

Neuro-Architectural Design of an Inclusive School Complex: A Response to the Needs of Autistic Children in Ngaoundere

¹NKONO AMBASSA Marie-Stéphane; ²BWEMBA Charles; ³MOHAMADOU Hafis; ³Architect HQE

^{1,2}Department of Architecture

^{1,2}Ecole Nationale Supérieure Des Travaux Publics

³Architecture Technique Construction

^{1,2,3}Yaoundé, Cameroon

Abstract:- In Cameroon, although efforts have been made to improve access to education, children with autism spectrum disorders (ASD) often remain excluded from the traditional school system, particularly in the northern regions where access to specialized infrastructure is limited. This article presents the results of a study on the design of a school complex adapted to autistic children in Ngaoundere, incorporating the principles of neuro-architecture. The survey conducted with specialists, parents, and educators provided crucial insights to create an inclusive and calming educational environment that meets the sensory and cognitive needs of the children. The site analysis in the Adamawa region, considering climatic and geographical constraints, confirmed the relevance of the location. The architectural design, focused on diverse spaces such as classrooms, sensory withdrawal zones, and common areas promoting inclusion, not only enhances the social integration of autistic children but also raises awareness in the community about the importance of their education. This project, rooted in an ecological and cultural approach, represents a sustainable and innovative initiative for Cameroon's education system.

Keywords:- *Neuro-Architecture, Autism, Inclusion, Education, Ngaoundere.*

I. INTRODUCTION

The integration of autistic children into the educational system remains a major challenge in many countries, including Cameroon. This thesis project focused on designing an innovative school complex in Ngaoundere, aimed at meeting the needs of children with autism spectrum disorder (ASD). The project is based on the principles of neuro-architecture to create an environment conducive to learning and well-being while promoting their social inclusion. To ensure a truly adapted environment, a survey was conducted among specialists, parents, educators, and other stakeholders who regularly interact with autistic children. This data collection helped identify specific needs and integrate architectural solutions that take into account the sensory preferences and educational requirements of these children, while also adapting to local constraints.

II. DATA ANALYSIS

As part of our research on the design of a school complex adapted to children with autism spectrum disorder (ASD), an online survey was conducted with people who regularly interact with these children, including specialists, parents, educators, students, and other professionals. This survey aimed to gather specific information about the needs of autistic children and to identify ways to best adapt architectural spaces to their particularities. Below is an analysis of the responses obtained for each question.

- Preferred shapes for autistic children: Circular and square shapes are the most favored, as they provide a sense of security (63% of respondents).
- Activities to prioritize: Includes bottles, jars, and other glass products. Glass waste typically makes up about 2-5 % of the total.
- Stress reduction: 60% Key architectural elements for reducing stress include well-ventilated open spaces (24%), calm zones (22%), and adjustable natural lighting (17%).
- Community acceptance: Over 90% of participants supported the creation of a school complex dedicated to autistic children, emphasizing the importance of this initiative for social inclusion.

III. SITE ASSESSMENT

➤ *Geographical Context*

The northern region of Cameroon, represented in Figure 1, which includes the Adamawa, North, and Far North, covers nearly 40% of the country's territory. This area is characterized by its cultural and ethnic diversity and is marked by a predominantly arid climate, with long dry seasons and irregular rainfall. The inhabitants mainly engage in agriculture and livestock farming, two activities that are heavily influenced by these difficult climatic conditions. From an architectural perspective, traditional constructions use local materials adapted to the climate but are not well-optimized for the needs of specialized education, particularly for autistic children, who require specific environments for their well-being.

➤ *Historical Background*

Ngaoundere was founded in the 19th century by the Foulbe people, after the region was conquered by Modibo Adama, a Fulani leader, which gave the region its name "Adamawa." The city developed around Mount Ngaoundere,

a landmark that gives the city its name and means "navel of the mountain" in the local language. Today, Ngaoundere is an important cultural center for the Foulbe and other ethnic groups in the region, and it continues to play a historic role in shaping the identity of Adamawa.

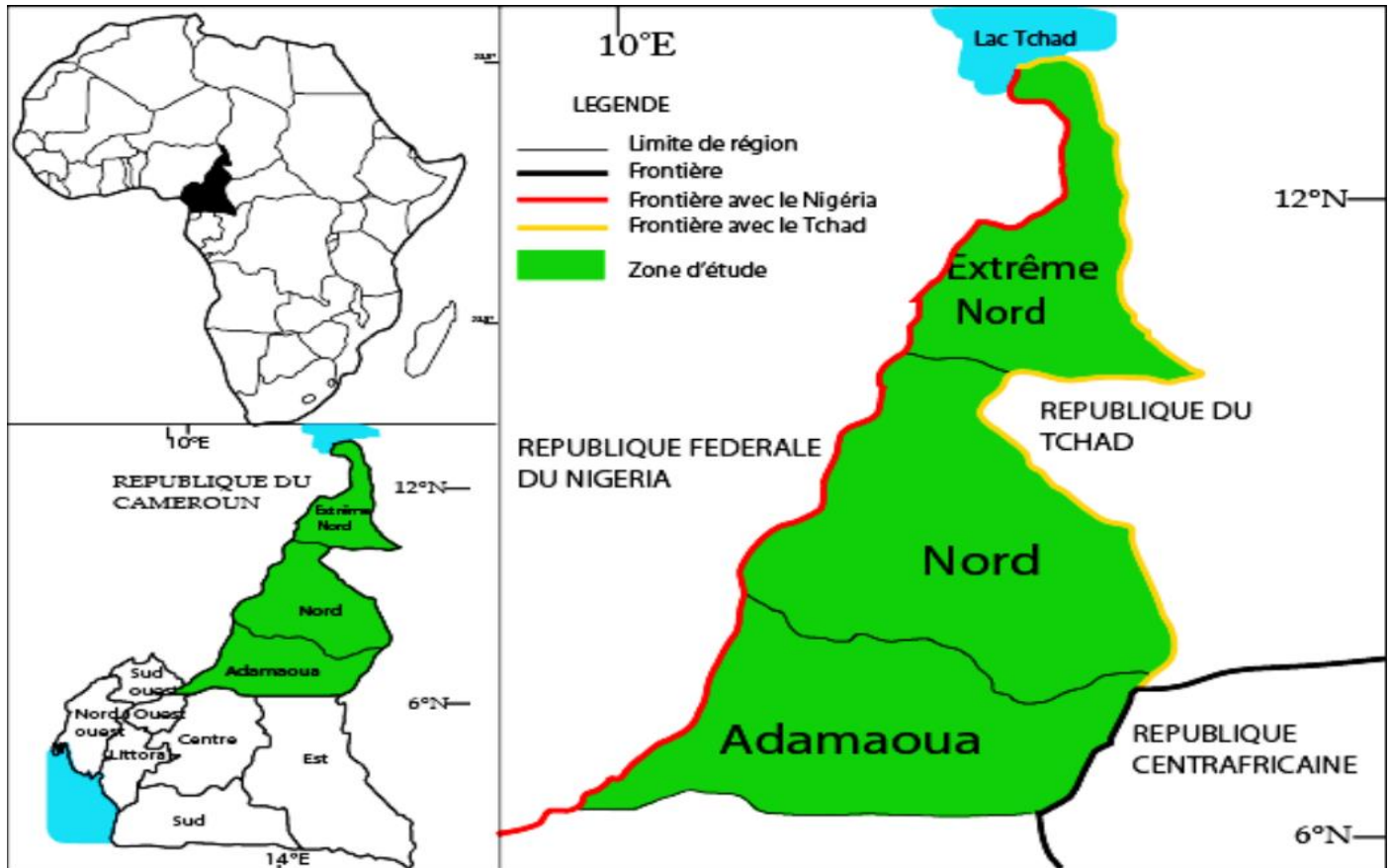


Fig 1 Presentation of the Northern Region of Cameroon

➤ *Site Selection and Location*

Located in the heart of the northern region, the Adamawa area is distinguished by its rolling hills and plateaus, with Ngaoundere as its regional capital. Ngaoundere, benefiting from a slightly more temperate climate than the North and Far North, provides a favorable setting for the implementation of this innovative project. Our school complex adapted for autistic children is situated in the city of Ngaoundere, specifically in the Administrative District.



Fig 2 Site Location

IV. SITE PRESENTATION AND JUSTIFICATION

The regional capital of Adamawa, the city of Ngaoundere, shown in Figure 3, is located 850 km from the country's political capital, positioning it at the center of

Cameroon. It is a strategic hub, connecting the northern region to other major regions of Cameroon, as well as neighboring countries like Chad and Nigeria. This city serves as an important administrative, economic, and cultural center, with a cosmopolitan population.

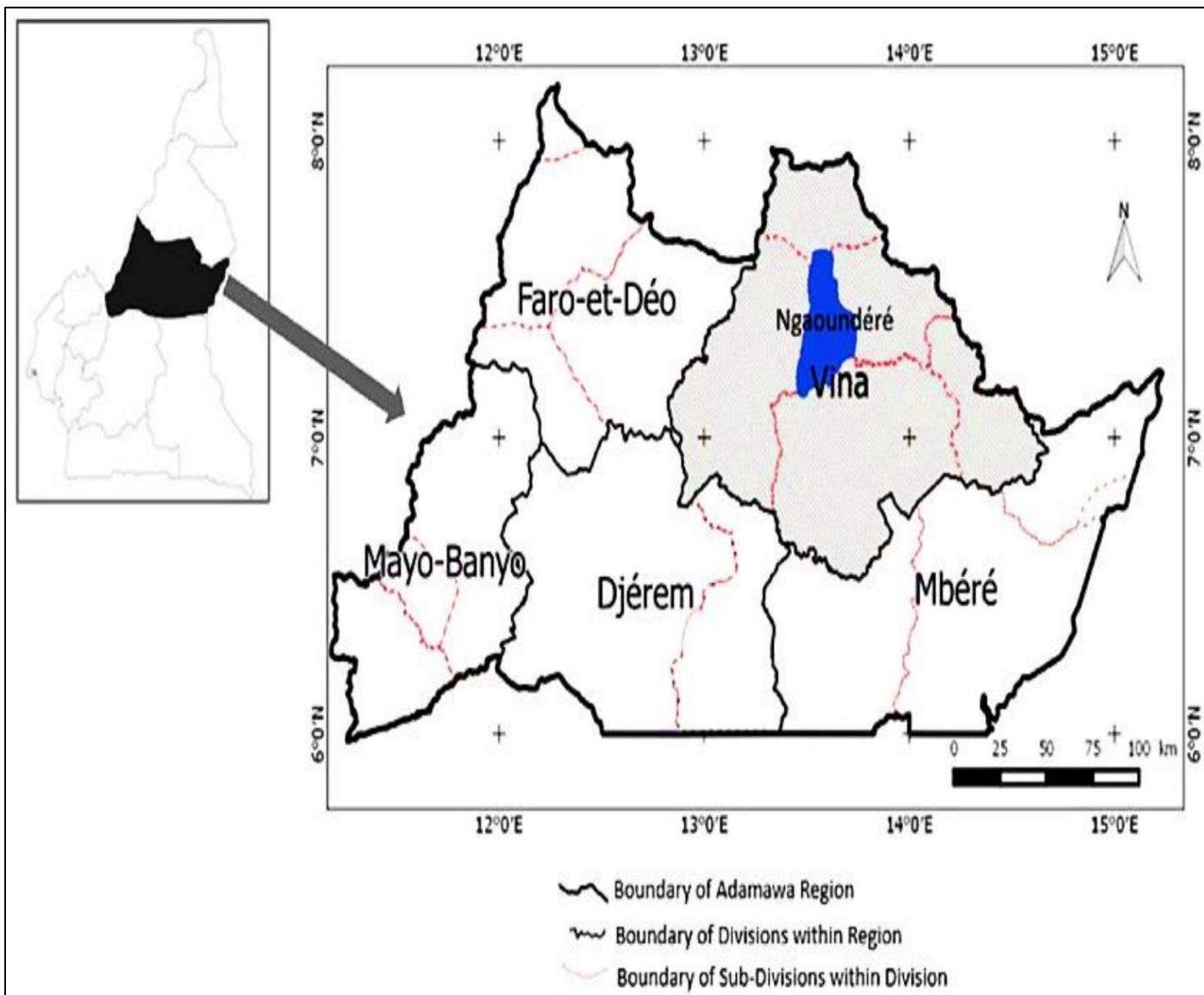


Fig 3 Location of the City of Ngaoundéré

➤ Historical Background

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➤ Demographics

Ngaoundere has an estimated population of about 200,000 inhabitants. The population is ethnically diverse, with a majority of Fulani (or Foulbé), but also a significant

representation of Gbaya, Dii, and other ethnic groups from Adamaoua and surrounding regions. This diversity contributes to the city's rich cultural fabric. As a regional hub, Ngaoundere also attracts populations from both the north and south of the country, creating a multicultural environment.

➤ Climate and Temperature

Ngaoundere enjoys a tropical highland climate, typical of the Adamawa plateau. It features a rainy season from May to October and a dry season from November to April. The temperatures are moderated by the altitude, ranging from 17°C at night to around 30°C during the day. This relatively mild climate makes the city more temperate compared to the hotter regions of the North and Far North.

	Janvier	Février	Mars	Avril	Mai	Juin	Juillet	Août	Septembre	Octobre	Novembre	Décembre
Température moyenne (°C)	23.6	25.5	26.3	24.5	22.7	21.4	20.5	20.3	20.9	21.9	23.4	23.3
Température minimale moyenne (°C)	17	18.8	19.8	19.8	18.9	17.8	17.3	17.2	17.4	17.6	17.6	17.1
Température maximale (°C)	31.3	33	33.6	30.9	28.5	27	25.6	25.2	26.6	27.8	29.9	30.6
Précipitations (mm)	0	2	27	180	301	350	375	410	366	215	22	0
Humidité(%)	24%	22%	30%	62%	81%	86%	88%	89%	86%	77%	48%	31%
Jours de pluie (jrée)	0	0	3	13	20	20	21	21	20	16	3	0
Heures de soleil (h)	10.6	10.7	10.6	9.4	8.4	7.1	6.2	5.5	6.3	8.1	10.2	10.5

Fig 4 Climatic Table of the City of Ngaoundéré (Climadata.org, 2021)

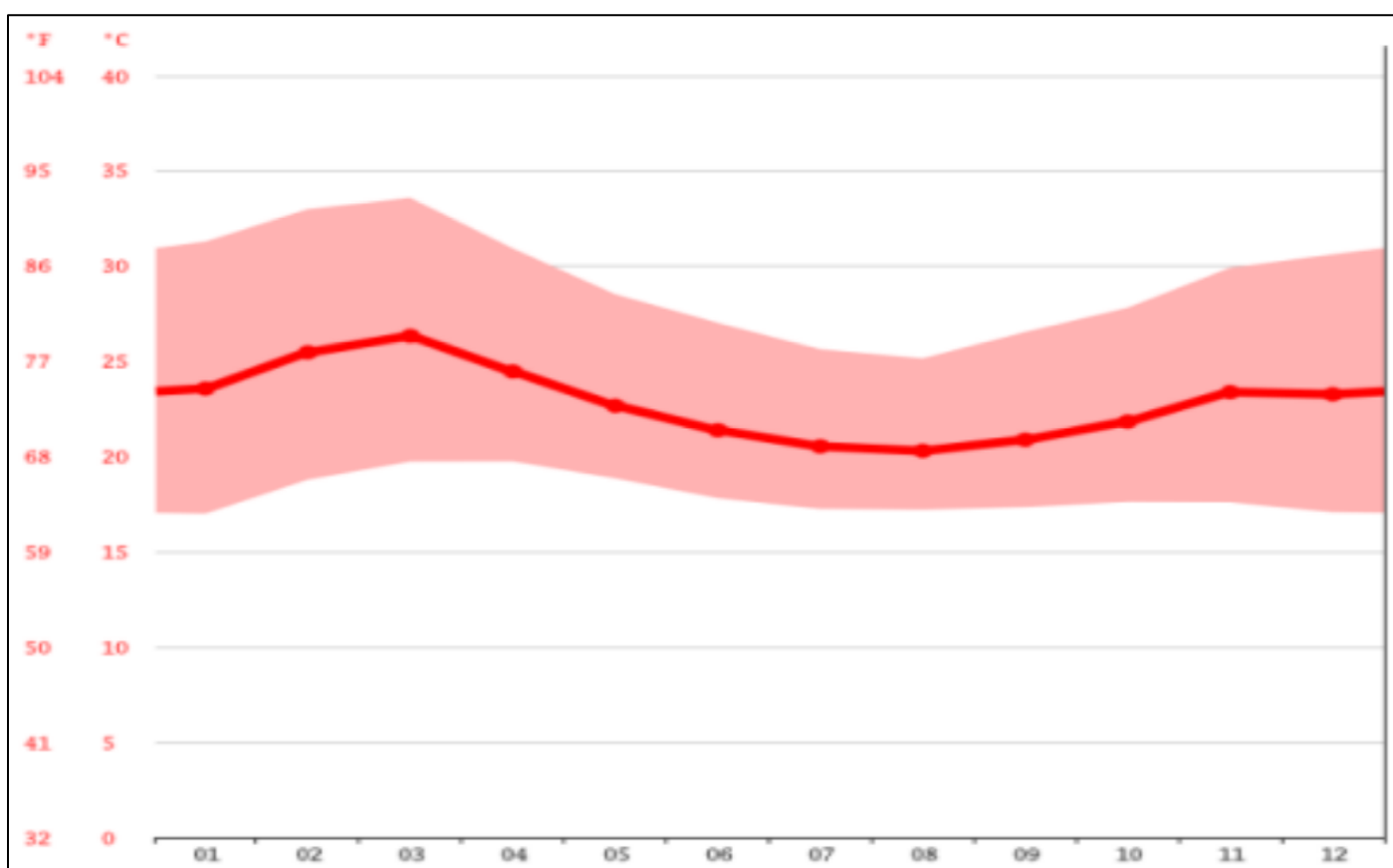


Fig 5 Temperature Curve for the Town of Ngaoundéré (Climate-Data.org,2021)

➤ *Relief, Hydrography, and Soil*

Ngaoundere’s landscape is dominated by plateaus and mountains, especially Mount Ngaoundere, a volcanic formation that gives the city its name. The city is surrounded by rolling hills, which contribute to its cooler climate. Hydrologically, the region is fed by several rivers, some of which originate from the surrounding mountains. The soils in the region are mainly ferrallitic and sandy, making the area suitable for certain agricultural crops like maize, cassava, and peanuts.

➤ *Topography and Site Characteristics*

• *Topography*

The site features slightly sloping terrain, or in some parts flat, as shown in Figure 6. The natural slopes are gentle, making the site suitable for constructing the educational complex for autistic children, with minimal need for leveling or significant modifications to the terrain.



Fig 7 Site Infrastructure and Accessibility

➤ *Site Characteristics*

The total area of the site is approximately 8,438 m², providing sufficient space for the development of the educational facility, associated installations, as well as future expansion possibilities. The size of the site also allows for the integration of green spaces, relaxation areas, and buffer zones, thereby creating a calming environment suitable for the specific needs of autistic children, while minimizing any potential impact on the surrounding natural environment.

➤ *Infrastructure and Accessibility*

• *Road Access:*

The site is accessible via a main road, facilitating travel

to the educational complex. This road connects the site to several important infrastructures nearby, such as the regional hospital, a school, and the CRTV station of Adamawa, as shown in Figure 7. This well-developed road network ensures smooth accessibility for families, staff, as well as necessary medical and educational service.

• *Public Services:*

Basic services like water, electricity, and telecommunications are available on or near the site, simplifying the development of necessary infrastructures for the project. The proximity of these existing infrastructures also allows for the efficient use of current networks to support the proper functioning of the educational complex.



Fig 7 Site Infrastructure and Accessibility

➤ *Socio-Economic Activities*

Ngaoundere is an important regional economic hub. Agriculture and livestock farming hold a central place, with notable production of cereals, tubers, and a well-developed livestock sector, mainly cattle. The city also hosts one of the country's largest slaughterhouses, contributing to both the local and national economy. Commerce flourishes due to its strategic geographic position. Ngaoundere is also a transportation hub, with the presence of a railway linking

the city to Douala, as well as roads leading to neighboring countries. Tourism is growing, especially thanks to the natural landscapes and Mount Ngaoundere, which attracts hikers.

➤ *SWOT Analysis of the Site*

The analysis of strengths, weaknesses, threats, and opportunities is presented as follows:

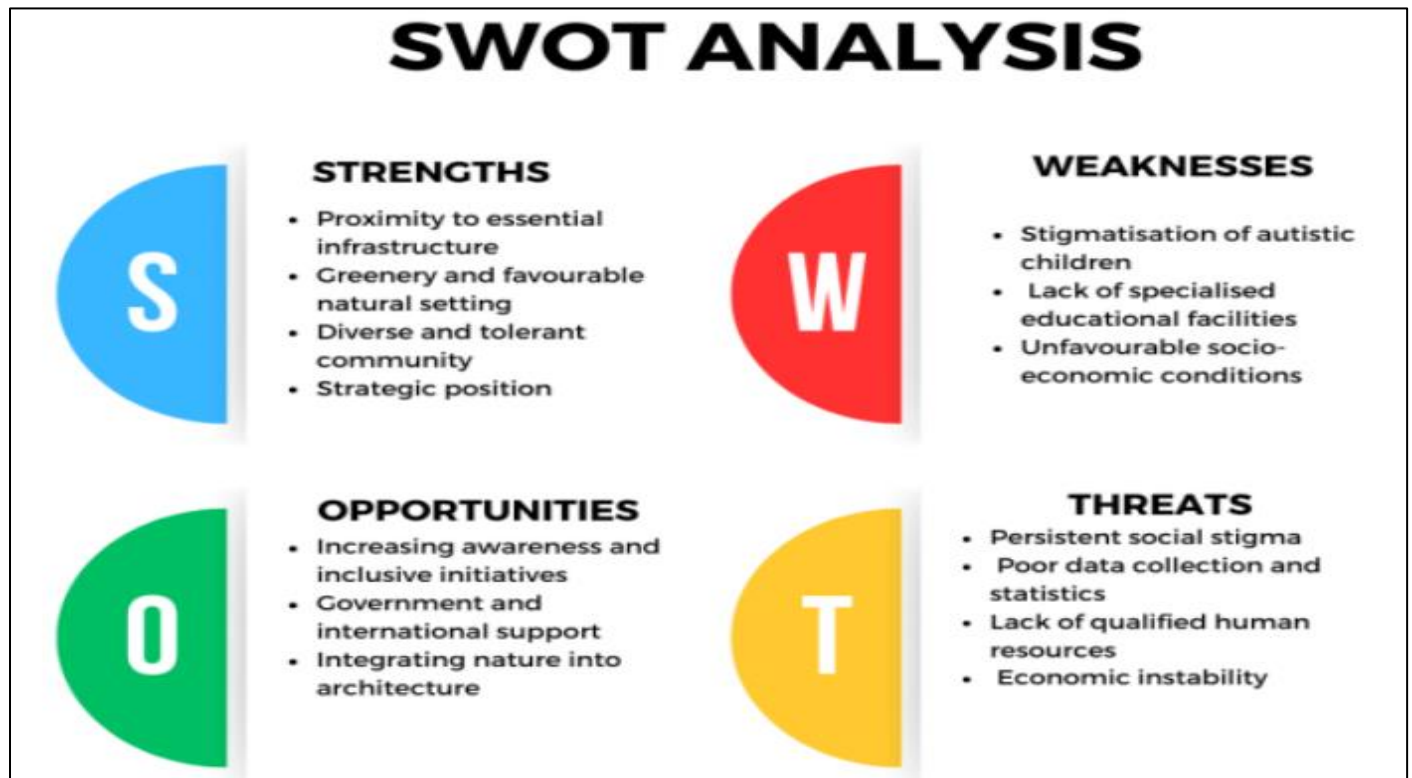


Fig 8 SWOT Analysis of the Site

V. PROJECT DESIGN

The design phase of the educational complex for autistic children is essential to create a facility that not only meets the specific needs of these children but also improves the social and educational environment of Ngaoundere through neuro- architectural design principles. This approach emphasizes well-being, sustainability, functionality, and social inclusion, ensuring that the complex is not only suited to the educational needs of the children but also serves as a true asset to the local community

➤ *Architectural Program*

The architectural program of the school complex stems from the needs identified during analyses and the survey. It is structured around several key areas, each serving a specific role in facilitating learning, socialization, and the well-being of both autistic and neurotypical children.

• *Administrative Zone:*

The administrative zone is the organizational heart of the school complex. It includes the offices of teachers, counselors, and management. This space is designed to be

accessible and easily identifiable, while ensuring a calm environment for daily operations. Circulation is smooth to facilitate transitions between this area and other parts of the school, while limiting auditory and visual distractions. Special attention is paid to ergonomics and acoustics to minimize sensory disturbances for autistic children;

- ✓ Secretariat
- ✓ Reception area
- ✓ Director's office
- ✓ Infirmary
- ✓ Teacher's room
- ✓ Restrooms

• *Primary School:*

The primary school includes classrooms adapted to the needs of both autistic and neurotypical children. Each classroom is equipped with visual learning aids and flexible arrangements to foster inclusion. The layout of the classrooms follows a structured spatial organization to reduce sensory overload. Windows allow natural light to enter, modulated to avoid glare, a key element in neuro-architecture to improve students' attention. Wide corridors

facilitate movement, and sensory retreat spaces are integrated to allow children to calm down in case of overload.

- ✓ Classrooms
- ✓ Assembly courtyard
- ✓ Restrooms

• *Kindergarten:*

The kindergarten is an inclusive space designed for all young children. The rooms are smaller, with ergonomic furniture and soothing colors that contribute to a serene environment. Play areas, both indoor and outdoor, are designed to encourage learning through play while considering the sensory characteristics of the children. The spaces are open to gardens and courtyards, allowing students to connect with nature, a factor beneficial for reducing anxiety.

- ✓ Classrooms + dormitory
- ✓ Teachers' room + changing rooms
- ✓ Playground
- ✓ Restrooms

• *Autism Space:*

The autism space is a specific environment designed for children with more severe autism spectrum disorders.

This area includes classrooms with accommodations adapted to their sensory and cognitive needs, as well as sensory retreat zones where children can withdraw in case of overload. Acoustic absorbing materials, soft colors, and dimmed lighting are used to create a calming environment and minimize disruptive stimuli.

- ✓ Specialized rooms.

• *Common Area:*

The common area is a place for socializing and interaction that fosters inclusion for all students. This space is designed to encourage social interaction between autistic children and their neurotypical peers while respecting their sensory needs. The materials chosen, along with the arrangement of the furniture, allow the space to be modulated based on activities, whether for group games or quiet moments. The connection with nature is strengthened by direct access to outdoor areas and gardens.

- ✓ Multipurpose room
- ✓ Library
- ✓ Computer room
- ✓ Cafeteria + storage
- ✓ Playground
- ✓ Restrooms
- ✓ Parkings

Table 1 Surface Program of our School Complex

Zone	Number	Unit Surface (m ²)	Surface Area (m ²)
Administrative Area			
Director's office	01	26.5	26.5
Archive room	01	12	12
Secretariat	01	10.8	10.8
Teachers' room	01	32	32
Reception area	01	42.8	42.8
Infirmary	01	28.3	28.3
Restrooms	01	15	15
Primary School			
Classrooms	06	64	512
Restrooms	01	53.6	53.6
Kindergarten			
Classrooms + Dormitory	03	60.5	181.5
Teachers' room + changing rooms	01	25.3	25.3
Common Area			
Multipurpose room	01	63.3	63.3
Computer room	01	96.9	96.9
Restrooms	01	14.8	14.8
Cafeteria	01	155.6	155.6
Kitchen	01	12.6	12.6
Storage	01	12.5	12.5
Library	01	58.5	58.5
Autism Space			
Classrooms	02	60.9	121.8
TOTAL SURFACE AREA			1 958.2

➤ *Architectural Concept and Block Diagram*

• *Architectural Concept*

The main idea of the architectural concept is to promote inclusion while maintaining a balance between collective and individual spaces. In this project, social inclusion and adaptability to the needs of autistic children are at the heart of the design. Collective spaces (common

areas, play zones, and playgrounds) are designed to encourage interaction, while private and sensory spaces allow children to withdraw when they feel the need. This combination ensures that every child, whether autistic or neurotypical, can evolve in an environment that respects their specific needs. The detailed concept is illustrated in Figure 9, Figure 10, Figure 11, and Figure 12.

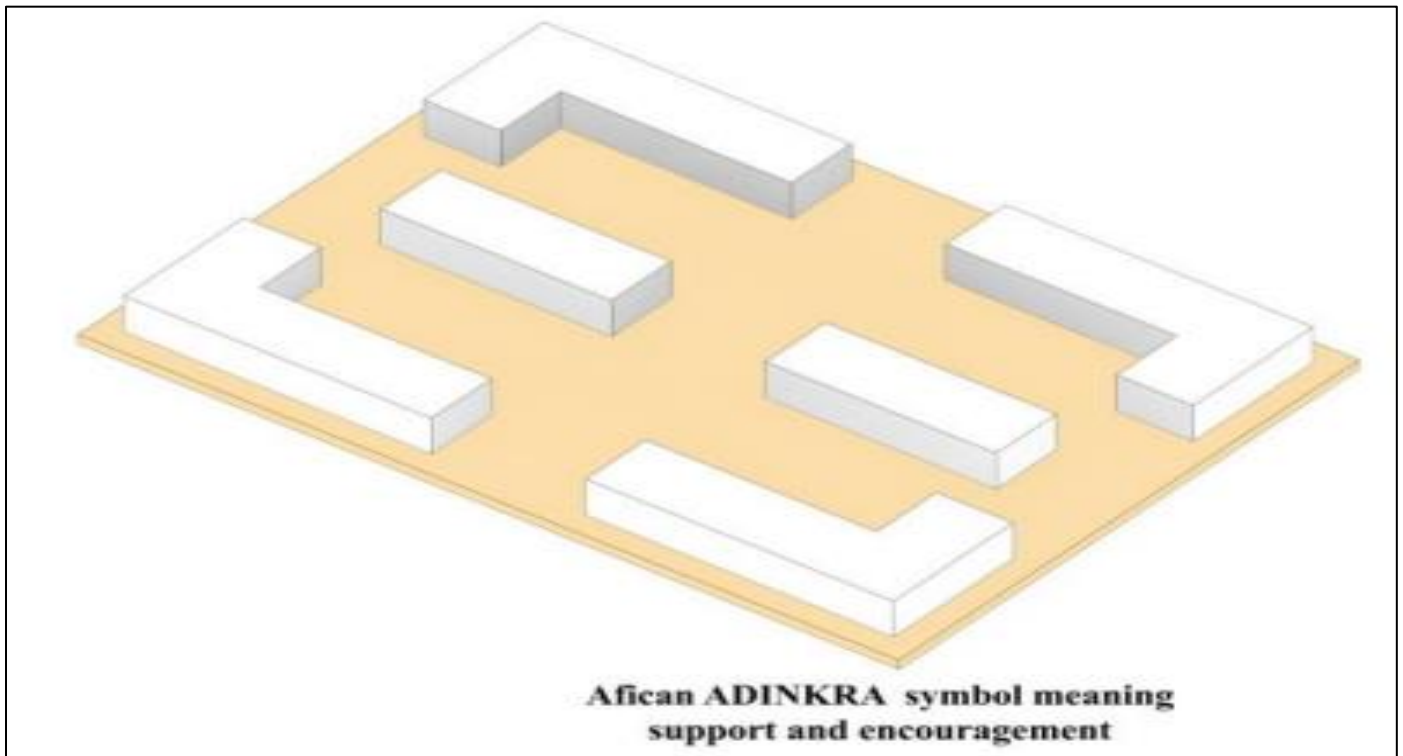


Fig 9 Phase 1 of the Concept

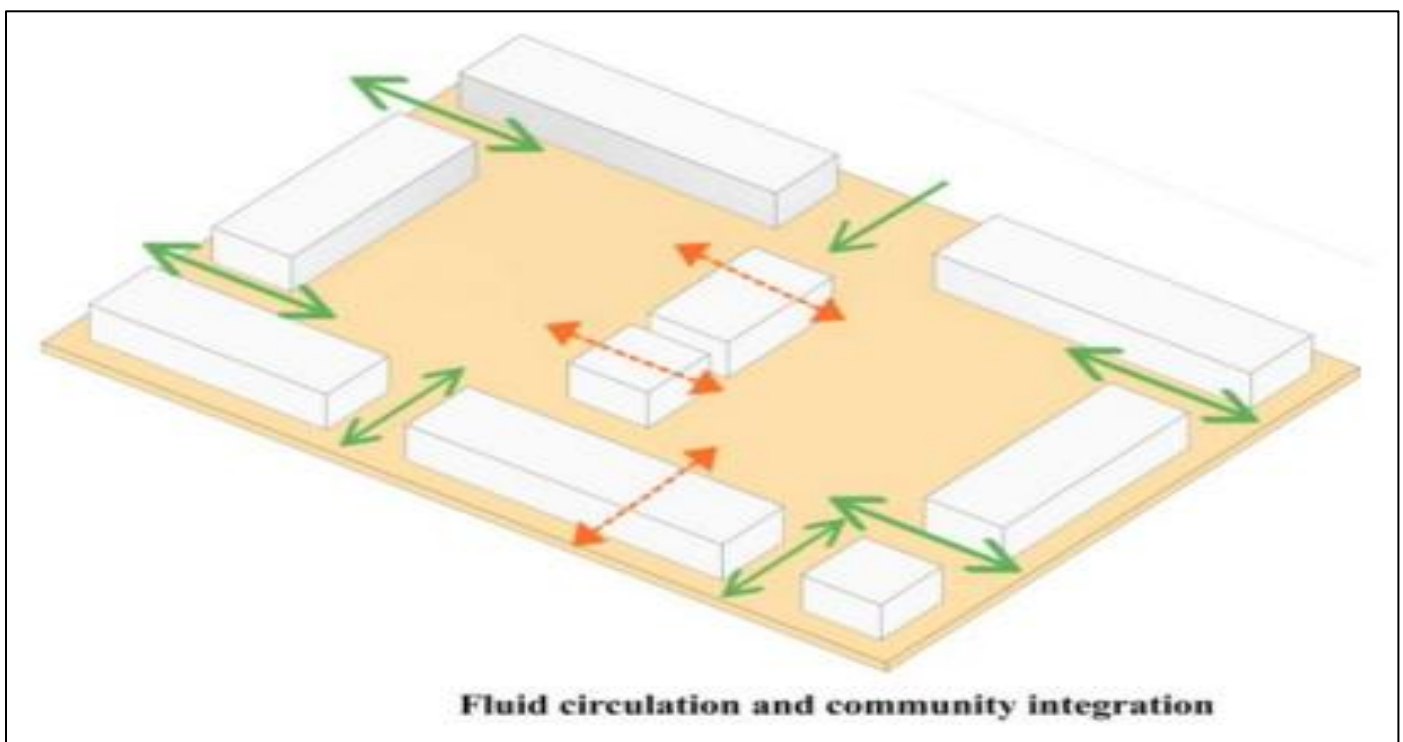


Fig 10 Phase 2 of the Concept

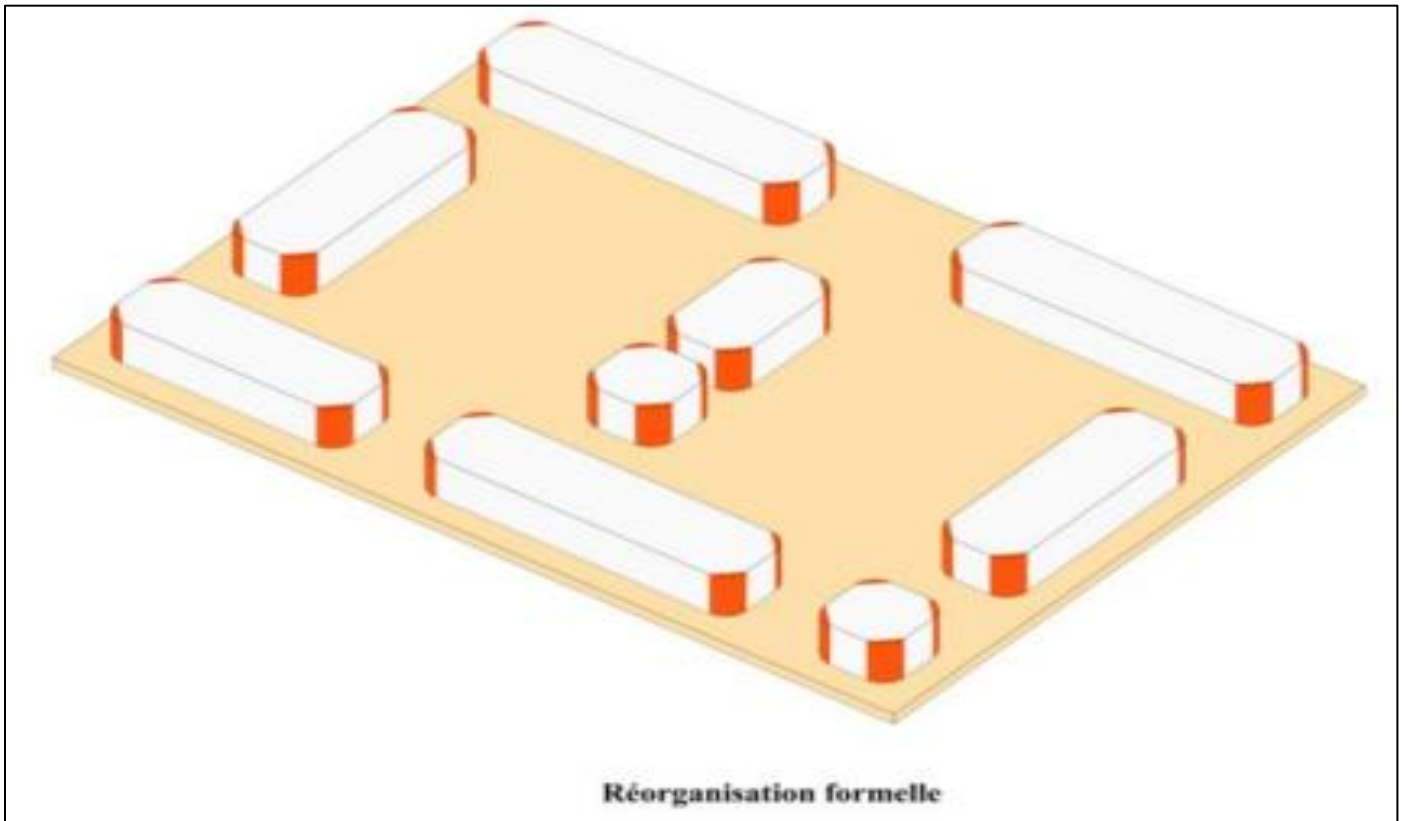


Fig 11 Phase 3 of the Concept

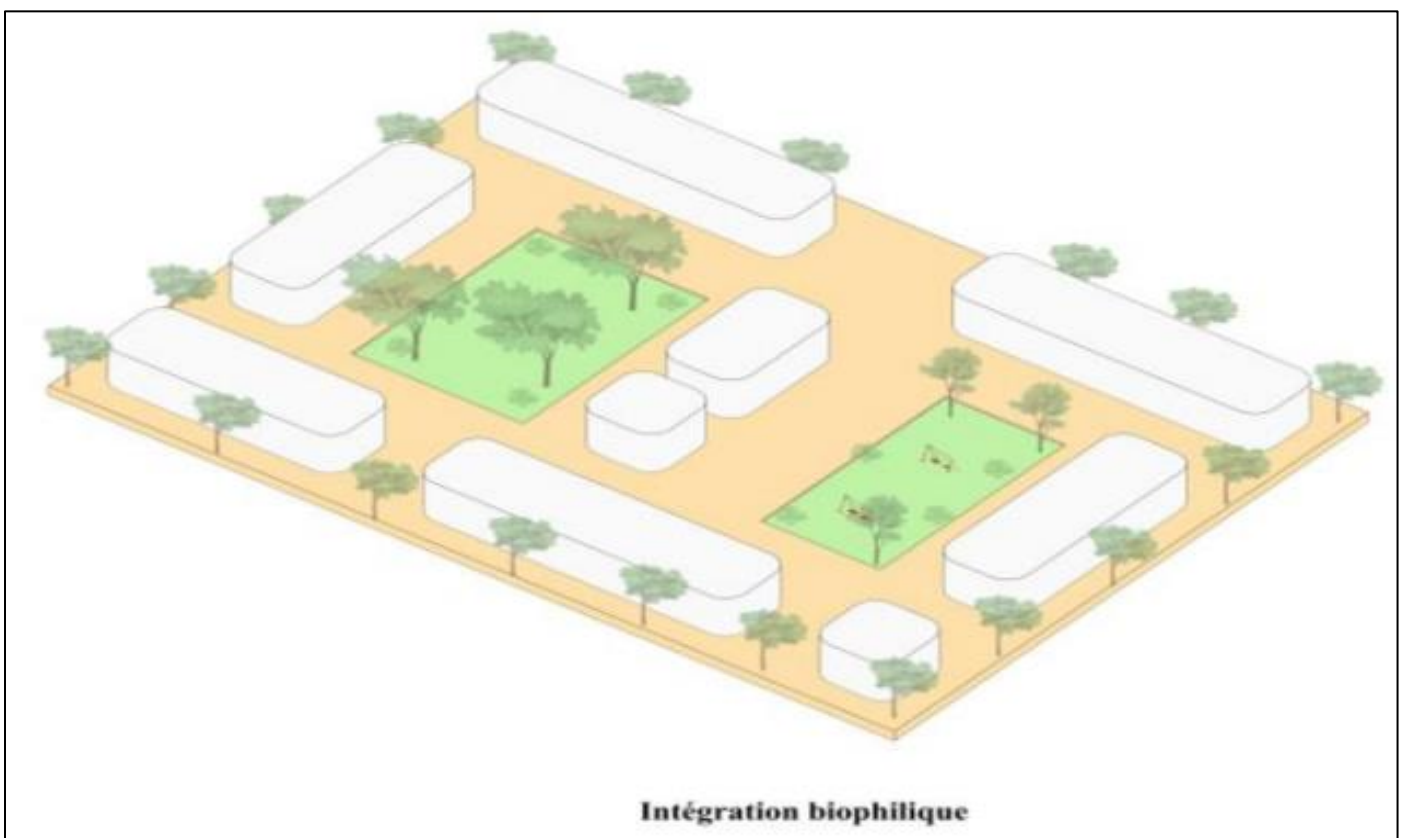


Fig 12 Phase 4 of the Concept

- **Block Diagram**

The block diagram below connects and communicates the main areas of the architectural program for the school complex (see Figure 13).



Fig 13 Block Diagram

VI. DESIGN STRATEGY

➤ Model Orientation

In our project, the school complex is oriented along a North-South axis, as shown in Figure 3.19, to maximize exposure to natural light while reducing direct sunlight during the hottest hours of the day. This approach helps minimize the need for air conditioning, providing a more

comfortable environment for autistic children, who are often sensitive to temperature variations and glare. The orientation of the buildings also takes into account the prevailing winds from the Northeast, which promotes natural ventilation and contributes to the energy efficiency of the complex, while creating a soothing and well-ventilated environment for the students.

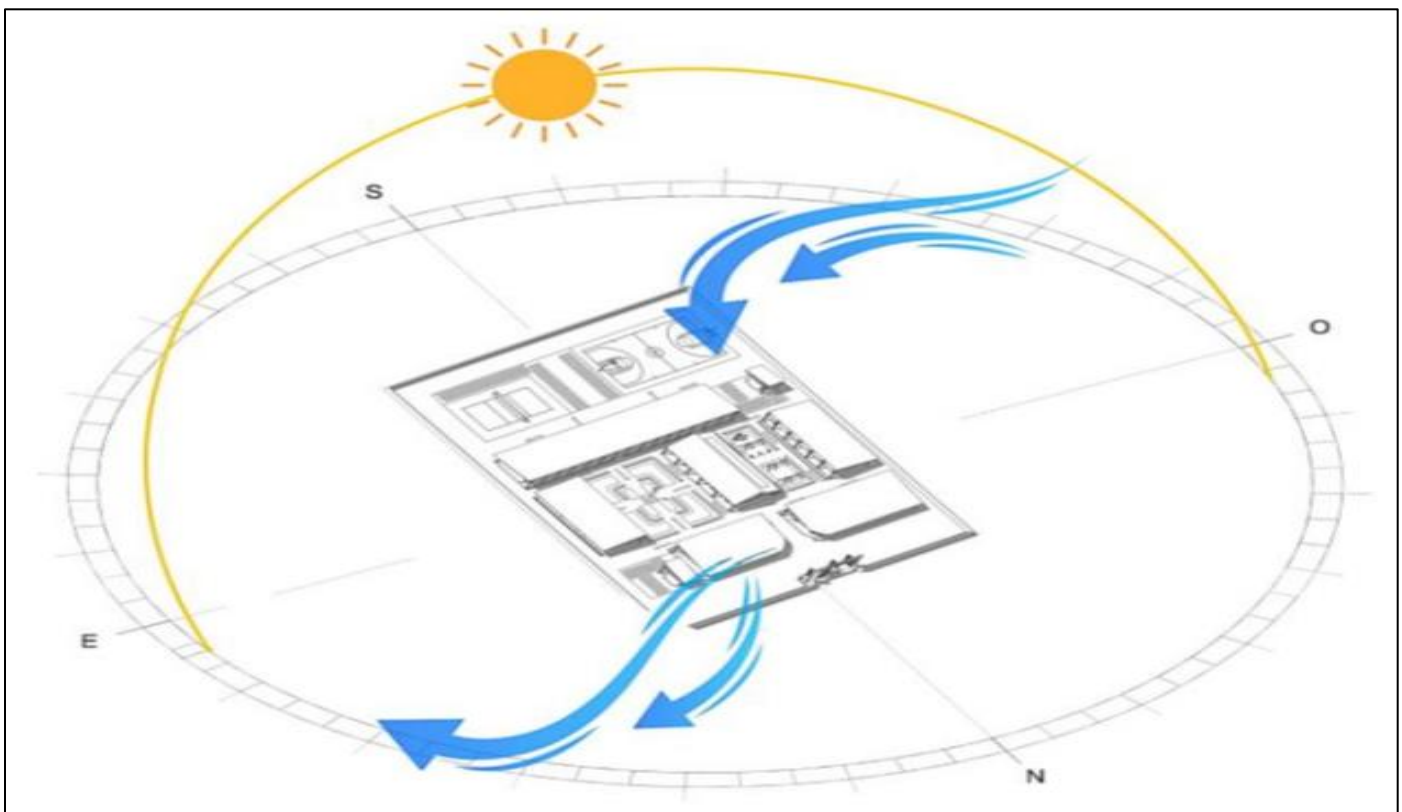


Fig 14 Building Orientation

➤ *Natural Light and Ventilation*

Natural light is maximized through large glazed openings equipped with anti-glare protections. Natural ventilation is ensured by high openings and consideration of the prevailing winds from the Northeast. Sloped roofs and openings allow for natural cross-ventilation. This helps to

expel hot air, especially in hot and humid climates, ensuring a comfortable indoor temperature without the need for energy-consuming air conditioning systems, as shown in Figure 15. These choices reduce the reliance on air conditioning and improve the energy efficiency of the school complex.

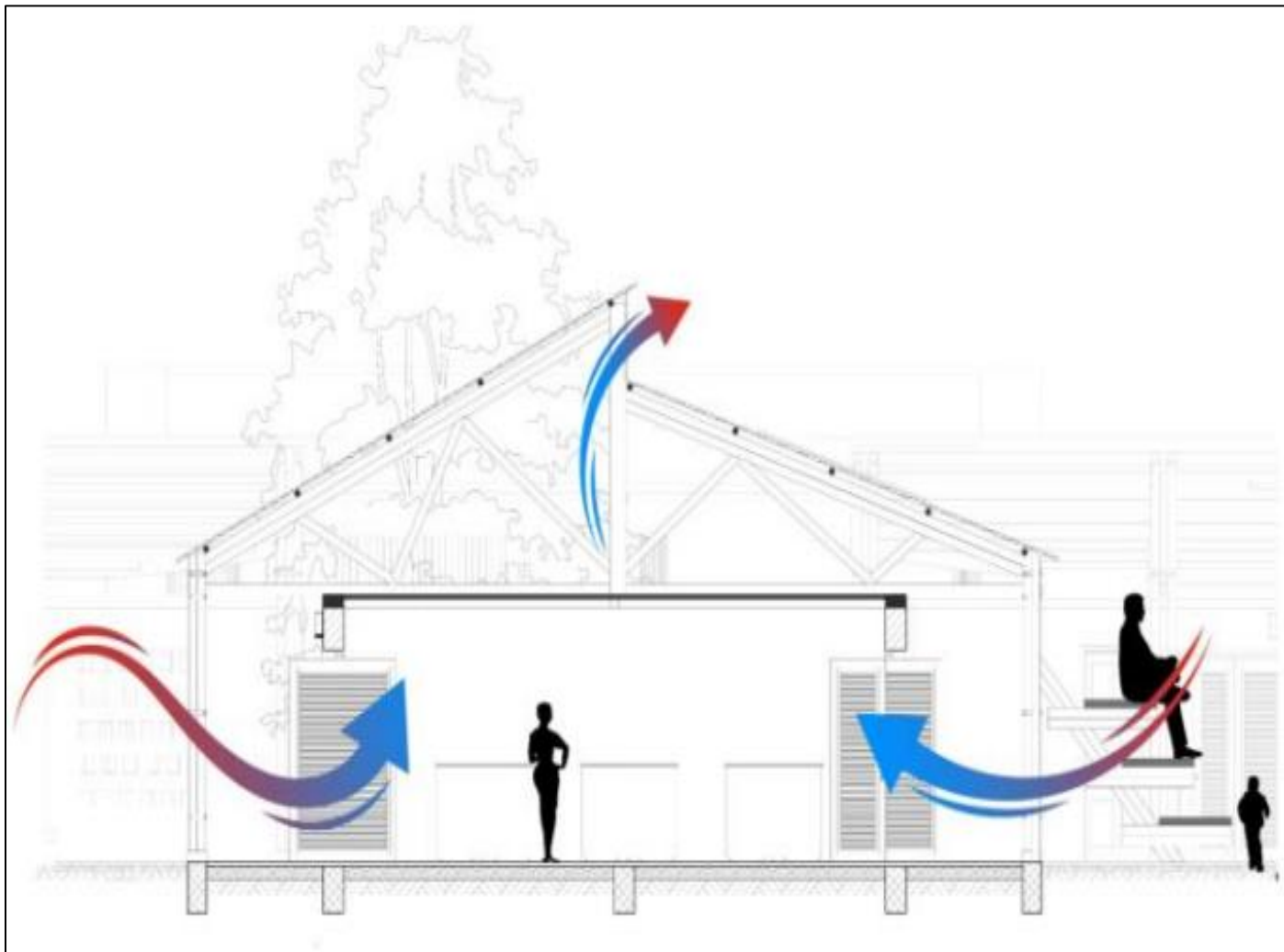


Fig 15 Natural Ventilation System

➤ *Building Form*

The rectangular shape facilitates the natural flow of air and allows for an even distribution of natural light inside. The open courtyard form promotes fluid circulation and easy access to outdoor spaces from each zone. This shape allows for a balanced distribution of spaces, fostering a visual connection with nature while creating calm and secure zones, essential for autistic children.

➤ *Construction Material*

The choice of materials was guided by environmental, economic, social, and cultural sustainability parameters. Traditional Cameroonian architecture is characterized by the use of natural materials, such as earth, creating a subtle harmony with the environment. This symbiosis led us to choose the ancestral technique of cob construction for our project, aiming for simple architecture rooted in the local

cultural context. The adoption of vernacular construction techniques and simple assemblies reflects the ambition to encourage a participatory construction process, in close collaboration with the community and local artisans, while optimizing costs. The earthen walls serve as structural elements while providing thermal comfort and acoustic insulation.

The lightweight and durable bamboo frame supports the thatched roof, which ensures internal thermal comfort. The fine ribs of a mixed wood and bamboo assembly provide natural ventilation and optimal lighting, filtering the intense light that bathes the school complex. The thatched ceiling offers significant advantages for the maternity center. It provides effective thermal insulation and natural ventilation, essential for occupant comfort. The materials used for the housing model are shown in Figure 16.

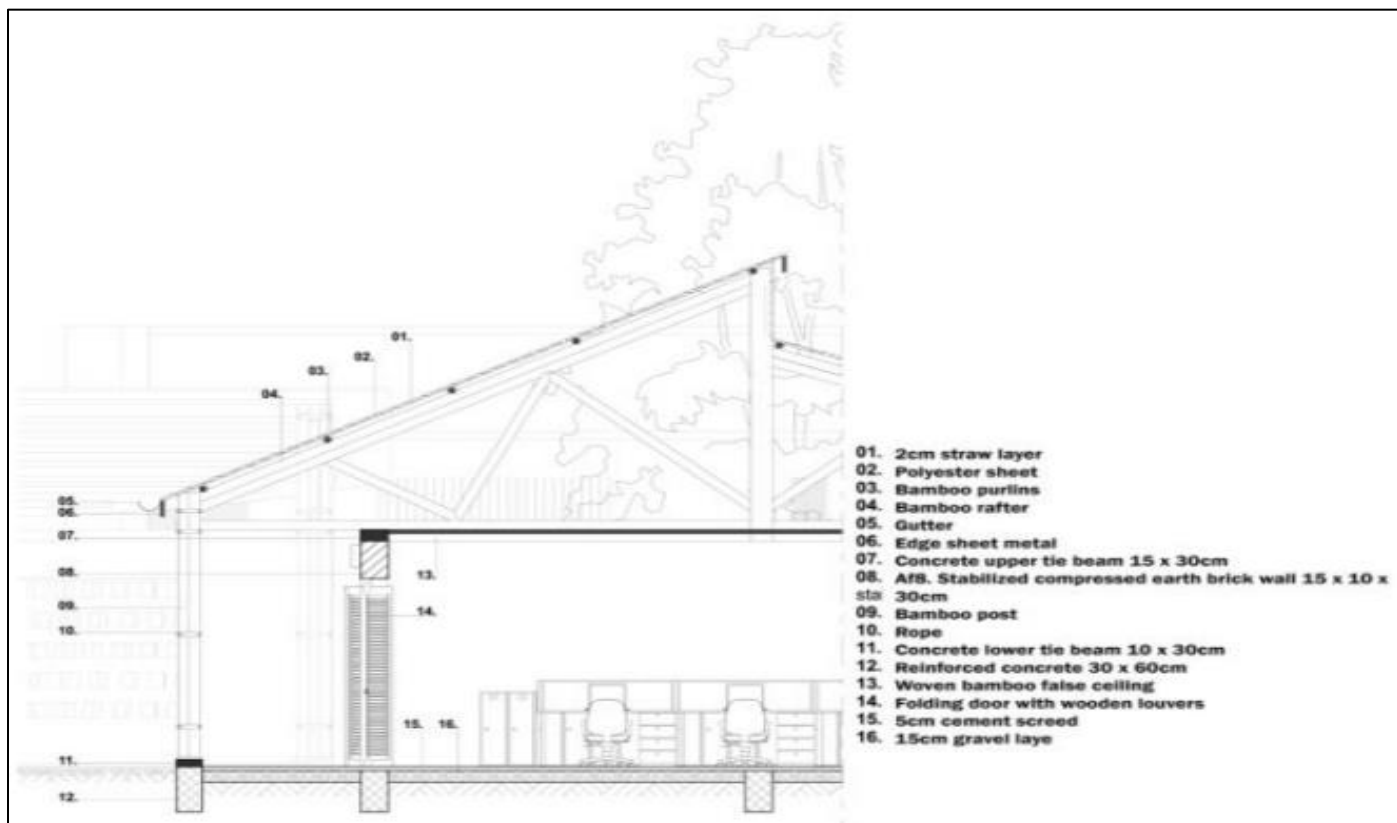


Fig 16 Construicuon Material

➤ *Renewable Energy*

The integration of renewable energy, such as photovoltaic solar energy, allows for long-term cost-effective electricity production. By using this energy, we also reduce our reliance on fossil fuels and contribute to the fight against climate change. See Figure 17.

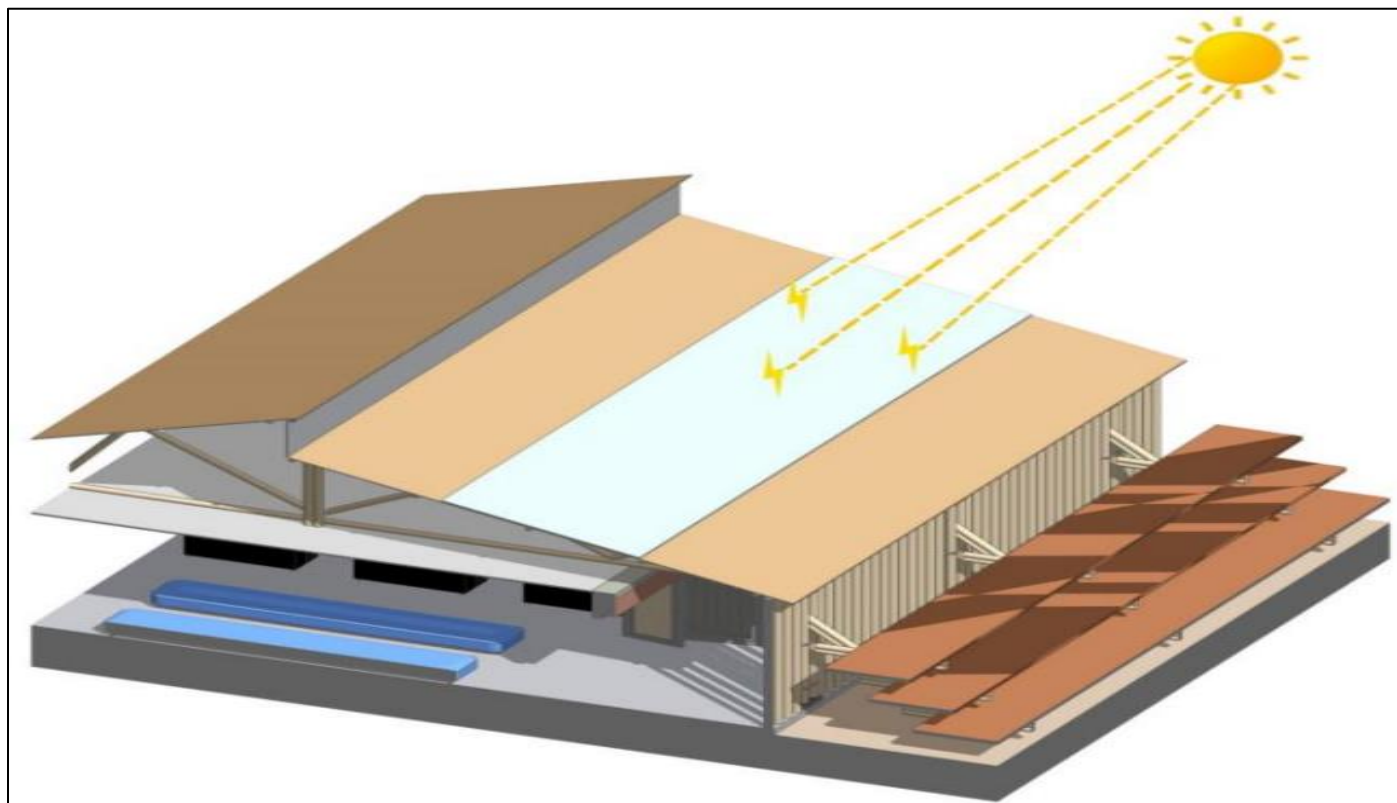


Fig 17 Renewable Energy

➤ *Rainwater Management*

The project incorporates sustainable rainwater management through natural drainage systems and rain gardens. Rainwater is collected, stored, and filtered in

underground water tanks and can be reused for gardens and toilets, as illustrated in Figure 18. These techniques help minimize flood risks while facilitating the recharge of groundwater.

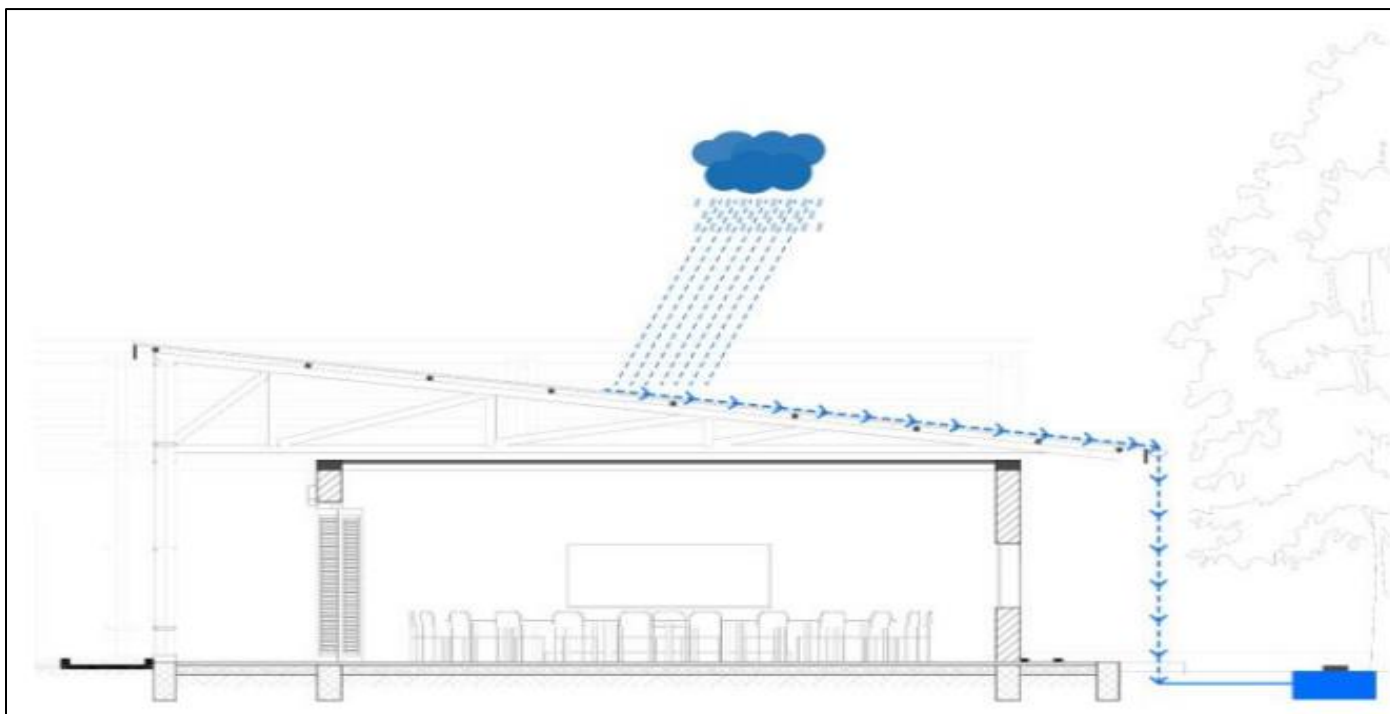


Fig 18 Rainwater Management

➤ *Neuro-Architectural Approach*

• *Colors and Patterns*

Soft and calming colors, such as shades of blue and green, were favored in the spaces for autistic children to

create a soothing environment, as illustrated in Figure 19. Complex patterns were avoided to reduce visual overload, and only touches of bright colors were used in play and community spaces, where excitement and stimulation are desired, as shown in Figure 20.



Fig 19 Soft Color Palette Used in Autistic Classrooms

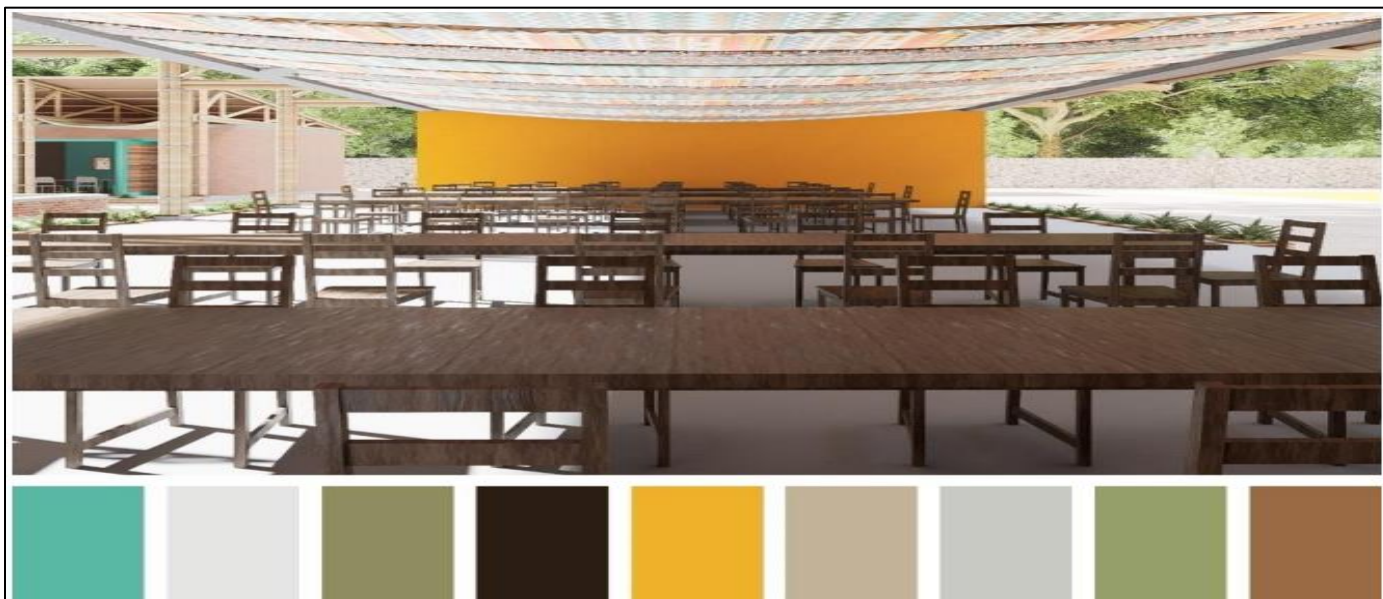


Fig 20 Bright Color Palette Used in the School Canteen

- *Biophilia*

The integration of green spaces in close proximity to classrooms and common areas allows children to be in contact with nature, as illustrated in Figure 21, a calming

element recognized in neuro-architecture. Outdoor gardens and rest areas surround the complex, reinforcing the connection between architecture and the natural environment.



Fig 21 Biophilic Integration

- *Circulation and Space Organization*

The circulation between different spaces is smooth and unobstructed, with wide three-meter corridors and gentle transitions, as illustrated in Figure 22. Children can

easily move from one space to another without feeling stressed or overwhelmed and are guided by the presence of signage.



Fig 22 Wide Circulation and Signage

VII. PROJECT IMPACT ASSESSMENT

➤ *Socio Economic Impacts*

The project will have a significant social impact by improving access to appropriate education for autistic children, who have so far been neglected in the traditional education system of Cameroon, especially in the northern region. It will also create local jobs in construction, specialized education, and support services.

➤ *Cultural Impact*

The school complex will contribute to greater awareness of autism and social inclusion, while also

promoting local architectural traditions through the use of African motifs and vernacular materials such as terracotta and bamboo. This will strengthen the sense of community belonging while respecting local customs and craftsmanship.

➤ *Environmental Impacts*

From an environmental perspective, the project is part of a sustainable approach, particularly by reducing its carbon footprint through the use of local materials and ecological solutions for energy and rainwater management. The building's orientation and bioclimatic design also help minimize energy consumption.

VIII. PHOTOREALISTIC IMAGES

High-quality visualizations of the plant, showcasing day views were produced with the help of D5 render software.



Fig 23 Exterior 1



Fig 24 Exterior 2



Fig 25 Autism Classroom



Fig 26 Kindergarden Playground

IX. CONCLUSION

The results of this study highlight the significant potential of designing a school complex tailored for autistic children in Ngaoundere. This project goes beyond merely providing educational infrastructure—it creates an inclusive and calming environment that addresses the specific needs of children with autism spectrum disorders (ASD). By incorporating neuro- architectural principles, the complex enhances student well- being while optimizing natural light, ventilation, and sensory spaces.

In addition to its educational impact, the complex raises community awareness and promotes social inclusion, fostering interactions between autistic children and their neurotypical peers. The project also embraces sustainability, minimizing environmental impact through the use of local materials and efficient resource management. These findings confirm the feasibility and importance of such a project, offering a durable and inclusive solution for educating autistic children in the Ngaoundere region.

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