process compliance is more reliably enforced than outcome quality (Transparency International Nigeria, 2023). Capacity constraints play a role: the technical expertise required to develop and defend locally adapted design standards against donor queries and contractor resistance is not uniformly available across Nigerian government agencies, particularly at state and local government level (Nwafor et al., 2022). Political economy plays a decisive role: construction contracts represent substantial rents in Nigeria's political economy, and the design specifications attached to contracts are not politically neutral they determine which contractors can compete and which materials suppliers benefit (Transparency International Nigeria, 2023; Mbeki et al., 2023).

The sovereignty paradox is this: the exercise of genuine architectural sovereignty the choice to build schools according to locally adapted, climate-responsive standards requires exactly the kind of state capacity, institutional coordination, and policy coherence that decades of structurally adjusted, externally directed development have systematically eroded. Nigeria cannot simply decide to do things differently. It must also have the institutional infrastructure to do so. Building that institutional infrastructure is itself a development challenge and one that international cooperation, as currently structured, does little to address (Rodríguez-Pose & Wilkie, 2022; Adeyemi & Olusegun, 2023).

Toward a Reform Framework: Aligning Cooperation with Climate Intelligence

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Reforming the Design-Finance Interface

The most manageable short-term reform is to incorporate climate-sensitive design factors into financing models for international and local programmes for education infrastructure. This will take coordinated action at three levels.

At the national level, the Federal Ministry of Education (FME) and Universal Basic Education Commission (UBEC) should formulate the National School Infrastructure Climate Standard setting minimum thermal performance requirements as maximum operative temperature, minimum air change rate per hour and window to floor area for all school construction in Nigeria at the national level. This standard needs to be adjusted to the six climatic subzones of Nigeria and should also reflect the passive cooling methods found to be effective in the pilot projects that have already been conducted in Nigeria (NIA, 2023; DBN, 2022). The presence of such a standard provides a legal reference that can be used to evaluate national and internationally-funded projects.

At the international cooperation level, Nigeria's government should engage in negotiations to have the National School Infrastructure Climate Standard be the guiding framework for all multi-lateral and bi-lateral school infrastructure programmes. This is a precedent-setting sovereignty exercise that succeeded without waivers from standard World Bank IPF requirements from Ghana's negotiations of climate-smart design requirements into its World Bank education programme in 2021 (World Bank, 2023b; GIZ, 2022). It needs political will at the highest level at the Presidency and Ministry of Finance where the relationships with donors are built and not the technical teams in charge of project implementation.

At the financing instrument level, Nigeria should work towards developing project ideas with Climate Finance Funding eligibility which bundle education infrastructure as an adaptation investment. The GCF's Simplified Approval Process is an avenue for smaller-scale adaptations that are directly accessed for up to $10 million (GCF, 2023), providing an immediate entry point. The Sustainable Energy Fund for Africa (AfDB) and the Global Environmental Facility (GEF) have also other avenues of financing for education infrastructure projects with proven climate adaptation impacts (AfDB, 2023; GEF, 2023).

Rebuilding the Knowledge System

Design knowledge is essential to design sovereignty. The resuscitation of a national indigenous knowledge base for building for climate change is not a culture-recovery exercise. This is a smart investment in technical foundations of infrastructure sovereignty.

The Nigerian architecture schools of the University of Lagos, Obafemi Awolowo University, Ahmadu Bello University and University of Nigeria Nsukka should adopt vernacular climate adaptation in their formal curriculum. The NUC's audit shows that the quality of provision is unsuitable. The Architects Registration Council of Nigeria (ARCON) should rethink their Architectural Education Standards so as to make climate responsive design a part of the basic competency of practising licensure, rather than an elective specialization at the postgraduate level.

The NUC in partnership with NIA and COREN should establish a group of practising architects and engineers who will be able to specify and defend climate responsive designs in the face of donor

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procurement obstacles. Information is not enough if it is not disseminated through institutions. It is a risky situation to use leverage without knowing. Both are essential and both are attainable at not too great a cost (Adesanya et al., 2024; NIA, 2023).

The purposeful programming and funding of south-south learning exchanges are needed. For three to six months, African architects at the field level are exposed to the green building sector in Rwanda, as well as the Building Regulatory Authority of Kenya and the pilots on climate-responsive school construction in Ghana. They come back with knowledge directly applicable that is not found in the field in temperate climates. Programming and financing such exchanges at scale is possible through various institutional avenues including the ECOWAS infrastructure harmonisation agenda, the African Union's Agenda 2063 infrastructure pillar and the African Development Bank's African Climate Change Fund (AfDB, 2023; ECOWAS Commission, 2022).

Political Strategy for Reform

Technical arguments will not be enough to achieve reform in this area. It will happen when political actors identify a climate responsive educational infrastructure as a voteable issue, when the relationship between building design and child welfare is made vivid, legible and salient to an electorate that is predominantly young and has children educated in public schools.

Political leverage is maximised when advocacy coalitions are formed by actors who are involved in civil society organisations on education quality, along with environmental NGOs on climate adaptation, building associations on building standards and parent-teacher associations on learning outcomes. There is evidence-based research showing the relationship between thermal stress and learning outcomes (Heal & Park, 2023; Oluwafemi et al., 2022). The moral narrative is provided by the dimension of distributive justice that poor children are the ones who bear the heaviest burden in thermally hostile schools. Economics is the argument for passive vs. active cooling. These three elements are each convincing. They're a highly political duo.

On the international scene, the Nigerian government has a good chance to play a climate leadership role by making the provision of climate responsive educational infrastructure a strong demand at the multilateral climate negotiation table. Nigeria's voice as Africa's largest economy and most populous country has normative weight in the context of adaptation finance at COP30 in Belem, Brazil which is explicitly dedicated to this topic (UNFCCC Secretariat, 2024). Nigeria's NDC revision process, in response to the global stock take in 2025, presents immediate possibilities to raise education infrastructure as a tangible, bankable adaptation priority.

A diplomatic effort is also needed on the bilateral front. The agreements on education cooperation with the United States, the United Kingdom, Germany, France, Japan and China among others are all set to expire or be revised between 2025 and 2028 (Federal Ministry of Foreign Affairs, 2024). The first one, which is pragmatic and achievable, is to put climate-responsive design requirements into these agreements and also have them recognise national design standards: it does not need to be invented but needs diplomatic signalling. It demands Nigerian policy makers who are cognizant of the fact that the architecture of the relationship, not the architecture of the schools is the one that gets built.

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5.0. CONCLUSION

Return to that school in Kano, the children are still sitting, the heat is still rising, the roof is still iron. Nothing about this is inevitable. Passive architecture offers Nigeria a path to school buildings that respond to their climate, that work with the sun and the wind rather than against them, that cost less to operate and more to design. The science is settled (UNEP, 2022; IPCC, 2022; Mensah et al., 2022). The existence of the vernacular knowledge has been established (Elleh, 1997; Ajayi et al., 2022; Abubakar & Mohammed, 2024). The current pilot evidence is building up (UNICEF Nigeria, 2022; DBN, 2022). However, there is nothing to stop the scale from being achieved. They are political. They inhabit procurement systems located on continents and under different circumstances. They reside in professional credentialling systems that are not up to date with post-colonial knowledge recovery. Their lives entail financing instruments that reward measurable over the meaningful.

In this article, three points have been argued.

The first is that Nigeria's education infrastructure crisis is not just the product of rising temperatures in the future tense, but measurable and tangible in the present tense of children, whose cognition, attendance, and learning outcomes are being directly harmed by the thermal conditions of their classrooms (Heal & Park, 2023; Aliyu & Sani, 2023; Oluwafemi et al., 2022).

Secondly, that passive architecture offers an adequately technically strong and contextually responsive solution that is also cost-effective, a solution for which Nigeria has the needed knowledge heritage and the growing professional expertise to scale up (Adekunle, 2021; Mensah et al., 2022; NIA, 2023).

Third, that it is changes in the political and institutional nature of international cooperation that are as consequential as changes in the physical nature of schools (Rodríguez-Pose & Wilkie, 2022; Acheampong & Boateng, 2022).

Current forms of international cooperation are contributing to the problem, and may also turn out to be part of the solution. It's a problem because it brings in building logic, it takes away design sovereignty, it takes away the institutional memory, it prioritizes delivery metrics over climate performance in the long term (Siddiqui & Christiansen, 2022; Gulbrandsen & Andresen, 2022). It may be a part of the solution as it finances systems change, acknowledges and values Southern knowledge systems, is aligned with national standards, and sees thermal comfort in schools as the climate adaptation issue that the evidence supports it to be (GCF, 2023; UNESCO & UNICEF, 2023; Climate Policy Initiative, 2024).

The reform program described in this paper is attainable. It is not dependent on any new scientific advances. It does not need resources which are not available. It is a matter of political will in the nexus of education policy, climate policy and international relations. It needs Nigerian policy makers who believe that the architecture of the school is a means of expression of its sovereignty, and international partners who believe that the partnership they claim to offer should be a truly respectful partnership of the knowledge system of the school's communities. The children will learn better if schools are built with all this in mind. The evidence is there, the knowledge is there. The question as it always is in development is whether the politics can catch up with the possibility.

Conflict of Interest

The authors declare that no conflict of interest.

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