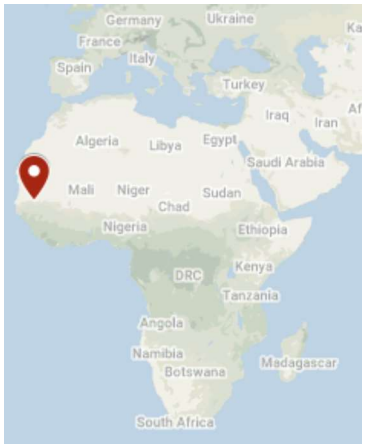
CASE STUDY 2-10: MAISON DES YVELINES | SENEGAL



GEOGRAPHICAL AND CLIMATE INFORMATION	
Location	Route Nationale 2, Ourossogui, Senegal
Latitude; Longitude	15.593247890123722, -13.311984869213356
Climate zone (Köppen–Geiger classification)	BWh : Hot desert
BUILDING INFORMATION	
Building Type	Other: Mixed-use residential and office building
Project Type	New construction
Completion Date	2016
Number of buildings	3
Number of storeys	2
Total Floor Area (m²)	479
Net Floor Area (m²)	367
Thermally conditioned space area (m²)	212 (offices, conference room and bedrooms)
Spaces with Natural Ventilation (with or without Ceiling Fans) Only (m²)	267
Total cost (€)	109 000,0
Cost /m² (€/m²)	297,0
Performance Standards or Certification	None
Awards	Low-carbon building prize from the Green Solutions Awards / Construction21 at the COP23 meeting in Bonn Terra Award Sahel+ 2019 winning project
STAKEHOLDERS	
Building Owner/ Representative	Conseil Départemental des Yvelines
Architect / Designer	AL-MIZAN Architecture & développement au Sahel – Mathieu Hardy
Construction manager	ONG Le Partenariat
Structural Engineer, Civil Engineer	Habitat Moderne

Technical expertise	The Nubian Vault Association (AVN)
Others	Regional Development Agency of Matam - Technical Partner Regional Urbanism Service - Technical Partner

PROJECT DESCRIPTION

Figure 133 : Exterior view of the 'Maison des Yvelines'.

The 'Maison des Yvelines' is a mixed-used building combining administrative and reception spaces, as well as accommodation spaces. It consists of three independent two-storey blocks, separated by inner courtyards offering ventilated and shaded spaces as additional quality spaces. The building is made of mud bricks and earth-based mortars, that are locally available and enhances thermal inertia.

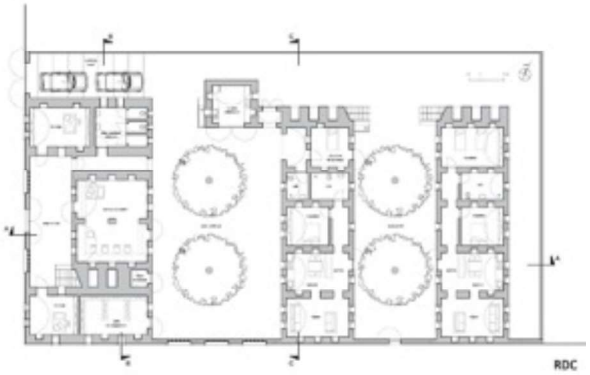


Figure 134: Floor plan of the first floor (©Al-Mizan Architecture)

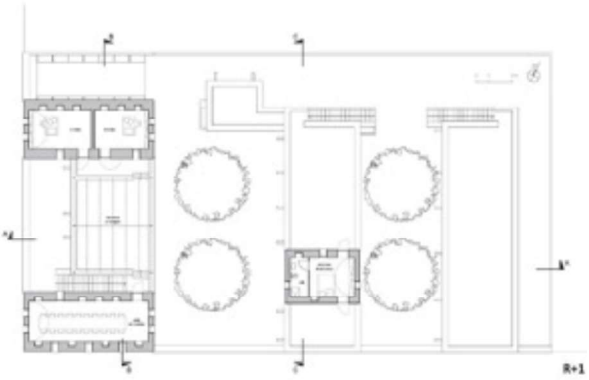


Figure 135: Floor plan of the second floor (©Al-Mizan Architecture)

SITE INTEGRATION

Figure 136 : Aerial view of the building in its surrounding environment

The Maison des Yvelines is located in Ourossogui, in the region of Matam, in eastern Senegal. It is a low-density area with some sparse vegetation.
The building is located along a highway and benefits from its high visibility. The three wings of the building are arranged parallel to the main road. The administrative and reception block is aligned with the main road and offers a welcoming facade while the accommodation blocks are more discreetly positioned behind.

CLIMATE ANALYSIS

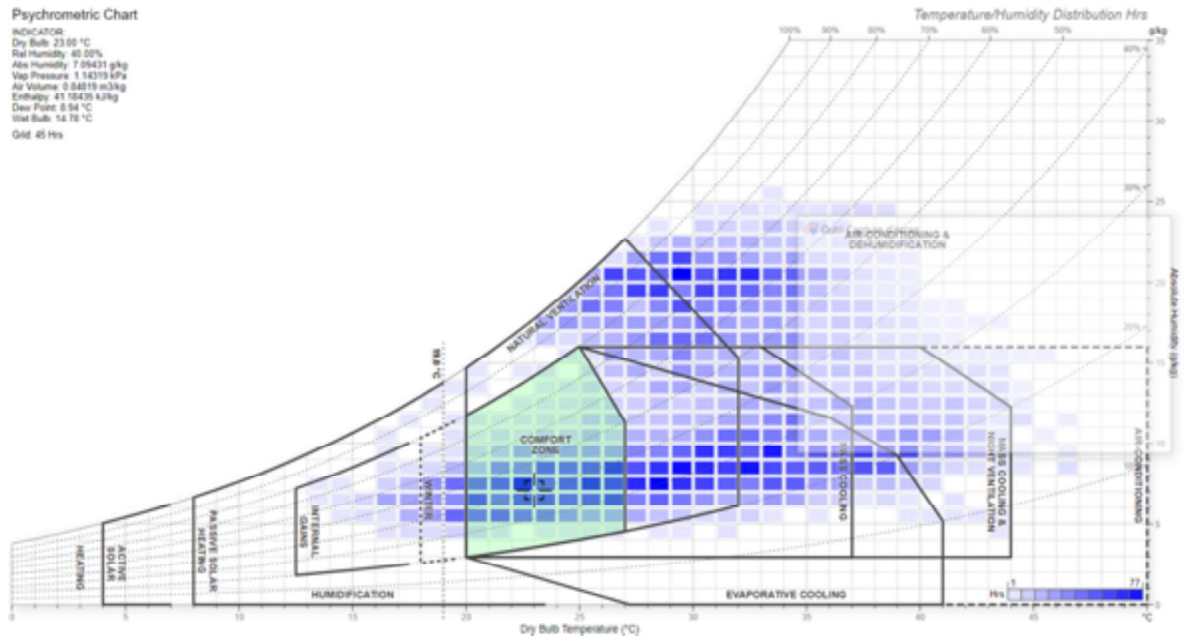


Figure 137: Givoni Bioclimatic chart for the climate of Matam using Andrew Marsh online tool [2]. Climate data are extracted from http://climate.onebuilding.org/WMO_Region_1_Africa/SEN_Senegal/SEN_MT_Matam.616300_TMYx.2004-2018.zip

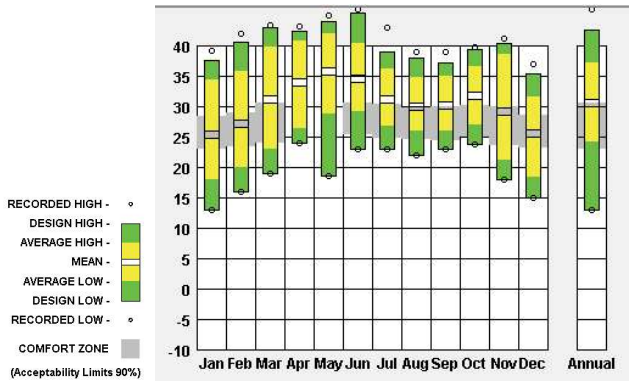


Figure 138: Temperature range by month for the region of Matam, Senegal. (Source: Climate consultant – Adaptative Comfort model).

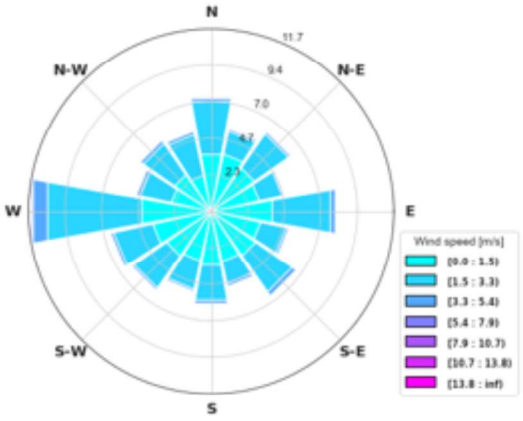


Figure 139: Wind rose for Matam, Senegal.

Global horizontal radiation (Avg daily total) Min (month) / Max (month)	Min: **5422** Wh/m² (Dec) Max: **7550** Wh/m² (Apr) Mean: **6421,25** Wh/m²
Annual Degree-Days for weather classification according to ASHRAE Standard 169-2020	HDD 18°C: **6** CDD 10°C: **7500**
Annual Degree-Days for the Adaptive Comfort Base Temperature according to the ASHRAE 55-2017	HDD: **92** CDD: **783**
Annual Degree-Days for a static comfort temperature approach	HDD 18.6ºC: **10** CDD 26º: **1940**

KEY BIOCLIMATIC DESIGN PRINCIPLES	
Passive cooling strategy	Comfort ventilation: Cross natural ventilation High thermal mass of the walls and roofs
Passive heating strategy	High thermal mass of the walls and roofs
Solar protection	The three building blocks are separated by inner courtyards offering ventilated and shaded spaces as additional quality spaces. A pergola built on a steel frame and covered by bamboos offers a protected space on the roof.
Building orientation	All the vaults are oriented East/West to take advantage of the wind.
Insulation	The walls are composed of 60 to 80 cm of mud bricks which provides a high level of insulation.
Vegetation	Sparse vegetation and some trees are present around the building and in the courtyards.
Natural daylighting	All rooms are fairly well lit with natural light thanks to the different openings.
Use of local and embedded materials	The building is made of locally sourced raw materials (earth, rocks and water) for adobe bricks and mortar.
Water saving and flood management	Rainwater seeps into the ground through unbuilt spaces. There is no rainwater drainage system.
Waste management	There is no proper waste management system.

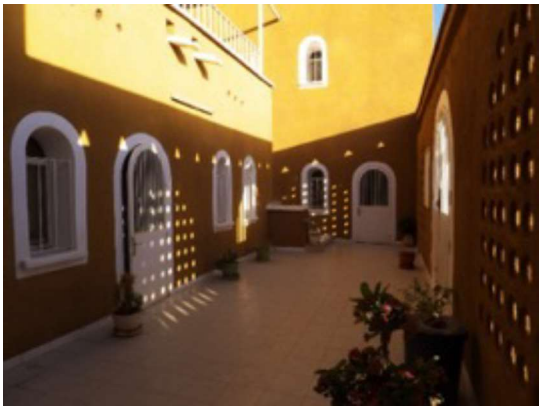


Figure 140: View of the patio shaded by the exterior wall

Figure 141 : The different facades present steel windows to allow natural ventilation

Figure 142:View of the inner courtyard and its vegetation

Figure 143: Metal and bamboo pergola provides shaded space on the 1st floor

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): **No**
Protected bike parking and showers	**No** 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: **Yes** *Laundry drying facilities are located on the terrace and in the sun.*
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	Waterproofing of the terraced roofs (from top to bottom): ▪ An anti-erosion plaster stabilised with tar of 3cm ▪ A 6 cm layer of packed earth ▪ Plastic sheet ▪ A 2cm layer of packed earth (at its lowest point) The roofs are buttressed to form flat roof terraces. The roof buttresses are made of mud bricks (banco) of 38 × 18 × 18cm recovered from the inside by a fine clay plaster, lime and paint.
Windows	Single-glazed windows protected with steel grills
Walls	The **Exterior Walls** are composed of (from outside to inside): ▪ Cement render ▪ Mud bricks [dimension: 38 × 18 × 18cm] with stony bricks (mud bricks with encrusted stones) on the outside layer ▪ A 2cm cement plaster and paint The majority of the exterior walls are 60cm or 80cm thick.
	The **Interior Walls** are made of mud bricks. The thickness of the walls can vary from about 20cm (for some of the partition walls facing the interior corridors) to 60cm (for the majority of the walls).

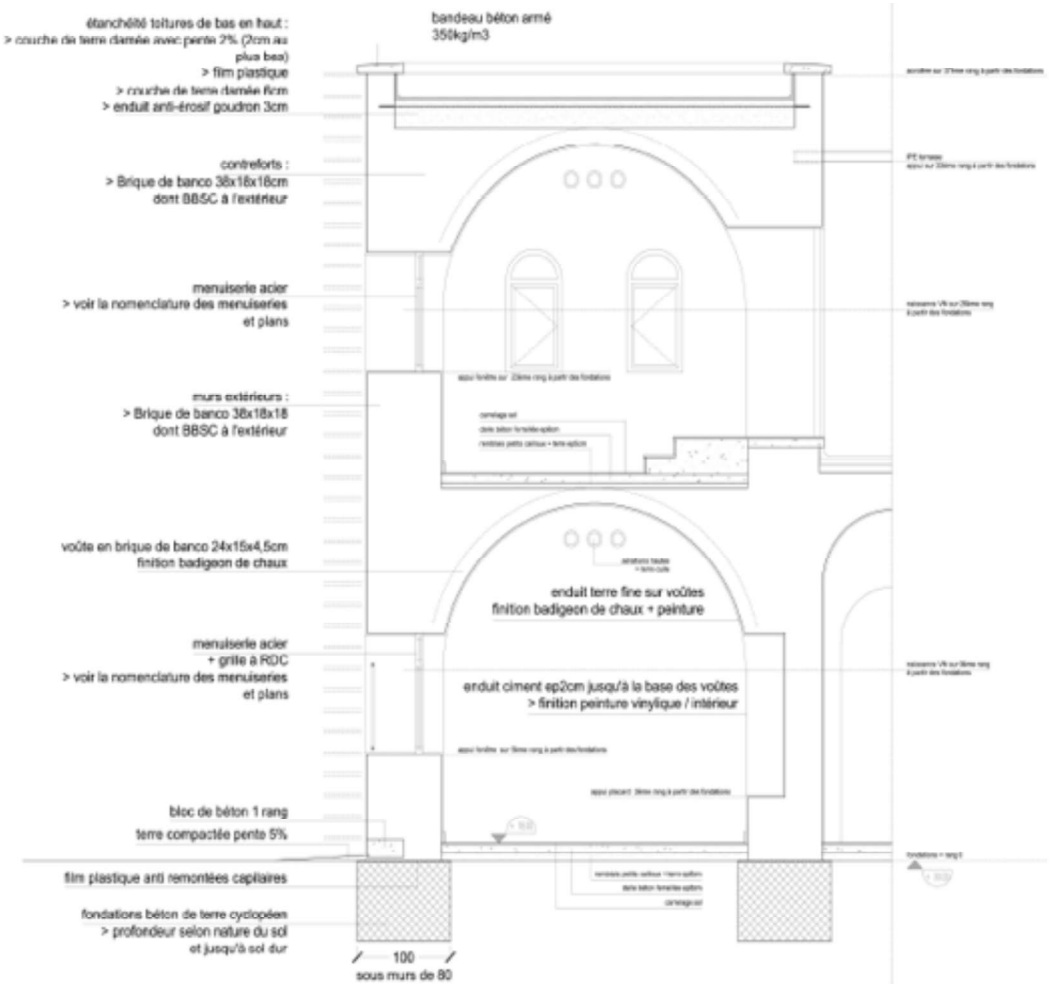


Figure 144:Cross-section of the vault principle

ENERGY EFFICIENT BUILDING SYSTEMS	
Low-energy cooling systems	**Split system** **Sharp brand / cooling capacity of 3.5 kW**
Low-energy heating systems	None
Ceiling fans	**All offices, bedrooms and living rooms are equipped with ceiling fans (Evernal type)**
Mechanical ventilation / air renewal	None
Domestic Hot Water	**Electrical water heater (Ariston type / capacity of 49l / power= 1500 W)**
Artificial lighting	**LED's lamps (8W)**
Control and energy management	None
RENEWABLE ENERGY	
PV	Two solar lamps for outdoor lighting
Solar thermal	None
Wind	None
Geothermal	None
Biomass	None

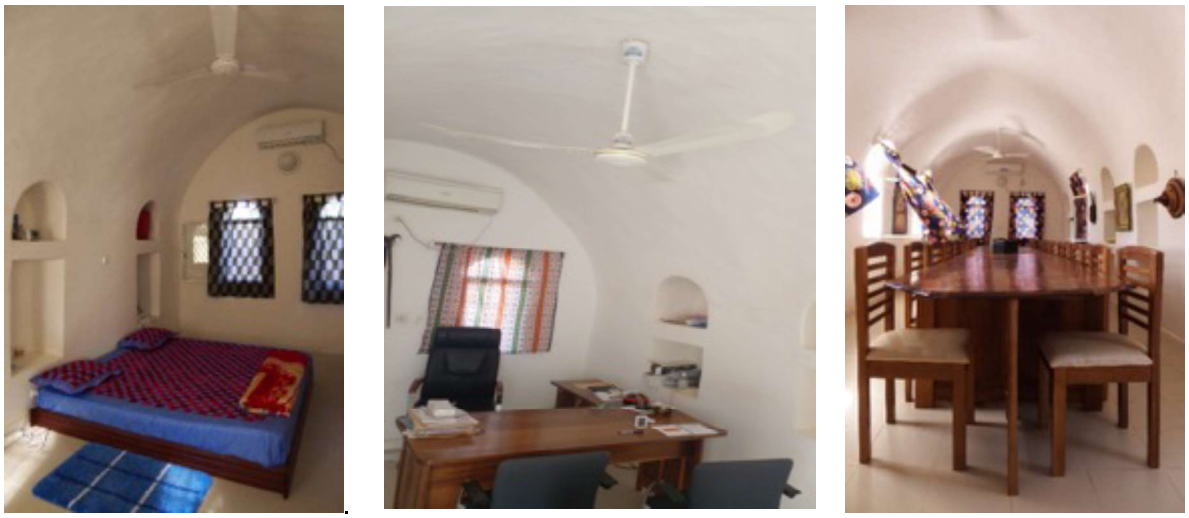


Figure 145: Interior view of a typical (a) bedroom, (b) office and (c) of the meeting room. All rooms are equipped with a split system and ceiling fans.

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
	6. Percentage of time inside the Givoni comfort zone of 0m/s
	7. Number of hours within a certain temperature range
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)
Acoustic comfort indicators	1. Airborne sound insulation
	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	-

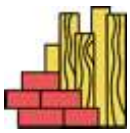
LESSONS LEARNED AND RECOMMENDATIONS

Lessons learned	The building was designed with the aim to disseminate an ancestral technical concept, perfectly adapted to the Sahel region: the Nubian Vault. The technical concept presents a simple, replicable and economical bioclimatic solution in hot climates. The technical method is **very easily taught,** with the **training of local workers on site**. A large range of architectural choices is possible, from housings to offices or health care buildings, and extensions can be easily added to the initial building.
Recommendations	-

BUILDING STRENGTHS AND WEAKNESSES

Strengths

Passive Design



Local Materials

Replicability

Affordability

The project is a bioclimatic design featuring **natural ventilation**, **thermal inertia** and the use of **locally available material** for construction. A key factor in its design is the **affordability**, the **replicability** and the **modularity** of the Nubian Vault technique.

Weaknesses

-

REFERENCES

1. https://almizan-sahel.com/a-propos
2. https://www.construction21.org/case-studies/h/maison-des-yvelines-nubian-vault,es.html
3. https://www.lavoutenubienne.org/the-nv-maison-des-yvelines-winner-of-the-low-carbon-green-solutions-award