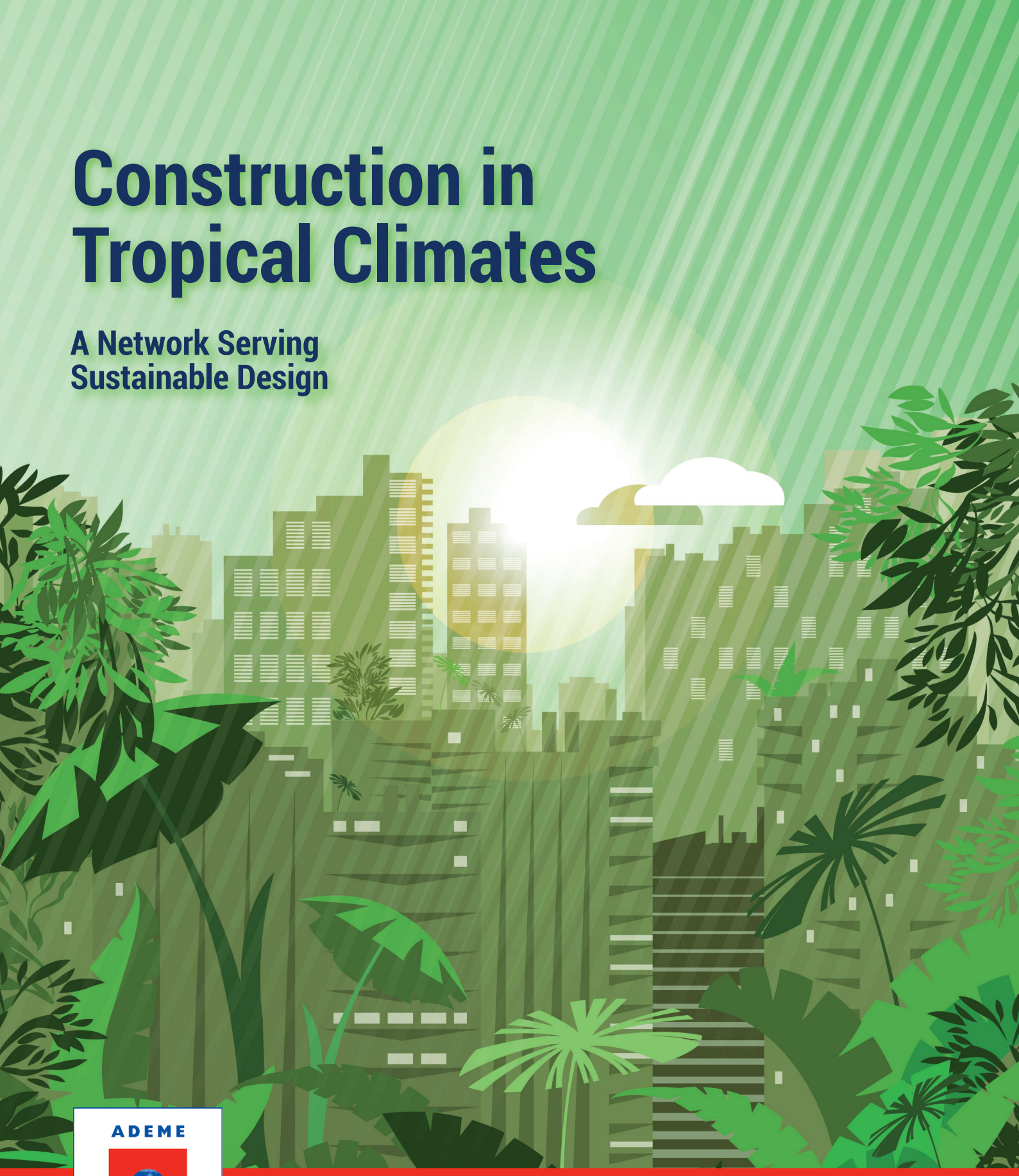
Construction in Tropical Climates

A Network Serving Sustainable Design



ADEME

French Environment & Energy Management Agency

Sustainable Design of Build

A challenge for the climate

Currently, 40% of the world's population lives in the tropical belt. By 2060, that figure will reach 60%. Emissions of greenhouse gases (GHG) in tropical zones are expected to at least quadruple by 2030 in comparison with GHGs in 2000, according to accepted reference scenarios.

Today, in tropical zone countries, most new construction (both residential and tertiary) is built without any particular consideration of the climate context. This results in excessive energy consumption (air conditioning) to compensate for discomfort caused by heat. In addition, regulations on energy performance for residential buildings, and measures of energy efficiency and comfort during the design and construction phase, are relatively undeveloped in most of these countries.

The tropical zone is also facing unprecedented urbanization. Tropical cities have become more dense, resulting in increased built area, a lack of green space and air circulation, and a sharp reduction in soil permeability. Urban heat islands increase temperatures by at least 6°C in the city, encouraging the use of artificial cooling and reducing the options for relying on natural ventilation.

If we are to keep global warming well below 2°C by 2100, as called for in the 2015 Paris Agreement, building design in tropical zones requires special attention.

An international expert network is developing

In 2015, ADEME and its partners launched an international task force called *Low Energy in Tropical Climate for Housing Innovation* (LETCHI). It was formed to find solutions and optimize the energy efficiency and comfort of buildings and housing in tropical countries. It aims to promote the principles of architectural design suited to the climate, the choice of local materials, and energy efficiency, with the goal of reconsidering the way buildings are designed and adapting the bioclimatic principles of vernacular architecture to current requirements and global architectural standards.

Experts from France (Reunion Island), India, Sri Lanka, Thailand, Vietnam, Malaysia, Indonesia, Singapore and East Africa are getting together to share their experience and expertise, demonstrating the feasibility of constructing passive, bioclimatic residential buildings with high energy efficiency, real thermal comfort, and at an affordable cost, in tropical areas.

Objectives of the LETCHI network:

- **exchange** best practices with professionals, decision makers, and experts;
- **showcase** tools and initiatives that can drive action among stakeholders;
- **conduct** joint actions to demonstrate the technical and economic feasibility of projects and promote their widespread adoption (through workshops, training, international events, etc.).

This expert network has already contributed to the following results:

- an online resource center featuring completed projects in participating countries (www.tropicalbuildings.org);
- analysis of the building codes in each participating country, focused on integrating the principles of bioclimatic construction and improvements to be made;
- a study of building design guides promoting passive approaches and local stakeholders and expertise;
- identification of environmental best practices in the construction sector of each participating country (urban planning rules), certifications, financial incentives, contests, etc.;
- support and promotion of pilot projects.

The elements studied and produced as part of this collaboration are available online at:
www.tropicalbuildings.org

Partnership

The LETCHI collaboration, supported by ADEME, is part of the Global Alliance for Buildings and Construction (GABC) and the Programme for Energy Efficiency in Buildings (PEEB), in partnership with AFD and GIZ.

ADEME — www.ademe.fr
Global Alliance for Buildings and Construction — www.globalabc.org
PEEB Programme for Energy Efficiency in Buildings — www.peeb.build

dings in Tropical Climates

USE OF LOCAL, BIOSOURCED MATERIALS

Buildings make an impact on the environment in two major ways: energy related to their operation (heating, cooling, lighting, hot water, etc.) and construction materials (including production, transportation, removal, etc.). The choice of materials is therefore important to a building's overall environmental footprint.
In order to build with a lesser environmental and socioeconomic impact, local and biosourced construction materials are well positioned to offer a range of efficient solutions (energy efficiency, comfort, health, etc.), including in tropical areas. Without resorting to imported insulation, these materials can also drive local development, create jobs, and reduce the need for transportation.

THE ISSUE OF URBAN HEAT ISLANDS AND ENVIRONMENTAL CONSIDERATIONS

For a building to be thermally efficient, the issue of urban heat islands must be addressed. Creating a microclimate around the building is required for natural ventilation. Vegetation near the building helps mitigate the effects of the heat island. Trees provide shade around the building. In tropical regions, which often experience heavy rains (monsoons, hurricanes, etc.), it is important to avoid increasing soil impermeability in order to prevent the risk of flooding. As an experiment, measures were taken on a combination of residential and tertiary buildings in Reunion Island to demonstrate the impact of vegetation on thermal comfort. The project was located downtown, and buffer areas were created between the street and living areas using a double skin made up of horizontal wooden strips and garden spaces. Measurements on the hottest day of the year show that temperatures in the street, in the shade, reached nearly 38°C. Adoption of shading and vegetation reduced that value to 32°C in the naturally ventilated inhabited areas (6°C less than outside).

NATURAL VENTILATION AND THERMAL COMFORT

In a tropical climate, natural ventilation is the most energy efficient solution for achieving comfortable conditions in housing. The basic principle is having doors and windows on several façades, ideally opposing façades to allow for a cross ventilation with a sufficient ratio of opening. Natural ventilation must be able to function at night without the risk of intrusion and while providing protection from rain.

This function is provided by louvered windows, which prevent intrusion while modulating the flow of air within buildings.

Natural ventilation serves three functions, with the minimum air replacement rates required to achieve each function indicated below:

- allowing for healthy ventilation of indoor spaces: 1 volume/hour;
- evacuating internal and external heat loads: 10 volumes/hour;
- creating indoor air movement to enhance occupant comfort: 60 volumes/hour for air speeds around 1 m/s.

The diagram shows that the maximum acceptable temperature increases with higher air speeds. For air speeds of around 1.5 to 2 m/s, maximum comfortable temperature is around 30°C: natural ventilation creates conditions that promote the thermal comfort of occupants, as long as humidity is not too high.

High-performance fans can mechanically create this air movement for a very low energy cost when natural ventilation is not sufficient. Still, in certain regions with a tropical humid climate, natural ventilation is not always sufficient to meet the requirements of thermal comfort. Mechanical cooling equipment can sometimes be a necessary complement. In these cases, equipment must be chosen and the facility designed on the basis of energy performance criteria.

USE OF RENEWABLE ENERGY

Renewable energy can produce electricity and domestic hot water at a reasonably low cost and with a small environmental impact.
The use of renewable energy should at a minimum be considered as a potential option when conducting design studies for buildings. Case studies have noted a low use of renewable energy (particularly for producing solar domestic hot water).

HIGH PERFORMANCE THERMAL ENVELOPES FOR BUILDINGS

A building's orientation is also critical in avoiding direct sun in the morning and evening (east/west) and emphasizing the less-sunny north/south façade when the sun is at its zenith. In tropical climates, the primary element of a building to protect is the roof, because it is subject to the highest solar radiation. In the case studies, various techniques including thermal insulation, ventilated double roofs to create shade, and green roofs are used. The façades (windows, openings, and walls) must also be protected from solar radiation. It is crucial to consider shading on the façades among the performance criteria to encourage solar protection of the façades. The method of installation then requires finding the right compromise between prevailing winds (natural ventilation) and building orientation (sun exposure).

Sample projects

Moufia Amphitheater

Conceived as an outdoor theater, the Moufia amphitheater in Saint-Denis, Reunion Island operates entirely using natural ventilation. Thanks to its innovative bioclimatic design, users enjoy thermal comfort without the use of air conditioning. It is supported by ADEME and is one of Université de la Réunion's low environmental-impact buildings.

Auroville Campus

Architects and thermal engineers of the LETCHI network have supported the design of an eco-campus featuring exemplary bioclimatic architecture in Auroville, India. It will promote the circular economy and best practices for sustainable development.

MOOC[1]

A Sustainable Construction MOOC on building in tropical areas is offered by ADEME for French-speaking countries. LETCHI network experts adapted the course into English in 2019, and it is now available for countries in Asia and East Africa.

(1) Massive Open Online Course.

Testimonials from LETCHI network experts

“There are no regulations governing thermal comfort in buildings in Vietnam; the emphasis is on energy efficiency instead. While the Building Energy Efficiency Code is obligatory, it is not enforced, and an approach must be found to effectively implement it. Several decades ago, bioclimatic building design focused mainly on reducing energy consumption and heat loads. Today’s architects mostly design buildings with windows and no solar protection.”

Nguyen Ngoc Tu, Architect with Enerteam (Vietnam).

“In Sri Lanka, the fact that bioclimatic design is not recognized and integrated into the development of urban areas is a serious drawback. It affects the sustainability of buildings and the health of people living in developing regions. Climate-sensitive urban development policy is crucial, because unfavorable microclimates can preclude the use of naturally ventilated buildings, for example.”

Narein Perera, University of Moratuwa (Sri Lanka).

“In India, regional seminars are held to accelerate implementation of the building code in the different States. A new National Building Code has been adopted (the previous one dated from the 1970s). The main characteristics of the revised Code are the implementation of standards for the use of solar energy and the addition of modern lighting technologies (LED and others). Implementing the code is still voluntary, but builders have become responsible for safety.”

Vikram Devatha, Auroville Consulting (India).

“The primary benefits of the program have been sharing experience and case studies to improve our knowledge. Developing a data sheet to summarize case studies will help amass a large database of sustainable buildings, so that we can share as much as possible.”

Antoine Perrau, architect (France/Reunion Island).

“It is very important for researchers and designers in different countries to share their knowledge about passive, low energy consumption buildings in tropical climates. Each country has a different history in terms of vernacular design, available materials, and construction techniques. The case studies selected in each country offer interesting information about how each country perceives passive, low-consumption bioclimatic design in different ways.”

Atch Sreshthaputra, Chulalongkorn University (Thailand).

About ADEME

The French Environment and Energy Management Agency (ADEME) is active in the implementation of public policy in the areas of the environment, energy and sustainable development. The Agency provides expertise and advisory services to businesses, local authorities and communities, government bodies and the public at large, to enable them to establish and consolidate their environmental action. As part of this work ADEME helps finance projects, from research to implementation, in the areas of waste management, soil conservation, energy efficiency and renewable energy, raw materials savings, air quality, noise abatement, circular economy transition and food wastage abatement.

ADEME is a public agency under the joint authority of the Ministry for an Ecological and Solidary Transition and the Ministry for Higher Education, Research and Innovation.

www.ademe.fr

ADEME

French Environment & Energy Management Agency

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

MINISTÈRE DE LA TRANSITION ÉCOLOGIQUE ET SOLIDAIRE

MINISTÈRE DE L'ENSEIGNEMENT SUPÉRIEUR, DE LA RECHERCHE ET DE L'INNOVATION

www.ademe.fr

AThis document was published by the Europe and International Division of ADEME. **Photo credits:** ADEME, Auroville Consulting, Vimal Bhoriaj, Hervé Douris – **Graphic design:** IDIX **Printing:** Printed in France – Imprimerie Cloitre, PEFC, FSC, Imprim'vert – **Brochure:** ref. 010728 – **ISBN:** 979-10-297-1252-4 – January 2019 – 400 copies – **Registered copyright:** ©ADEME Éditions.

ISBN 979-10-297-1253-1

0 10728

9 791029 712524