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Technological Imagination in the Green and Digital Transition

Springer

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ISSN 2365-757X ISSN 2365-7588 (electronic)
The Urban Book Series
ISBN 978-3-031-29514-0 ISBN 978-3-031-29515-7 (eBook)
https://doi.org/10.1007/978-3-031-29515-7

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

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Foreword by Antonella Polimeni

Good afternoon to all participants, ladies and gentlemen, and welcome to Rome.

On behalf of the Community of Sapienza University of Rome, it is a real pleasure to welcome all of you to the first edition of the International Conference "Technological imagination in the green and digital transition". I am also pleased to give my best welcome to Dr Antonio Parenti, Head of the European Commission Representation in Italy, and to Prof. Mario Losasso, President of the Italian Society of Architectural Technology, as well as to all guests, students and colleagues.

The conference that we are about to open, organised by the Department of Architecture and Design and directed by Prof. Alessandra Capuano in cooperation with Sapienza Foundation, is to be a moment of methodological debate about built environments and the rise of contemporary urban challenges, so engaging for public and private institutions at national and international level.

The proposed key points of this conference—namely Innovation, Technology, Environment, Climate Changes and Health—are all interconnected priorities that cannot be further postponed, representing in the meantime strategic research and education activities for our University, perfectly aligned with the Italian National Recovery and Resilience plan, to be implemented in Italy as well as European member States, in order to overcome the present financial and social challenges.

I truly believe that Universities are, by definition, places of imagination, where planning the future is intended as an unavoidable "existential condition" as well as an essential moment of collective participation for an accomplished society.

Thank you for your attention, and I wish you a fruitful continuation of the conference.

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Foreword by Eugenio Gaudio

My warmest greetings to Dr. Antonio Parenti, Head of the European Commission Representation in Italy, to the President of the Italian Society of Architectural Technology Mario Losasso, to the Director Alessandra Capuano, and to Pietro Montani who will open with a Philosophical Lecture the Conference "Technological imagination in the green and digital transition".

A special greeting to Prof. Anna Maria Giovenale, my dear colleague and friend, who invited me to be here today. Thank you Anna Maria.

Let me also greet all other speakers as well other participant that will follow this Conference organized by the Department of Architecture and Design, together with the Fondazione Roma Sapienza.

From the very beginning, as President of the Fondazione Roma Sapienza, I supported the initiative of an international Conference on the theme of "Technological Imagination" having clear in mind that human imagination is inseparable from the "technical practice" with which it is entangled from the earliest origins of mankind, as Pietro Montani states in his book, *Technological destinies of the imagination.*

When the contents of the Conference were increasingly defined and focused around the areas of the green and digital transition, I realized that the very core of the Conference was becoming an attempt to respond to the contemporary challenges of the National Recovery and Resilience Plan, in their key role of revitalization for Research and University.

In this sense, the potential of technological culture is reaffirming its role of strategic tool for the conceiving, design and validation of future scenarios.

The sessions into which the Conference is structured, namely: Innovation, Technology, Environment, Climate Changes and Health, identified in order to outline the evolutionary scenarios of architectures and cities, allowing us to reflect at different levels on innovative models of building and management process, as well as design and products.

The goals of promoting digital transformation, supporting innovation in the production system, improving sustainability and ensuring an equitable environmental transition, find their clarification in the elaborations and experimentation presented through the contributions in the different sessions.

Modern technological innovation allowing multiple possibilities in all areas: nowadays digital technologies are enabling us to interact with people and things, all over the world.

There are astonishing, yet untapped potentials, suggesting that digitization, rather than a strict sense adaptive development, should be seen as an important evolutionary phenomenon and in the meantime a great opportunity.

Innovations connected with new technologies can provide to civil society a better quality of life, both at indoor and urban scale settings, addressing scientific development toward an effective culture of sustainability, reuse and security.

The employment of new technologies, a careful approach to the containment of land consumption as well as a careful consideration towards soil coverage modality and urban density, the recycling strategies and technological and typological redevelopment of degraded areas and buildings applying an energetic and eco-systemic approach, are the key elements for the conception of healthy and resilient urban habitats, able to adapt to the present global changes, as well as promoting prosperity, inclusiveness and social equity.

Last but not least, "health" issues, that need to be conceived at the very core of the potential determined by 'technological innovation and processes of ecological and digital transition.

The structure of the Conference is rooted on all these interrelated themes, and on that same basis also research needs to be reoriented.

I am confident that this first edition of the Technological imagination conference will contribute to pave the way of an innovative and interdisciplinary scientific approach to technology and policies for built environments, considered the real human challenge of the twenty-first century.

Thank you so much for your attention and enjoy the Conference.

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Foreword by Antonio Parenti

New European Bauhaus

Good morning,

Magnificent Rector of Sapienza University of Rome Professor Antonella Polimeni
President Fondazione Roma Sapienza Professor Eugenio Gaudio,
Director Department of Architecture and Design Professor Alessandra Capuano
and others.
Ladies and Gentlemen,

It is my pleasure to address you today and to open this International Conference "Technological Imagination in the digital and green transition" organized by Sapienza University of Rome.

Let me say that the title, the contents, and the proposals envisaged by the Conference match perfectly with the main pillars of the flagship initiative shaped by the President Ursula von der Leyen and launched in September 2021: the New European Bauhaus.

The New European Bauhaus is by nature transdisciplinary: it invites architects, designers, artists, scientists, engineers, artisans and citizens to share their expertise in preparing for the future.

With the New European Bauhaus, we want to make the European Green Deal tangible and "palpable".

We want to add a cultural dimension to the economic and technological transformation. This is essential to achieve our overarching goal: making Europe the first climate neutral continent by 2050. And thus reconciling our way of life with nature.

To get there, we need both: a real transformation of our economy and society, and a debate about how we can live in respect of nature and our planet.

The historical Bauhaus was founded in Weimar and Dessau. It turned into a worldwide movement. This did not happen by chance. Some ingredients of what made the historical Bauhaus a success can also be an inspiration for the New European Bauhaus.

Let me mention three.

The first ingredient: The historical Bauhaus was created in a time of **profound transformation**. People were facing the challenges of industrialisation. Gropius and the founders wanted to respond to the emerging needs of a new era. They aimed for solutions that were functional, affordable, but also beautiful. With this principle in mind, they shaped buildings, fabrics and furniture. They always aimed higher than just innovative design. The New European Bauhaus is also striving for this mix of aesthetics and affordability. But we want to add another element: sustainability. Because the New European Bauhaus wants to match sustainability with style.

Now, the second ingredient: **The historical Bauhaus boldly promoted new materials like steel and cement**. Today, we also need to look into new building materials. But this time, it is about sustainability. It is about materials that need less CO_2 in their production process. The New European Bauhaus wants to accelerate the transition of the built environment. It wants to scale up nature-based materials, to support circular design and architecture. Buildings are responsible for 40% of our energy consumption. And if we manage to change this, we have a chance to keep global warming below 1.5 degrees.

The third important element from the historical Bauhaus is **interdisciplinarity**. We want to convene people from different backgrounds and with different competences to share and grow their ideas and visions. We can create a better tomorrow, if culture and technology, innovation and design go hand in hand.

For our New European Bauhaus, the European Commission needs scientists, activists, artists, designers, architects and entrepreneurs. We want to include the ideas and perspectives of all ages and all backgrounds.

Today, at this conference we can contribute to this evolving New European Bauhaus network.

This project is a project of hope. It is a project of change and of economic transformation.

So I hope that this conference can contribute further to making the transformation happen and to connecting more and more people who want to make it happen.

Thank you very much and have a great conference.

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Foreword by Mario Losasso

Presentation of CONF.ITECH 2022

The green and digital transition represent in the contemporary research field the two new challenges for the evolution of technology within the themes of sociotechnical innovation. Consequently, technology and innovation in contemporary world must adapt to this general objective. Innovation in its hard and digital components once again becomes a central factor in the experimental propulsion that the project is assuming within a processuality and technologies that enable its conception and implementation.

Today, research is increasingly characterised by the need to focus on specialisms that lead to and contribute to the advancement of knowledge and the predictive value of what is studied in the disciplinary fields. However, with respect to the evolving complexity of phenomena, research requires continuous disciplinary interactions to be developed because we understand that one disciplinary field cannot alone address the most important challenges of contemporary society.

New forms of coexistence must be organized in a vision of interdependence and connection, while the green transition requires the definition of the limits of design action and the characteristics of the transformation processes. The new perspective of co-evolution will have to express a design attitude that allows to repair and, where necessary, rebuild the lost links between man, technology and nature.

The green and digital transition represent the two new challenges for the evolution of technology within the themes of social innovation. The Italian society of architectural technology SITdA has been working for a long time on the topics of the relationship between technology and urban and building development within a process-oriented and eco-systemic approach. In the field of technological design of architecture, the scientific society of the technology of architecture has activated research and training sensitivities on the themes of design experimentation framed within process and ecosystem dynamics, aimed at optimising the efficiency of products and processes by reducing inefficiencies and waste.

The SITdA supports research and spin-off outcome on territories through the activities of its scientific clusters. The Scientific Society SITdA has granted its patronage to the CONF.ITECH 2022 Conference, sharing its importance and topicality in view of the new challenges identified in the urban construction and environmental fields by the Next Generation EU Programme and the implementation programmes in the various nations of the European Union.

The topics that will be addressed during the three-day conference are fascinating and challenging, linking innovation, technology, environment, climate change and health.

These topics are strongly interrelated themes in which we are realising that it is impossible to deal with them separately, arriving in the most recent reflections at considering a single health for human beings and for the entire environment which is their living environment.

I would like to remind that the topic of digital culture, nature and technology was the central topic of the SITdA Naples 2020 Conference held last July with a delay due to pandemic difficulties, while the 2022 Conference of the Scientific Society is focused on the topic of the centrality of processes. As we can see, the work carried out in the Departments of Architecture and by the Scientific Societies in the area of architecture is an activity that has picked up significantly, foreshadowing new approaches, new fields of enquiry and new paradigms necessary for the new complexities that constitute the reference scenario of the future.

The experience of this Conference can provide a significant contribution to the sustainable and environmental evolution of the design area in its trans-scalar, multidisciplinary and challenging dimension, overcoming technocratic responses to a demand that requires the integration of the humanistic and technical-scientific dimensions.

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Foreword by Orazio Carpenzano

Welcoming Address from the Dean

On behalf of the Faculty, I wish to thank the organisers for asking me to give this opening address, while congratulating them on their efforts to bring together, in an international encounter, various perspectives on topics of such decisive importance for the future of our respective territories, as well as their people, living organisms and architecture.

My thanks go to Anna Maria Giovenale, Fabrizio Cumo, Eugenio Arbizzani, Carola Clemente, Eliana Cangelli and Francesca Giofrè, who will be giving talks on technological innovation, the environment, climate change and public health.

Thinking of energy in terms of how it relates to architecture during the green and digital transition means cultivating a *technological imagination*, a topic which leads to the broader question of the man–nature relationship and the possibility that architecture, by applying innovative ideas and concepts while promoting a growing social and emotional intelligence of its own, can contribute to inventing of new types of habitat for mankind on the planet earth, under a new pact for survival that allows all elements, both artificial and natural, to coexist in a sustainable balance which can serve as a preventive measure against the intrinsic destructive force of the Cosmos, an especially pressing problem where mankind has neglected certain methods for dissipating the energy of calamitous events made available by both ancient wisdom and scientific advances.

The 2021 Architecture Biennial, entitled "How Will We Live Together?", implicitly drew the attention of visitors to the need for a new approach to the man–nature relationship, following a thorough review of its historical and ethical premises. Hashim Sarkis, the curator of the exposition's seventeenth edition, passed on the following message: "In a scenario of exasperated political divisions and growing economic inequality, we call upon architects to imagine spaces in which we can all live in fruitful fellowship".

The man–nature relationship has always been a distinctive feature of humanistic and artistic thought on things technical, expressed in the construction of the *civitas*, the physical and political synthesis of civilisation. Medieval mysticism viewed nature as a foreboding wilderness, while the Renaissance redeemed the sense of *technè*, and the Romantic Period, with its high-strung, emotive outlook, led to the elaboration of the concept of the sublime.

Controlling and putting to use the energy generated by nature through sources of heat and movement (wind, sun, water), first through manual effort and then using the tools and machines produced by human ingenuity, was also a topic and challenge that led architecture to express, during the Modern Movement, boundless enthusiasm for the theories of Taylorism, which Corbusier summed up by interpreting human dwellings as machines of habitation.

But it is from the time of Vitruvius that architecture, engaged more or less explicitly with the triad of *utilitas-firmitas-venustas*, has addressed the problem of dissipating heat (or thermal inertia), as well as kinetic and elastic energy (in the case of earthquakes), at various latitudes of the globe, drawing on the available resources and raw materials. Historic Italian buildings, for example, built with walls roughly a metre thick and a structural layout measuring 4 × 4 or 5 × 5 m, have offered excellent thermo-hygrometric performance (in terms of energy consumption), as well as structural dependability (against seismic risk). In both cases the objective is to "mitigate", a term used by many modern-day scholars, the dissipation of different types of energy.

The history of architecture is filled with archetypes that need to be updated and reinvented. Think of the ingenuity it took to build Venice atop a giant underwater forest, or the aesthetic quality of the Tu'rat walls constructed by Southern Italian peasants, the windmills of Northern Europe and countless other magnificent examples of *swarm intelligence* collected by Bernard Rudofsky in his well-known book *Architecture without Architects: a short introduction to non-pedigreed architecture*, published by Doubleday & Company Inc., Garden City, (in 1964), following an exhibition at New York's Museum of Modern Art. Though, in truth, Roberto Pane and Gino Capponi had already touched on the topic in articles on the architecture of Ischia published in "Architettura e Arti decorative" in 1927, as did Giuseppe Pagano at the Milan Triennial "Rural Italian Architecture", published in the Notebooks of the Milan Triennial by Hoepli in 1936.

Looking beyond the confines of architecture, a recent reconsideration of the topic of Cinema and Energy can provide potentially useful points of affinity with architecture, especially in the collection of essays found in issues 7 and 8 of the periodical Imago, under the title *Cinema & Energy. Interdisciplinary Outlooks Combining Science, Aesthetics and Technology*, edited by Marco Maria Gazzano and Enrico Carocci (and published by Bulzoni in 2013). In an essay entitled *Dissipation and Aesthetic Experience*, the physicist Giuseppe Vitiello, in commenting on the film Transeurope Hotel by Luigi Cinque, writes: "The brain [which leads me to think of *swarm intelligence*] is described as an open system engaged in continuous exchanges with its surrounding environment. In both models and films, antinomies such as information/knowledge, feeling/knowing, blend with each other in the aesthetic experience, the favourable connection between 'me and the object' that characterises our existential dimension."

Dissipation, therefore, should be seen as part of the evolution of our ecosystem, of our contemporary habitat. It gauges the possibilities for losing and exchanging, through a rekindling of collective emotional intelligence and technical and intellectual micro-revolutions. It is a risk that we must continue to face, as otherwise architecture will die, depriving man of an indispensable tool for managing the complexity of the physical habitat through creativity, in order to transfigure energy in a way that, at times, can prove so unreal, and yet so effective and indispensable, that it leads to the construction of new values and sublime beauty.

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Thanks to:

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Dr. Antonio Parenti, Head of the European Commission's Representation in Italy, to Prof. Mario Losasso, President of the Italian Society of Architectural Technology, and to Prof. Orazio Carpenzano, Dean of Faculty of Architecture of the Sapienza University of Roma;

All the patrons of the conference: the Ministry of Ecological Transition; the European Commission; the Italian Society of Architectural Technology; the European Association for Architectural Education; Eurosolar; Healthy Urban Environment;

The Sponsors: CEFMECTP, the Joint Body for Construction Training and Safety of the City and Province of Rome; the Construction Pension Fund of the City and Province of Rome;

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Chapter 47
Integrated Design Approach to Build a Safe and Sustainable Dual Intended Use Center in Praslin Island, Seychelles

Vincenzo Gattulli, Elisabetta Palumbo, and Carlo Vannini

Abstract A flexible multi-purpose center for a dual intended use—hospitality and observation and research related to climate change—has been designed in the fragile environment of Praslin Island, Seychelles. The technical solutions adopted for a low environmental impact LCA based in the designed center during the life cycle will be illustrated: starting from the local supply raw materials, the self-disassembling construction system, the described process is compatible with the site use that the owners have foreseen. Specific logistic systems have been chosen both to the transportation of the material on the site, and to the integrated structural and architectural solutions. In addition, a reconstruction of the natural characteristics of the building site has been developed both by google-earth observation and with a survey directly on the site through processing acquired images. The multi-disciplinary perspective through which the project has been conceived shows beneficial effects in terms of reduced impact on the original and resilient natural environment. Future developments of the work will be devoted to the optimization of this multi-disciplinary approach.

Keywords Sustainable new construction · Life cycle assessment · Resilient built environment · Seychelles

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E. Arbizzani et al. (eds.), *Technological Imagination in the Green and Digital Transition*, The Urban Book Series, https://doi.org/10.1007/978-3-031-29515-7_47

47.1 Introduction

The Seychelles is extremely vulnerable to growing threats due to the greenhouse effect.

Additionally, considered an ecological paradise for its natural beauty, the Seychelles Island attracts many tourists and hence needs to meet their increasing request for tourist accommodation service.

Tourism is an important lever for poverty alleviation of naturalistic and desirable tourist destinations (e.g., offering job opportunities for local residents). Several authors recognize the effectiveness of tourism as an adequate method to boost the economic status of local communities, such as small islands (Tsung and Fen-Hauh 2019).

The Seychelles has played a leading role in implementing all 17 Sustainable Development Goals defined by the 2030 Agenda (Seychelles National Climate Change Strategy—NCCS) (Escamilla et al. 2018).

More specifically, within the Seychelles' commitment to tackle climate change and minimize its impacts, the promotion of sustainable practices in the tourism industry plays a key role.

Among the many African certification programs, Seychelles Sustainable Tourism Label (SSTL) is one of the three developed by the Government (Sebestyén et al. 2021).

SSTL is a voluntary sustainable certification program for tourism accommodation in Seychelles, locally developed and introduced by the Ministry of Tourism in 2012. It is a points-based certification scheme, and is third-party assessed.

In order to be certified by the SSTL, a hotel needs to meet three conditions:

- satisfy all the 22 mandatory criteria;
- reach a minimum score in each category, according to business size (5 points for enterprises with rooms from 1 to 24; 6 from 25 to 50 rooms and 7 for more than 51 rooms);
- obtain an additional six points in any area.

There are 8 evaluation areas defined by the scheme: Management, Waste, Water, Energy, Staff, Conservation, Community and Guests.

Despite the scheme being recognized as good and comprehensive for tourism accommodation, it proves to be limited for different uses such as multi-purpose centers.

Sustainable construction is one of the keywords in the debate on environmental development of the most sought-after holiday destinations, which are mainly characterized by increasingly fragile contexts such as natural hazards and changing climate. In the last few years, the building life cycle impacts and energy efficiency have been examined sufficiently. A small number of them consider the environmental impacts from the view of structure design, which indeed could play an important role in reducing emissions.

Therefore, with the aim to design a sustainable and safe flexible center situated in a small location on Praslin Island, this study has adopted a multi-disciplinary approach to identify low environmental impact technical solutions taking into consideration several life cycle (LC) stages. Specifically, the LC stages analyses are: supply of raw materials, self-disassembling construction systems and a minimum-impact building site.

The method used to quantify the environmental impacts is the Life Cycle Assessment (ISO 14040-14044, EN 15804).

The final purpose is to understand how the Life Cycle Thinking approach, and in particular a Life Cycle Assessment (LCA) application can support a multi-disciplinary methodological design approach (structural and architectural), for the calculation of ecological footprints related to a flexible small center project located on Praslin Island.

47.2 Methodology Adopted at the Design Phase

The design proposal stands on a sloped site of 31.500 m^2 left in a state of total neglect.

After a first exploratory phase, focused on the analysis of the climatic context, the need to preserve the fragile island's environment and mitigation of the impact on natural resources to the maximum possible extent, was outlined in the design requirements shown in Table 47.1.

The general morphology of the plan was evaluated taking into particular consideration the natural ground feature and hence the position of the buildings which follow the shape of the ground (Figs. 47.1 and 47.2).

The key design concept was to promote a "modular" style of architecture based on a rapid assembly of structural components and consequently easier replicability (Fig. 47.3).

Table 47.1 Brief of factors and solutions satisfying design requirements

Needs	Design solutions
To reduce the amount of solar radiation	Orienting the building on the North–South axis
To promote natural ventilation	Correct choice of the position of the openings and elevating from the ground
To favor shading	Using of a single pitch sloping roof
To avoid flood problems	Elevating from the ground
To use of alternative resources	Providing tanks for water recovery
To reduce environmental impact	Using of eco-sustainable materials
To ease of assembly	Adopting of dry systems
To reuse at the end of life	Using of dry assembled materials

Fig. 47.1 Site plan (1:1000 scale)

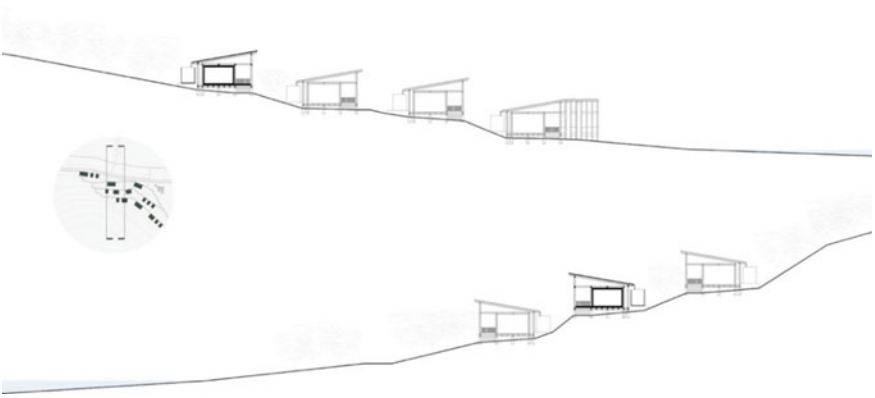

Fig. 47.2 Elevation section profile (1:500 scale)

47.2.1 Architectural and Structural Design Concepts

The environment, the climate, the morphology of the land and the scarce availability of materials on site were all considered in the choice of a modular structure that could be suitable for different uses and with a reduced environmental impact.

The pile dwelling shelter has been identified as the right building typology with the aim to improve the uncultivated and still scarcely used land. A raised structure that

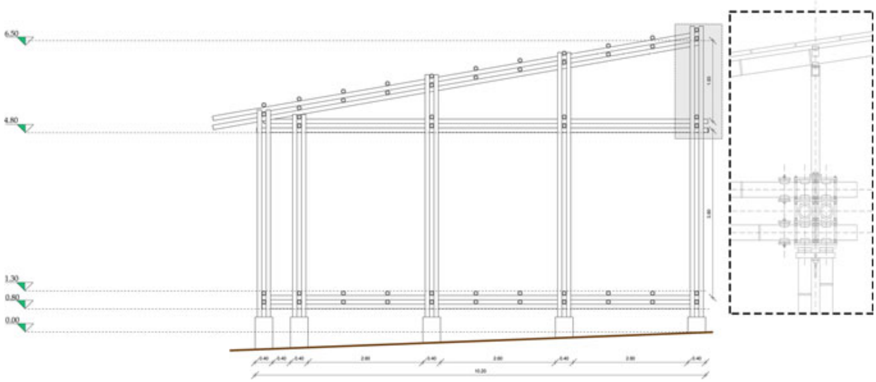

Fig. 47.3 Design schemes to illustrate the structural system realized by modular bamboo elements with a special metal joint

develops the surrounding environment without damaging it determines that earth movements or excavations on the ground are not necessary, while light materials such as wood and steel allow easy installation and quick disassembly, granting the involvement of local labor.

How can we build architecture that is aware of climate, light and air, through technical choices that are also structurally linked to the project? Lightness and slim elements shall be the main architectural features: the roofs rest on light uprights, wrapping them in minimal structures and covering transparent spaces. Permeability becomes the language of these spaces, while continuity is what they bring to the internal–external relationship: the architectures are drawn in the landscape and strengthened by their diversity. In this way a cordial and friendly relationship with nature is established, one capable of combining the use of poor and inexpensive materials (wood and steel industrialized elements, hemp fiber). Raising the house above the ground without the need for deep excavation protects the dry ground and the surrounding trees.

The structure of the module is made up of a symmetrical rectangular mesh with a constant trend and designed on a grid (6.40 × 9.70 m). All the components should be as much modular as possible with serial production in mind. The load-bearing elements (vertical and horizontal) are made up of bamboo rods and connected with a special joint—a metal cage composed of multilayer metal plates and bolts. The distances between the plates can be adjusted and adapted to the different dimensions of the raw bamboo, thus avoiding drilling holes. An elastic cushion is provided to protect the bamboo rod from the pressure exerted by the metal plate—this element increases friction, reducing the slippage and rotation of the wooden element. The vertical elements are raised and anchored to the foundation with metal brackets.

The module is designed to be used as a bedroom for guests. It has an external area, a covered and shaded patio that functions as an entrance and an internal area, with a space dedicated to the night and one to services. This module can be assembled creating different scenarios—for instance with a double or triple version—used as a tourist resort or as spaces for research and analysis labs.

This conscious design is based on improving energy efficiency so that the project provides several interventions on the building's envelope and systems, choosing a lightweight construction site and therefore technological solutions for customized industrial production (Table 47.1).

Despite the fragmentation and distribution on several levels of the settlement's lot, the modular units are spaced and rotated on the contour lines of the steep slope, creating a simple design in harmony with nature. It is a matter of designing economical buildings, which will save energy and which can easily adapt to this particular morphological connotation of the land and merge with the surroundings. It is also important to remember that the area is characterized by a tropical climate, with a high percentage of humidity and high temperatures, especially in the winter months. The construction is adapted to the needs of this particular climate—especially the needs for heat and ventilation—without resorting to artificial systems such air conditioners but instead paying close attention to the movement of the sun, the moon and seasons as well as designing buildings that can be in harmony with the movement of light and wind.

The orientation of the building and the exposure of the individual facades have a significant influence on the energy performances. By positioning the building along the North–South axis, the openings on these facades prevent direct sunlight from penetrating. In this way it is possible to keep the rooms cooler, to reduce exposure to the sun at noon and to take advantage of the winds and breezes for greater natural ventilation. To optimize ventilation and maximize breezes, in addition to lifting the building off the ground, openings such as windows and doors have been aligned to allow air flow and to minimize internal dividers for an unobstructed ventilation. The roof, with a single pitch, protrudes to shade the side walls and has a ventilated double skin.

The external skin shades the internal layer and absorbs solar heat based on its reflectivity while the cavity guarantees ventilation of the space between the roof and ceiling and acts as an insulator in the absence of winds.

In the context of the new policies for sustainable growth of Seychelles the opportunity to design an energy efficient experimental house in Praslin Island is very current and challenging. The proposal explores the potential of minimizing carbon emissions while maximizing environmental protection and natural ecological development through the use of the natural elements available in the area, such as sun, wind and natural materials (Fig. 47.4).

The end goal is to achieve a high-standard innovative house for the Seychelles context.

The topics that we have considered for the design of the module are the following:

Bamboo—a very special natural element which we use as structural for the house;
Modularity and Industrialization—modular elements to create an innovative industrialized bamboo construction system.

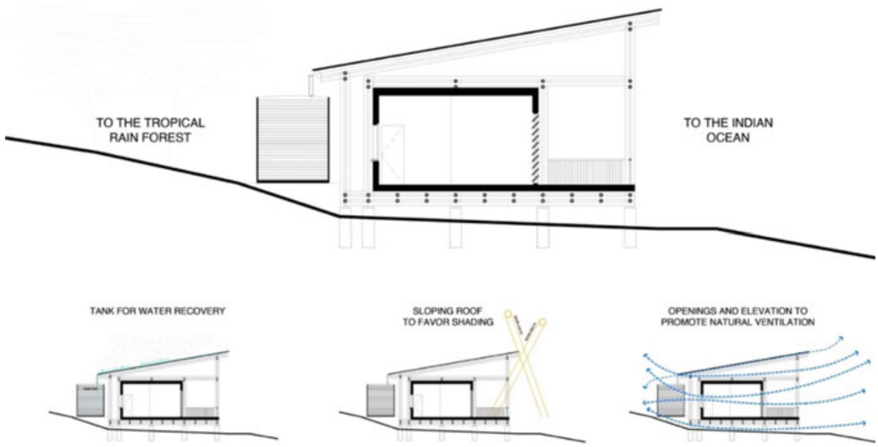

Fig. 47.4 Design schemes to illustrate the relevance of the project under sustainability point of view

Bamboo is the plant that absorbs the most carbon dioxide during its life cycle. It is strong enough after cultivation for 3 years and grows much faster than any other tree species. For the structure of the house we explored new ways of building using bamboo as a construction material. Sustainability is ensured not only by the use of natural materials such as bamboo but also by designing appropriate construction solutions—for instance dry-mounted connections that do not weaken bamboo through perforation nor fill it in with concrete and by allowing the replacement of bamboo poles if needed.

Also, an industrialized construction system can be achieved by designing light and easy to assemble aluminum connections, using same length bamboo poles and combining bamboo (known as vegetable steel) and steel together.

47.3 Choosing Materials

The aim of selecting materials including the following considerations:

- materials from renewable or replaceable sources,
- recycled materials,
- materials that are in plentiful supply,
- materials with a lower environmental impact across their whole life cycle.

The choice was thereby directed toward plant-based or local materials (Escamilla et al. 2018; Zea Escamilla et al. 2016), which consist of:

- bamboo for structural components,
- light-gauge steel produced in Africa for metal connections,

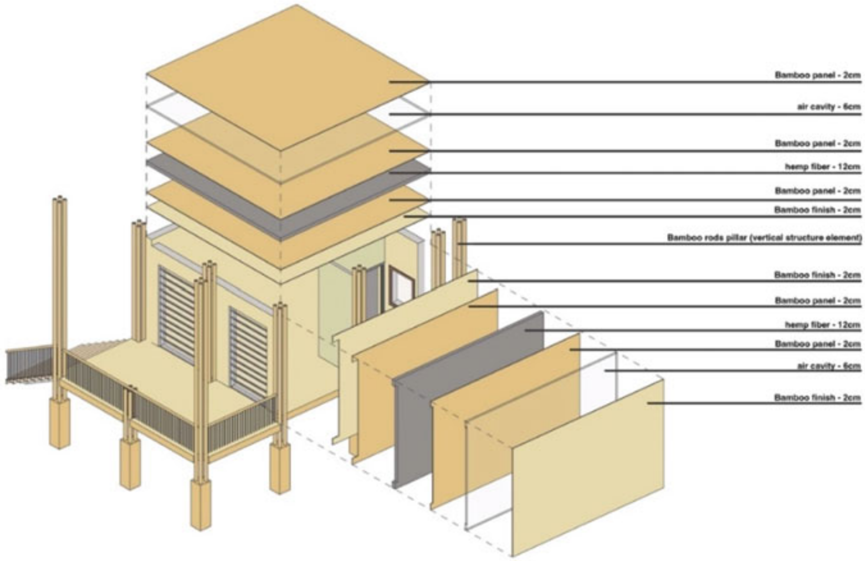

Fig. 47.5 Isometric view about technological solutions

- laminated bamboo for vertical and horizontal elements;
- hemp fiber for insulation (Fig. 47.5).

47.3.1 Life Cycle Assessment Considerations of the Case Study

To examine the environmental benefits of the constructive solutions adopted in the project, some relevant impact indicators were calculated by employing the Life Cycle Assessment method (Vogtländer et al. 2014). In particular, the aim of this additional analysis was to evaluate the environmental impact connected with the materials adopted, focusing attention on raw material supply and manufacturing process (Escamilla et al. 2018).

In this study, the use of specific impact values like Environmental Product Declaration (EPD) indicators developed by producers was preferred. The materials selected in the project were assumed to be sourced and processed locally. The data acquisition to model the Life Cycle Inventory (LCI) are shown in Table 47.2.

As there is little to no specific LCI data available for Africa, and specifically for the Seychelles, the data related mostly to EPDs of products with the same performances. Where EPD's product data was not matched with the product's performance literature data was used to determine the LCA impacts.

Table 47.2 Bill of materials for building with the mass and volume per material category for each building component

	Material	*Component*	*No. elements*	*Density* (kg/m^3)	*Volume* (m^3)	*Tot.* (m^3)
Structure	Bamboo	Beams	13	1080	0.611	7.94
		Columns	12	600	0.078	0.94
		Piles	9	600	0.026	0.23
			Thickness (m)	*Density* (kg/m^3)	*Quantity* (m^2)	*Total* (kg)
Vertical elements	Laminated bamboo	Internal wall finishing	0.02	700	61	823.5
		External wall finishing	0.02	700	61	823.5
	Hemp	Insulation	0.12	35	61	256.2
Horizontal elements	Laminated bamboo	Upper part	0.02	700	43	
		Lower part	0.02	700	43	5160
	Hemp	Insulation	0.12	35	43	180.6
Roof	Laminated bamboo	Lower part				
	Pine		0.2	450	43	5160
	Pine Hemp	Lower part	0.2	450	43	5160
		Insulation	0.12	35	43	180.6

47.3.2 LCA Data Assumption and Impacts

The GWP indicator of the designed technical solutions was assessed. Table 47.3 summarizes the LCA indicators considering the Global warming potential indicator for production and end of life phases, expressed in value impact (kg) and percentage contribution (%) to environmental impact analysis, respectively. GWP is expressed in kilograms carbon dioxide equivalents (kg CO_2 eq.) shows the problem of other gases and shows the problem of other gases (e.g., carbon monoxide, carbon dioxide, methane, HFC) standardized with reference to their lifespan in the atmosphere as compared to a unit of CO to a unit of carbon dioxide. The LCA indicators adopted in the assessment are based on EPDs' producers. According to these references, in relation to end of life phase, it was assumed the as scenario incineration for energy production. More specifically, 95% as incineration and 5% as dump (Table 47.2).

Figure 47.6 shows results of the whole building. The bars in this figure present the results for the studied technical solutions, and they represent the CO_2 emissions for each of them in the two life cycle scenarios: production and end of life (Table 47.3).

The results for the cradle-to-gate and end of life are presented in Fig. 47.6.

Table 47.3 Cradle-to-gate plus end of life impact assessment for the building component designs

Building component	Global warming potential (GWP)			
	Production		End of life	
	kg CO_2 eq	%	kg CO_2 eq	%
Structure	7949.9	65.2	−5726.3	70.4
Vertical elements	1871.7	15.4	−915.1	11.2
Horizontal elements	1181.3	9.70	−744.8	9.2
Roof	1181.3	9.70	−743.0	9.1
Total	12,184.3	100	−8131.1	100

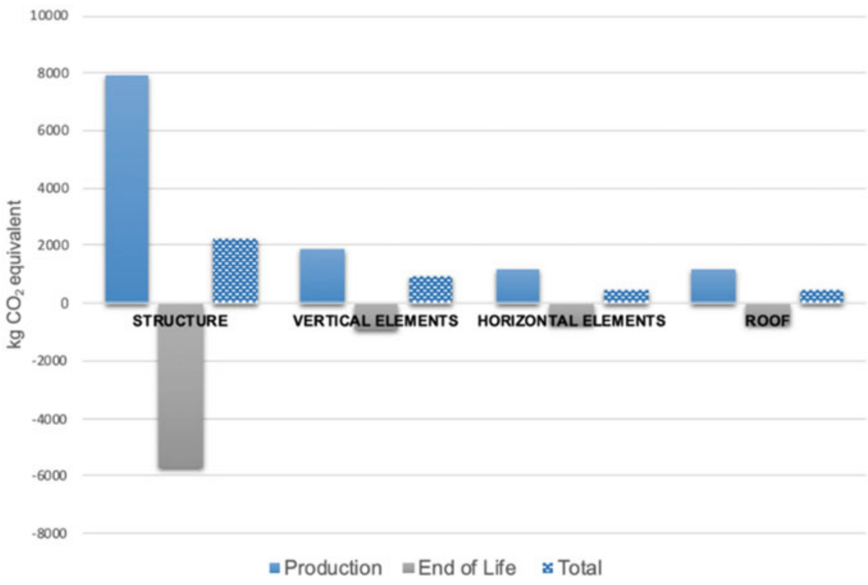

Fig. 47.6 Environmental impact in kg CO_2 equivalent

As can be observed in Table 47.3 and Fig. 47.6, for the bamboo-based structure (assumed for structural components like columns, beams and piles), the contribution from the life cycle phases ranges from 65% (production) to 70% (end of life) of their total environmental impact, whilst the laminated bamboo-based construction materials (adopted for walls) contribution ranges from 9.7% (production) to 15% (end of life) of the total environmental impact. These results support the idea that in order to obtain low carbon, it is necessary to optimize the amount of reuse materials post demolition, whereas the material production would require the optimization of manufacturing process.

Fig. 47.7 Sustainable dual intended use center development in Praslin Island, Seychelles

47.4 Conclusions

LCA-based design may have a great impact in approaching new solutions respectful European green deal. Climate change and environmental degradation are an existential threat to Europe and the world. To overcome these challenges, the European Green Deal will transform the EU into a modern, resource-efficient and competitive economy, ensuring: no net emissions of greenhouse gases by 2050; economic growth decoupled from resource use; no person and no place left behind.

The technical solutions adopted for a low environmental impact LCA based in the proposed designed center during the life cycle is a possible example of a new approach of conceptual design in fragile environment (Fig. 47.7).

Acknowledgements Part of the work has been developed during the master thesis in Project and Construction Management of Building Systems of Eleonora Cruciani. Her work is acknowledged.

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