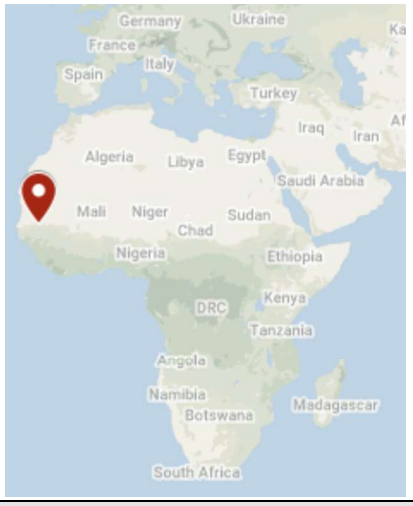
CASE STUDY 2-08: Centre de Formation Professionnelle de Nioro | SENEGAL



GEOGRAPHICAL AND CLIMATE INFORMATION	
Location	P6VM+M9P, Nioro du Rip, Sénégal
Latitude; Longitude	13.744376437735298, -15.76656745830613
Climate zone (Köppen–Geiger classification)	BSh: Hot semi-arid steppe
BUILDING INFORMATION	
Building Type	Educational
Project Type	New construction
Completion Date	2018
Number of buildings	14
Number of storeys	1
Total Floor Area (m²)	-
Net Floor Area (m²)	2100
Thermally conditioned space area (m²)	400
Spaces with Natural Ventilation (with or without Ceiling Fans) Only (m²)	1560
Total cost (€)	2 134 286
Cost /m² (€/m²)	1 707
Performance Standards or Certification	None
Awards	None
STAKEHOLDERS	
Building Owner/ Representative	LuxDev (agence luxembourgeoise pour la Coopération au Développement)
Architect / Designer	KHôZé architecture
Mechanical engineering and environmental consultancy	TERRANERGIE
Structural Engineer, Civil Engineer	LUXCONSULT
Construction company	ELEMENTERRE

PROJECT DESCRIPTION [1][2]

Figure 109 : Exterior view of the CFP Nioro buildings.

Figure 110: Site plan of the CFP Nioro buildings.

The professional training Center of Nioro (CFP of Nioro) combines several uses into one place, such as food production, hairdressing trade as well as dyeing, cutting and sewing activities; catering area; accommodation area; classrooms and conference rooms; technical rooms and lavatories. Based on a pavilion type architecture; the different elements are linked by exterior walkways, forming a compact unit, with a shape close to that of the square. This allows it to be easily adapted to any plot of similar size which could be the subject of a similar program in the future, as requested by the project owner. The project relies on a bioclimatic concept and a sustainable approach in terms of energy and comfort based on the optimization of the physical characteristics of the building.

SITE INTEGRATION

Figure 111 : Aerial views of the building in its surrounding environment. (Source: Google Map)

The CFP of Nioro is located in the urbanised area of the city of Nioro du Rip.

CLIMATE ANALYSIS

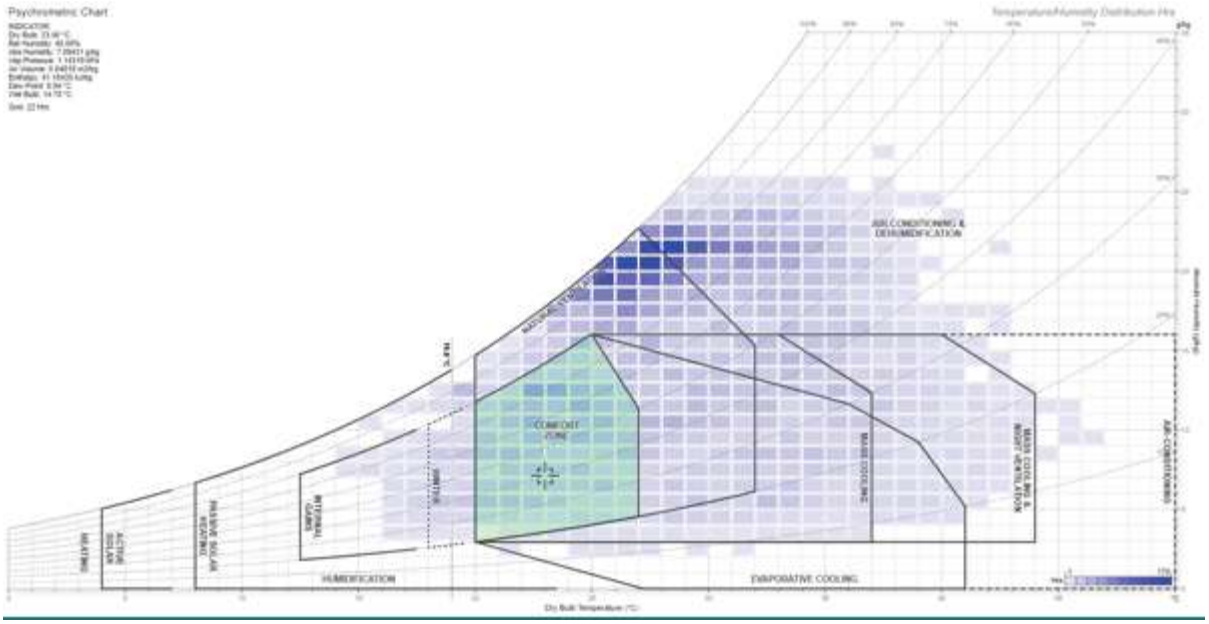


Figure 112: Givoni Bioclimatic chart for the region of Kaolack, Senegal using Andrew Marsh online tool [2]. Climate data are extracted from the database of the climate.onebuilding.org website.

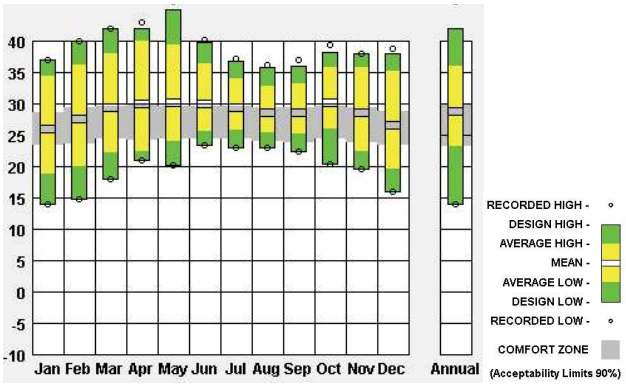


Figure 113: Temperature range by month for the region of Kaolack, Senegal (Source: Climate consultant – Adaptative Comfort model).

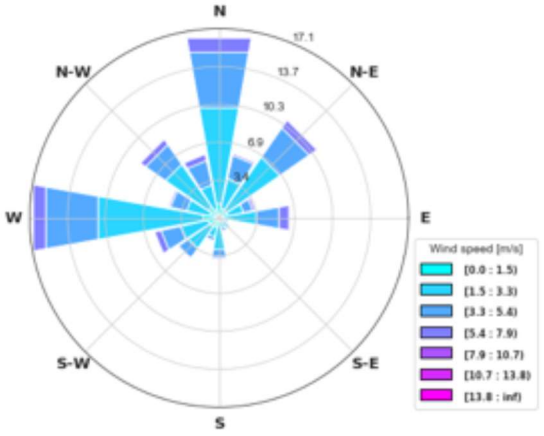


Figure 114: Wind rose for Kaolack, Senegal (Beaufort wind scale).

Global horizontal radiation (Avg daily total) Min (month) / Max (month)	Min: **5091** Wh/m² (Sep.) Max: **7453** Wh/m² (Apr.) Mean: **6174** Wh/m²
Annual Degree-Days for weather classification according to ASHRAE Standard 169-2020	HDD 18°C: **3** CDD 10°C: **6 845**
Annual Degree-Days for the Adaptive Comfort Base Temperature according to the ASHRAE 55-2017	HDD: **90** CDD: **514**
Annual Degree-Days for a static comfort temperature approach	HDD 18.6ºC: **6** CDD 26º: **1 321**

KEY BIOCLIMATIC DESIGN PRINCIPLES	
Passive cooling strategy	Comfort ventilation (natural cross ventilation) Evaporative colling, Mass cooling Radiant cooling The large openings present on the two opposite sides of the facades allow the buildings to be naturally ventilated.
Passive heating strategy	N/A
Solar protection	Detached overhanging roofs protect the interiors from excessive heat while sheltering them from rain and sun.
Building orientation	The main facades of the buildings are facing North-East / South-West
Insulation	None
Vegetation	Vegetated patios allow to cool the air before entering the buildings.
Natural daylighting	Large openings allow enough light to enter the interior.
Use of local and embedded materials	The main structure of the building is made from compressed earth blocks.
Water saving and flood management	None
Waste management	None
Others features	-

Figure 115: Interior view of the rooms equipped with ceiling fans and fluorescent tubes.

Figure 116: Outdoor pathways.

Figure 117 : Interior view of the meeting room.

Figure 118: The planted patios create a comfortable microclimate between the buildings.

INFRASTRUCTURES and REGULATIONS to enable SUFFICIENCY ACTION	
Dressing code	Informal dressing, adapted to the season, is welcome and promoted (e.g. short trousers and short leaves in hot periods): **Yes** *Students are dressed in gowns or T-shirts in addition to their usual clothing.*
Protected bike parking and showers	**No** If yes, Ratio with number of users: **0**
Ceiling fans	In every room, even those conditioned: **Yes**
Lighting system fractioned to allow using light only in zones occupied and where daylighting insufficient	In every room, even those conditioned: **No**
Space and facilities for line drying clothes (especially important in residences, hotels, sport facilities…)	In every room, even those conditioned: **No**
Book of instruction for correct use of the passive features (windows, solar protections, water savings) and active (lighting…) in order to promote sufficiency and efficiency actions	Available through leaflets and posters at relevant places, online, etc.: **No**

BUILDING FABRIC AND MATERIALS	
Roof	The roof structure is composed of (from outside to inside): ▪ Over-roof made of aluminium sheet ▪ Aluminium trays ▪ Waterproofing layer ▪ Cement mortar [0.04m] ▪ Vaulted under roof in compressed earth bricks [0.30 ×0.14 ×0.10 m] ▪ (Coating and painting or tiles for some rooms)
Windows	Single-glazed with clear glass. Some openings are protected with iron grills. Dimension of the main openings: 0.90 ×0.75 ×0.60 m
Walls	The **Exterior walls of the classrooms, offices and accomodations** are mainly composed of compressed earth bricks with a thickness of 0.30m. Some other walls (for instance in buildings C, D and E) are made of (from outside to inside): ▪ Compressed earth bricks [0.14m] ▪ Cement filling [0.04m] ▪ Concrete block [0.10m] ▪ Tile [0.02m]
	The **Interior Walls** are structured as the exterior walls for the classrooms, offices and accommodations buildings, i.e, compressed earth bricks with a thickness of 0.30m. In the sanitary rooms and kitchens, interior walls are made of concrete wall tiled on both sides, with a thickness of 0.14m.

Figure 119: Exterior view of the walls and openings

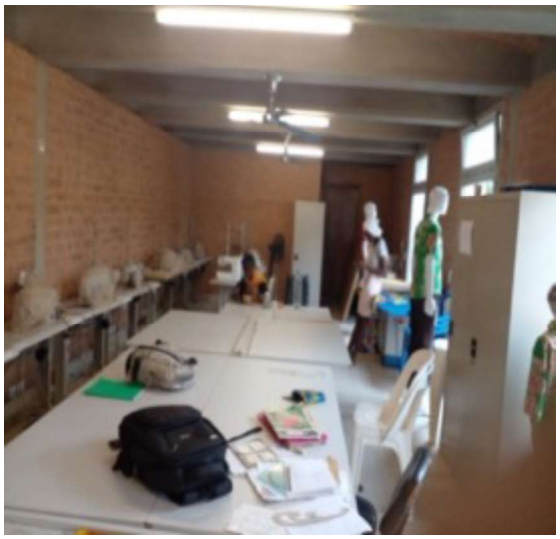


Figure 120: Interior view of the sewing room.

ENERGY EFFICIENT BUILDING SYSTEMS	
Low-energy cooling systems	**Adiabatic systems and split systems** All rooms in the accommodation area are air-conditioned, equipped with fans and humidifier system. The other rooms of the centre are equipped with single air fans and others with fans and humidifier systems.
Low-energy heating systems	None
Ceiling fans	All rooms are equipped with air fans.
Mechanical ventilation / air renewal	None
Domestic Hot Water	Solar thermal for the sanitary rooms.
Artificial lighting	Fluorescent tubes
Control and energy management	None

Figure 121: Interior view of the ceiling and lighting tubes.

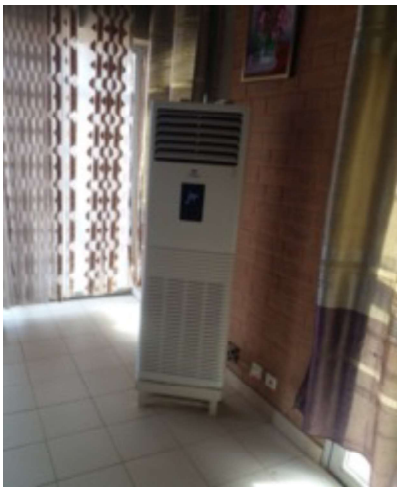


Figure 122 : Floor standing air conditioner have been installed in some rooms.

RENEWABLE ENERGY	
PV	None
Solar thermal	Solar thermal panels have been installed for the production of hot water.
Wind	None
Geothermal	None
Biomass	None

BUILDING ANALYSIS AND KEY PERFORMANCE INDICATORS

Thermal comfort indicators

1. Percentage of time outside an operative temperature range (Adaptive)
2. Percentage of time outside an operative temperature range (Fanger)
3. Degree-hours (Adaptive)
4. Degree-hours (Fanger)
5. Percentage of time inside the Givoni comfort zone of 1m/s

   Seewing classrooms : 86% | Conference room : 38% | Bedroom : 58% | Office : 59%
6. Percentage of time inside the Givoni comfort zone of 0m/s

   Seewing classrooms : 34% | Conference room : 0% | Bedroom : 1% | Office : 1%
7. Number of hours within a certain temperature range

Oct 22 to Feb 2023	Seewing classroom 2		Seewing classroom 1		Office		Bedroom 1		Conf room		Weather Station	
	Nb of Hours	Fq.	Nb of Hours	Fq.	Nb of Hours	Fq..	Nb of Hours	Fq..	Nb of Hours	Fq..	Nb of Hours	Fq.
Ta<16°C	0	0%	0	0%	0	0%	0	0%	0	0%	1	0%
16°C≤Ta<18°C	0	0%	0	0%	0	0%	0	0%	0	0%	8	2%
18°C≤Ta<20°C	0	0%	1	0%	0	0%	0	0%	0	0%	10	2%
20°C≤Ta<22°C	13	3%	2	0%	0	0%	0	0%	0	0%	20	5%
22°C≤Ta<24°C	17	4%	19	4%	0	0%	0	0%	0	0%	20	5%
24°C≤Ta<26°C	114	26%	88	20%	0	0%	0	0%	0	0%	26	6%
26°C≤Ta<28°C	194	44%	209	48%	114	26%	114	26%	9	2%	32	7%
28°C≤Ta<30°C	85	19%	110	25%	224	51%	223	51%	214	49%	27	6%
30°C≤Ta<32°C	14	3%	8	2%	92	21%	97	22%	152	35%	42	10%
32°C≤Ta<34°C	0	0%	0	0%	7	2%	3	1%	54	12%	75	17%

Energy performance indicators

1. Energy needs for heating (kWh/y/m2)
2. Energy needs for cooling (kWh/y/m2)
3. Energy use for lighting (kWh/y/m2)
4. Energy needs for Sanitary Hot water (kWh/y/m2)
5. Total Primary energy use (kWh/y/m2)
6. Renewable Primary energy generated on-site (kWh/y/m2)
7. Renewable Primary energy generated on-site and self-consumed (kWh/y/m2)
8. Renewable Primary energy exported to the grid (kWh/y/m2)
9. Ratio of renewable primary energy over the total primary energy use (with and without compensation) (%)
10. Delivered energy (kWh/y/m2) (from electricity bills) : **26,5 [kWh/m²/year]**

1. Airborne sound insulation

Acoustic comfort indicators	2. Equivalent continuous sound Level
	3. HVAC noise level
	4. Reverberation time
	5. Masking/barriers
Visual comfort indicators	1. Light level (illuminance)
	2. Useful Daylight Illuminance (UDI)
	3. Glare control
	4. Quality view
	5. Zoning control
Indoor Air Quality indicators	1. Organic compound
	2. VOCs
	3. Inorganic gases
	4. Particulates (filtration)
	5. Minimum outdoor air provision
	6. Moisture (humidity, leaks)
	7. Hazard material
Users' feedback	The users are happy with their working environment and appreciate the architectural design (based on a pavilion type architecture) and the presence of vegetation in the outdoor spaces. The feedback from users is reserved about the comfort conditions of the building.

LESSONS LEARNED AND RECOMMENDATIONS

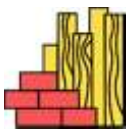
Lessons learned	- Some spaces remain hot, dry and uncomfortable and must be improved in terms of thermal comfort - There is a lack of information about how to use the building properly.
Recommendations	- Teach the occupants and the staff how to use properly the building (nocturnal convective cooling, adiabatic system); - Check if the adiabatic system works well ; - Improve the management of passing cooling strategies (nocturnal convective cooling, evaporative cooling, natural cross ventilation); - Check if the density of ceiling fans is correct (1 CF/10 m^2); - Extend the adiabatic system to the seewing classrooms and classrooms.

BUILDING STRENGTHS AND WEAKNESSES

Strengths

Passive Design

Renewable Energy



Local Materials

Replicability

Weaknesses

REFERENCES