



THE NUBIAN VAULT

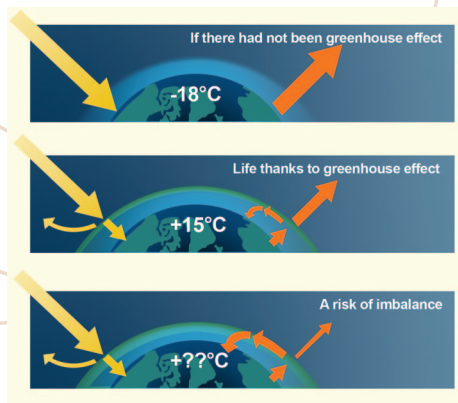
Low carbon housing,
adapted to climate change,
for as many people as possible,
resulting in numerous environmental,
economic and cultural benefits.



CONTEXT

CLIMATE CHANGE

Due to greenhouse gas emissions linked to human activities (deforestation, industry, agriculture, residential, commercial and public buildings, electricity production, transport, waste), climate change can already be observed and will increase in the future: **global temperatures rising, the cryosphere melting, sea levels rising...**



Greenhouse effect: a phenomenon unbalanced by Man © ADEME

In order to limit these devastating and irreversible impacts, IPCC (*) experts urge to limit the increase in global temperatures to +2°C. **For this, it is imperative to reduce our CO2 emissions by 50% by the year 2050 and 90% by the year 2100.**

HOUSING, A MAJOR ISSUE

In the Sahelo-Sudanian area, millions of families lack access to decent housing because of the disappearance (through deforestation and desertification) of natural ligneous resources used in traditional architecture, as well as demographic and economic realities, and urban growth.

Despite the cultural appeal they may hold, « modern » technical alternatives have not enabled the greatest number of people to access appropriate and sustainable housing. They require highly inappropriate materials (cement, iron steel, etc.) and do not fit into local economies (imported material, use of numerary).

(*) Intergovernmental Panel on Climate Change

DEMOGRAPHY AND ACCESS TO BASIC SERVICES

In 2010, the global construction industry was responsible for 19% of greenhouse gas emissions linked to energy use. This energy consumption and its associated emissions are expected to double and even triple by the middle of the century, due in particular to a very important trend: **the need for millions in developing countries to access to an appropriate housing, electricity and improved cooking equipment.**

Source: *Climate Change 2014, Mitigation of Climate Change, IPCC Working Group III Fifth Assessment Report, chapter 9 Building, pp 675 and 679.*

In the Sahelo-Sudanian strip, this trend will be widely magnified by demographics: its population will grow from 250 million inhabitants in 2013 to **650 millions in 2050***. In such a context, the need for appropriate and sustainable housing, adapted to climate change is considerable.



*Sahelo-Sudanian population based on the *World Population Prospects, United Nations, 2013 (Medium Variant)* and the geographical delimitation of the Sahelo-Sudanian strip

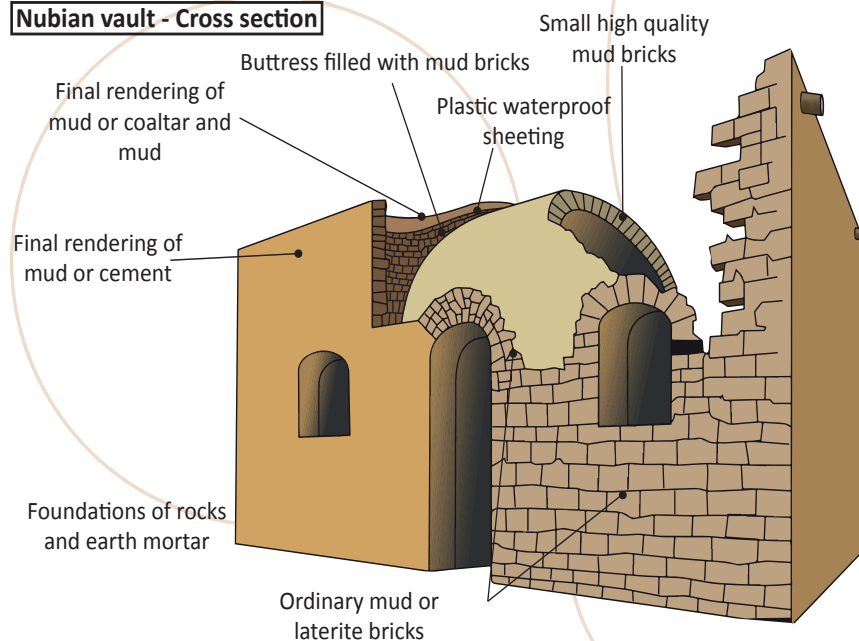
THE NUBIAN VAULT TECHNIQUE, AN APPROPRIATE HOUSING SOLUTION

The Nubian Vault is an **age-old architectural technique** originating in Upper Egypt and historically unknown in other African regions.

This technique allows the construction, with basic tools, local materials and simple skills, of modern, solid, comfortable and modular buildings with vaulted roofs. Its specificity is marked by **the use of earth, a widely available raw material**, to make a mortar and sun-dried bricks, and by the lack of timber formwork in the vaulted section.

The inertia of the Nubian Vault structure (substantial thickness of the raw earth walls) helps to even out temperature fluctuations inside the building.

Nubian vault - Cross section



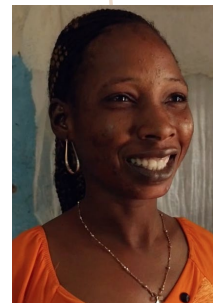
CLIENTS' TESTIMONIES



Testimonies collected in 2015 among the 1 500 clients who have constructed a Nubian Vault since 2000 in over 700 towns and villages in West Africa (in Burkina Faso, Mali, Senegal, Benin, Ghana, and Mauritania).

« In that period, it's cold outside, but in these rooms the climate is good. We spend the night under metal roofs, but we are always cold. But here, we feel good, that's why all the children come here to spend the night. »

Malick SY, Nubian Vault client in 2012, Diatar, Senegal



« That house, it's a good house. If you've built that house, you don't need any more wood, you don't need any more metal sheets, nothing. When it rains, it isn't like metal sheet. When it rains, if you're sleeping even, you go out in the morning, you see the water in the courtyard, you didn't even know there was rain in the night. Tin roofs make a lot of noise, you can't even sleep. »

Ebou KANKOU, Nubian Vault client in 2006, Boromo, Burkina Faso



« For sustainability, the Nubian Vault is better than the other constructions. For comfort, warmth or coolness, we feel that it can increase the life expectancy of the elderly. »

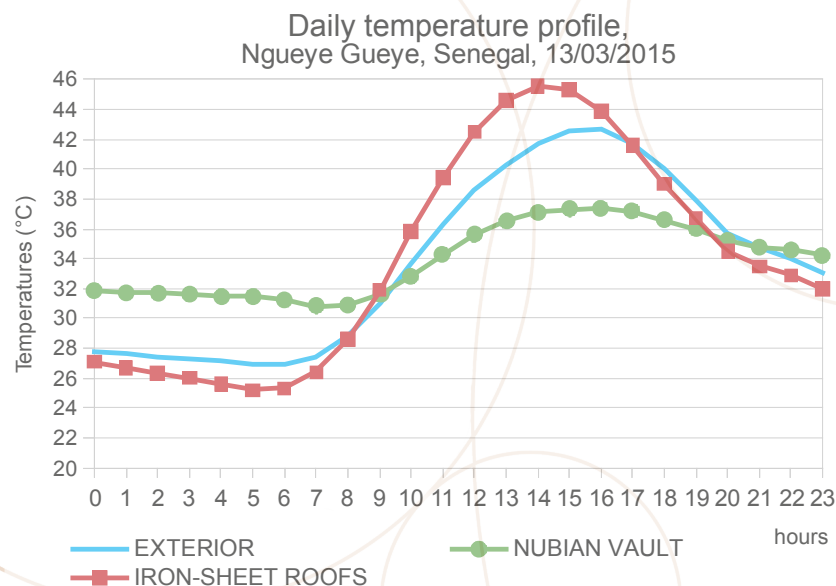
Michel DIOUF, Nubian Vault client in 2015, Ngueye Gueye, Senegal



« The Nubian Vault is good for one's health, you think there is air-conditioning in the room, it's cooler. »

René NDONG et Brigitte PHIOW, Nubian Vault clients in 2014, Ngueye Gueye, Senegal

THERMAL COMFORT



There have been a number of comparative thermal measurement studies carried out in Burkina Faso and Senegal since 2007, and they confirm the significant increase in thermal comfort felt by the Nubian Vault clients.

Cold discomfort (temperatures < 20°C) is very low or nonexistent.

Very hot discomfort (temperatures > 37°C) is significantly reduced compared to a house with a corrugated iron roof.

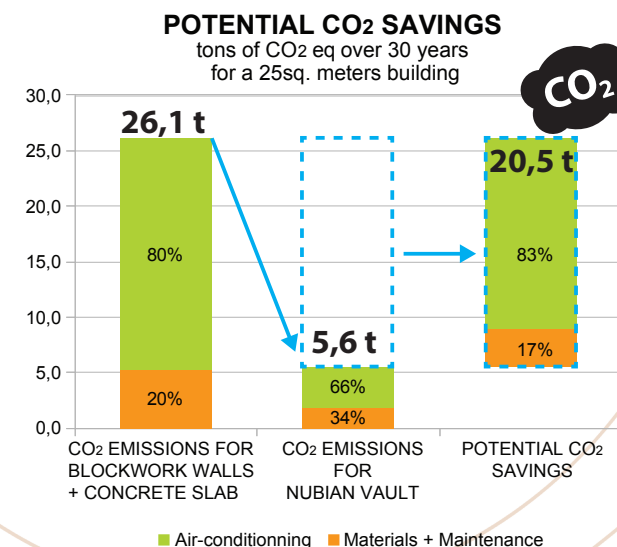
Nubian Vault structures also bring **considerable acoustic comfort during rain and efficient protection in adverse weather like strong winds.**

GREENHOUSE GAS BALANCE

Quantification of greenhouse gas emissions during the building life-cycle (basic materials, construction, transportation, usage) calculated over 30 years (*)

For a 25 sq.m. housing, greenhouse gas emission gains are **20,5 tons of carbon equivalent**, compared to a cement block building with a concrete roof, which would provide the same usage levels (viability of the structure, thermal and acoustic comfort, weather protection):

- **3,4 tons of carbon equivalent** saved during the construction and maintenance phase thanks to the use of very low environmental impact materials (raw earth).
- Up to **17,1 tons of carbon equivalent** can be saved during the air-conditioning phase to reach an acceptable level of thermal comfort (< 32 °C).



(*) Average potential CO₂ savings calculated, subject to change depending on the size of the buildings, the place of construction and the climate, according to « Etude portant sur la technologie Voûte Nubienne comme modèle de construction, rapport final » (2015).

LOW CARBON HOUSING, ADAPTED TO CLIMATE CHANGE FOR AS MANY PEOPLE AS POSSIBLE

The use of raw earth, a readily available local material with an exceptional ecological balance, allows a significant reduction in carbon emissions associated with construction. Furthermore, it signifies the reappropriation of an « architecture » and traditional knowledge and skills.

The thermal performance of the Nubian Vault structure ensures a significant **increase in comfort and quality of life.** It contributes to the capacity for resilience of Sahelo-Sudanian populations, among the most vulnerable to the impacts of climate change (rise in extreme and average temperatures, rise in extreme weather variations, desertification, etc.)

*Energies House,
Matam region,
Senegal, 2011*



*Classroom,
Saint-Louis region,
Senegal, 2013*



This energy performance also permits the reduction of electricity consumption for air-conditioning, and the ensuing greenhouse gas emissions, in a context in which electricity production and distribution infrastructures struggle to meet the unceasingly increasing popular demand.

The objective is to anticipate and reduce future demands in electricity, and the associated greenhouse gas emissions, that will continue to grow due to three complementary trends:

- expectations of improved living standards,
- demographic growth,
- the rise in global average temperatures.

*Air-conditioning system model
« split » on the facade of a building
in Ouagadougou (Burkina Faso)*



THE NUBIAN VAULT, A SOLUTION FOR ADAPTATION TO AND MITIGATION OF CLIMATE CHANGE

The large-scale dissemination of the Nubian Vault technique (market growth > 25%) over the entire Sahelo-Sudanian region **would provide millions of people with access to sustainable, comfortable housing adapted to climate change.**

This adaptation would be accompanied by a **significant diminution of greenhouse gas emissions linked to the construction industry**, at around 45 million tons of carbon equivalent by 2040 along with **many other benefits:**

- cultural (use of local and appropriate technologies),
- economic (hundred of thousands of green jobs created),
- technological (control over the energy demand),
- environmental (preservation of ligneous resources).



According to the following scientific and technical studies:

- Rapport technique «Indicateurs de confort dans la technique de la Voûte Nubienne», Wyss Urs, Ing. Civil Dipl. EPFL, Sauret Hugues, Ing. énerg., ENERSOL-A, 2007
- Streamlined Carbon Footprint - AVN, Environmental Ressources Management, ERM, 2010
- Impact of Climate Change and Energy Saving in Buildings for Burkina Faso, Bachir Ismael Ouedraogo, 3rd year PhD School of Mechanical, Aerospace and Civil Engineering, 2011
- Confort thermique des bâtiments en voûte nubienne, Madiana HAZOUME, Mastère Spécialisé - EINTC ICAM Nantes, 2013
- « Promotion des pratiques de Gestion Durable des Terres pour restaurer et améliorer les stocks de carbone grâce à l'adoption d'initiatives d'habitat vert en milieu rural: Étude portant sur la technologie Voûte Nubienne comme modèle de construction », Bruno JARNO pour, Ministère de l'Environnement et du Développement Durable, République du Sénégal, 2015
- Instrumentation thermique comparative de bâtiments de conservation de l'oignon, groupe GCIUS, Université de Sherbrooke, En cours.

The Nubian Vault, an innovative program...

... endorsed by political actors:



« It is the living and housing standards that participate the most in the health and well-being of the populations. The Nubian Vault should be supported by the Ministry for Environment and Sustainable Development because it corresponds exactly to our policy for resource management and the fight against poverty. »

Abdoulaye BALDE, Minister of Environment and Sustainable Development of Senegal, testimony received in Dakar, January 2015.

... supported by many financial partners,



... and recognized by numerous awards, especially concerning the environment and sustainable development.





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