versus

VERSUS
HERITAGE FOR TOMORROW
Vernacular Knowledge for Sustainable Architecture

edited by
Mariana Correia
Letizia Dipasquale
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FIRENZE UNIVERSITY PRESS

This scientific publication resulted from an intensive and significant teamwork research, based on the common main aim of establishing key principles, regarding vernacular knowledge and its contribution for sustainable development.

Lessons learned from vernacular heritage are systematised through principles that define a wide number of strategies to consider and to integrate for sustainable contemporary architecture. This was possible through the initial establishment of operational definitions, regarding vernacular architecture and sustainable architecture. It was also critical to define a profound reflection concerning the state of the art of environmental, socio-cultural and socio-economic sustainability, as well as resilient vernacular heritage, and the definition of parameters for vernacular sustainability during the 20th Century.

This publication presents the design of the VerSus research method and operative approach, which were decisive for the systematisation of strategies and solutions identified in urban, local, architectural, technical and constructive terms. Each area of study was represented by specific case studies from Europe and around the world, addressing vernacular environments and contemporary contexts.

VERSUS, HERITAGE FOR TOMORROW: Vernacular Knowledge for Sustainable Architecture is the final outcome of VerSus, an European project developed in the framework of the Culture 2007-2013 programme, funded by the European Commission from 2012 to 2014.

versus

Vernacular Heritage
Sustainable Architecture

European Research Project

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Vernacular Heritage Sustainable Architecture
European Research Project

With the support of the Culture Programme of the European Union

Project Leader

Escola Superior Gallaecia
PORTUGAL

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FRANCE

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Università degli Studi di Firenze
ITALY

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SPAIN

With the collaboration of

Culture Lab, Brussels,
BELGIUM

Under the Aegis of

Chaire Unesco *Architecture de terre, cultures constructives et développement durable*

International Committee of Vernacular Architecture
ICOMOS-CIAV

International Scientific Committee on Earthen Architectural Heritage
ICOMOS-ISCEAH

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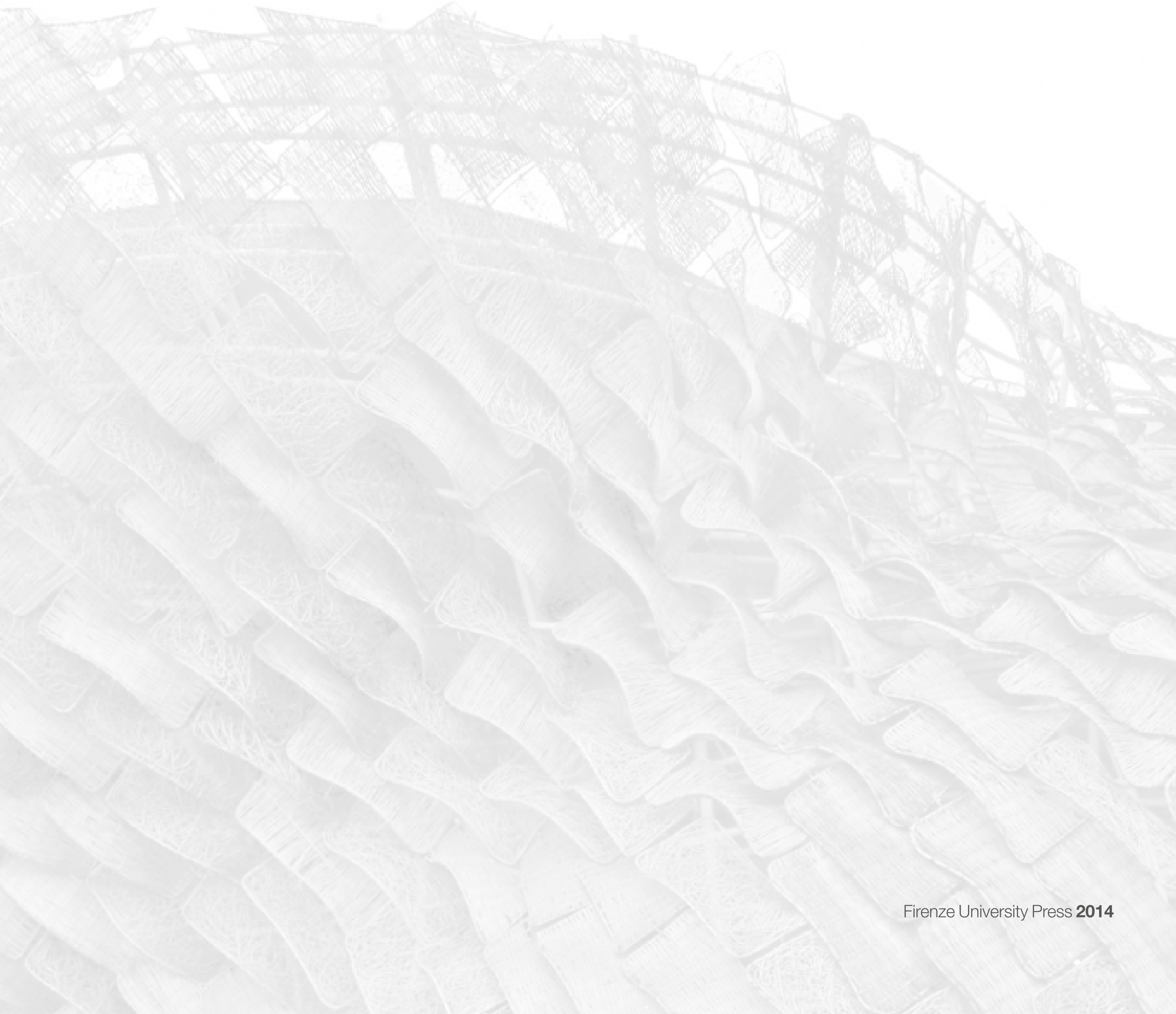

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Vernacular Knowledge for Sustainable Architecture

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Content

Corbelled Domes dwelling near Aleppo, Syria,
(photo: S. Mecca)

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Mosque in Mopti, Mali
(photo: M. Correia)

Ghardaia, Algeria (photo: L. Dipasquale)

Understanding our built vernacular heritage

Gisle Jakhelln
President of ICOMOS-CIAV

This publication is the last stage of VerSus project, an important international research endeavour. Its main objective is to gain knowledge from the fundamental principles of sustainability learned from the vernacular heritage, and to explore new ways to apply these principles in modern sustainable architecture. The project group, under the leadership of ESG/ Escola Superior Gallaecia, has done a remarkable job in accomplishing this project.
ESG/ Escola Superior Gallaecia has succeeded in bringing together qualified experts and interested students to discuss the themes of sustainable vernacular architecture. The presentation of these discussions through the given chapters is of great importance. The papers discuss vernacular architecture on economy, energy use, cultural and social aspects, while presenting some case studies as well. Bringing the social aspects[1] into the discussion points to intangible elements. I find this of utmost importance and I do not think that this had been sufficiently discussed earlier, especially in presenting and following up the built vernacular heritage for the people of today.
CIAV took part in the International Conference on Vernacular Heritage and Earthen Architecture *CIAV2013 | 7ºATP | VerSus,* in Vila Nova de Cerveira, Portugal, in October 2013. CIAV also supported this project since its candidature. CIAV is the International Scientific Committee on Vernacular Architecture and is part of the ICOMOS organization.

ICOMOS (International Committee on Monuments and Sites) is an NGO of professionals working on heritage and CIAV consists of members with established expertise in the field of Vernacular Architecture.

"The object of CIAV is to promote, consistent with the aims of ICOMOS International, co-operation in the identification, study, protection and conservation of Vernacular Architecture including vernacular monuments, groups of buildings and sites [...]".

(CIAV Statutes, Article 2)

CIAV is an international platform for the dialogue and cooperation between professionals, experts, academics and students of the built vernacular heritage. We work primarily through our annual meetings and scientific conferences. CIAV fosters discussions and activities on national and regional levels.
CIAV is pleased to support this project not the least because it has brought the students, as well as the established experts to deepen the understanding and the development of reflections on our built vernacular heritage.
I am also impressed, and congratulate the VerSus project, for having managed to present all the contributions to this book. This is of importance for future references and further studies.

[1] Correia, M., Duarte Carlos, G., Guillaud, H., Mecca, S., Achenza, M., Vegas López-Manzanares, F., Mileto, C. 2014. 'VerSus project: lessons from vernacular heritage for sustainable architecture'. In Mileto, Vegas, García, Cristini (eds). *Vernacular Architecture: Towards a Sustainable Future.* London: Taylor & Francis group, p.211-215.

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Chefchaouen, Morocco (photo: L. Lupi)

New vernacular architecture vs sustainable development?

Pierre Frey
Professor at EPFL
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The combined and reasoned elements for the VerSus research project are part of a robust and careful documented sample, concerning the best of ancestral knowledge which still reveals the vernacular built heritage of the studied regions. This is an important step and a crucial relay following the gigantic enterprise completed by Paul Oliver (Encyclopaedia of Vernacular Architecture of the World). The research teams involved in the VerSus project demonstrate that polytechnic universities, faculties and schools of architecture have become aware of the knowledge value condensed in what remains of cultures that have mostly disappeared.

This passage through academics is essential. It demonstrates the vitality and curiosity of these institutions; it reflects an admirable modesty since it basically postulates that the University itself, as well as Cartesian scientific research, do not hold the monopoly of knowledge. Finally, this academic research is essential because by considering the domain of empirical knowledge it not only recognizes it, but also opens the way to acknowledging its value and its systematization, which finally leads to the drafting of standards, laws and rules that are essential for these techniques to have a chance to be disseminated and implemented in the contemporary world.

The relevance and the radicalism of the VerSus approach can be read on two levels: on the one hand, the specific qualities of the proposed contemporary examples, and on the other the fact that the whole remains separated from the major infrastructure programs and urban issues. There is indeed cause for concern, when the question of whether the contemporary hyper-urbanization is inevitably dictated by natural laws or if on the contrary it is imposed by the pyramid of power that contemporary financial capitalism imposes upon the world.

The location of the projects selected by VerSus is somehow inevitable and raises a central problem, which is how humanity will distribute, or on the contrary, how a part of it will monopolize the world's resources. This is a fundamental point. Indeed, we believe that faced with the fact that vital resources are available in finite quantities, passengers from planet earth[1] will seal their fate and survival in the way in which they will figure out how to manage and distribute these resources. The answers given to these questions will determine the place of the new vernacular architecture. The lessons of this heritage are a wonderful encouragement; they will probably motivate the social choices of those who will be capable of understanding them.

[1] Buckminster Fuller, R. 2010, *Manuel d'instruction pour le vaisseau spatial «Terre»*, Lars Müller, Baden.

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Ménéham, fishermen's village, Brittany, France
(photo: H. Guillaud)

versus

The idea for VerSus project

Mariana Correia
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Escola Superior Gallaecia, Portugal

The idea for the VerSus project emerged from a discussion among ESG research team concerning the terms *Vernacular* and *Sustainability*, and the question of how they were connected.
The concept of sustainability, which arose during the eighties, evolved very rapidly from an ecological friendly approach to a series of rather high-tech and expensive responses. Nevertheless, vernacular heritage throughout the world was, and is, very much alive and can still play an active role in contemporary society and its architecture. So the main question is: *which are the lessons embedded in vernacular heritage that can contribute to sustainable architecture today?* For us, it was clear that we had to work with students to reach future generations. It was also fundamental that dedicated teachers, researchers and leaders of schools of architecture had to be a targeted audience, since the main aim was to transfer knowledge through an active experience.
Therefore, the choice of partners was strategic – CRAterre-Ecole d'Architecture de Grenoble with Hubert Guillaud and Thierry Joffroy, Università degli Studi di Cagliari with Maddalena Achenza, Università degli Studi di Firenze with Saverio Mecca and Letizia Dipasquale, Universitat Politècnica de València with Fernando Vegas and Camilla Mileto and the support of Culture Lab with Alexis Castro –, all have contributed to strengthening the challenge.
Due to the relevancy and significance of the research, VerSus project and this final publication were developed with the support of the European Commission and the Aegis of the Chaire UNESCO Earthen Architecture, Constructive Cultures and Sustainable development; ICOMOS-CIAV International Committee of Vernacular Architecture; and ICOMOS-ISCEAH, International Scientific Committee on Earthen Architectural Heritage.
The strong partnership shared a common vision to make a difference, to produce high quality outcomes and relevant results.The common research achievements of the past revealed that we could go beyond the usual projects, and face VerSus as a great challenge to produce further impact.
The project's main aim was to obtain knowledge from the study of the principles of sustainability identified in the vernacular built heritage, and to contribute to their cultural diffusion especially among students and academic audiences. However, the project went beyond the targeted public. We are now receiving feedback from universities in Brazil and Nepal, where 'lessons from vernacular heritage' are being undertaken in engineering, architecture and anthropology classes.
We are very proud of all that was achieved during these last two years. This was made possible only with the contribution of university students, authors, researchers, architects, professionals and the general public that responded to our challenge.
To all the contributors, thank you. All of this would not have been possible without the effort of all the people involved.

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Chefchaouen, Morocco (photo: L. Lupi).

Lessons learned and VerSus outcomes

Mariana Correia, Gilberto D. Carlos, Saverio Mecca, Letizia Dipasquale, Hubert Guillaud, Fernando Vegas, Camilla Mileto, Maddalena Achenza, Alexis Castro

Vernacular heritage represents a great resource that has significant potential to define principles for sustainable design and contemporary architecture. The fact is that vernacular architecture and its methods and strategies are undervalued and seldom applied in recent building trends in the West.

The main objective of the project was to gain knowledge from these fundamental lessons and principles of the vernacular heritage, and to explore new ways of integrating those principles into contemporary sustainable architecture.

Very important ecological and sustainable lessons can be learned which have an enormous potential to be applied nowadays. Vernacular architecture is composed of traditional buildings, which represent a morphological response to both environmental and climatic constraints, as well as to the socio-economic and cultural characters of societies. Additionally, the materials and architectural components used are climate responsive and tailored according to distinct locations, and have therefore adapted to seismic, geographic and topographical features, as well as to local climates. This type of architecture normally presents a good climate adaptation and provides good thermal comfort due to the choice of natural materials and bio-climatic features adapted to the environment. Besides, it is a cost effective architecture, both in economic and social terms, self-sufficient as regards natural and knowledge resources and with a low environmental impact, and therefore, with a sustainable input.Much has been published recently concerning both sustainability and sustainable architecture, but a real discussion is missing on the subject matter covered, as well as regarding vernacular architecture. Even during the most important scientific seminars and events on the subject of sustainability in architecture, the contents are usually reduced to specific cases that are commonly viewed by their authors as ecological and/or sustainable projects. These punctual technical inputs, which attend mainly the integration of passive systems or components in particular projects, are indeed pertinent, but remain very far removed from the overall conception of an interpretation of Sustainable Architecture, its strategies and methodologies.

On the first part of the project, the five partners undertook the literature review of more than a thousand articles. The revision of literature also encompassed the scientific revision and publication of the proceedings of two international conferences edited by the partners. Additionally, a deep systematisation of contents resulted in the VerSus booklet and on a clear definition of principles. In the present publication, a definition of the state of the art was established, as well as a critical and profound reflection on the principles and the strategies to recognise in the different contexts.

As a consequence, lessons learned from vernacular heritage were systematised through 15 principles that established a wide number of strategies to consider and to integrate in contemporary sustainable architecture. This was also possible through the establishment of operational definitions, in terms of vernacular architecture and sustainable architecture, but also by defining a research method and an operative approach within the VerSus project. Additionally, it was fundamental to address a literature review regarding vernacular architecture that could define the state of the art of environmental, socio-cultural and socio-economic sustainability, as well as resilience of vernacular heritage and the parameters of vernacular sustainability during the 20th Century.

Through this work the team was able to define strategies and solutions emerging from vernacular architecture which would contribute

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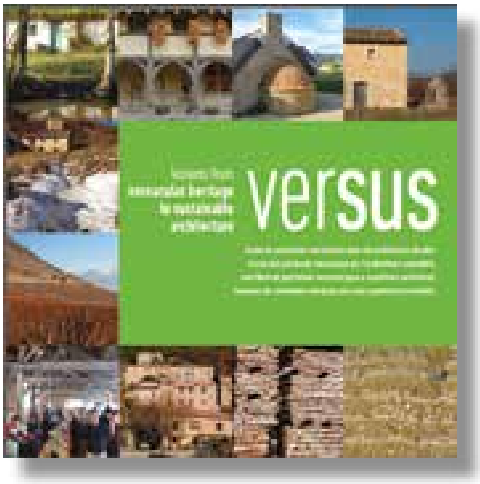


Cover of the VerSus booklet

towards sustainability. The approach undertaken in this final publication was designed to systematise strategies and solutions in urban, local, architectural, technical and constructive terms. Each area of study from the established strategies and solutions was represented by specific case studies from Europe and around the world, addressing vernacular environments and contemporary contexts.

Operative approach

The project advanced much further, following the implementation of a specific research and operative method, based on the state of the art literature review, developed by each partner research team and systematised by the project leader. The operative method was revised in each plenary meeting and its structure and operability improved through each scientific workshop. In each international scientific workshop it was possible, through direct observation of the implementation of the concept of the project, to improve its impact on the main target audiences.

Project outcomes

The main outcomes of the project included two International Conferences: CIAV2013 | 7°ATP | VerSus (the annual conference from ICOMOS-CIAV International Scientific Committee on Vernacular Architecture, the 7th National Portuguese conference on Earthen Architecture, and the 1st VerSus Project Conference) and VerSus2014 | 2° MEDITERRA | 2° ResTAPIA (the 2nd VerSus project Conference, the 2nd Mediterranean Earthen Architecture Conference, and the 2nd Earthen Conservation Conference).

The outcomes also comprised five scientific workshops; six practical workshops in natural materials; one Documentation Vernacular Architecture Camp VERNADOC 2013; a website; the promotion and development of an international competition and award; five plenary meetings of the partners; several field and survey missions; data collection, its analysis and the systematisation of findings; content elaboration and scientific work.

For a better dissemination of the results among different audiences, the project partners produced several communication tools. This was the case of a booklet in five languages with free download, addressing key-principles of sustainability in vernacular architecture; three international proceedings published by Taylor & Francis and indexed on the Web of Science [a) Vernacular Heritage and Earthen Architecture: Contributions for Sustainable Development (2014); b) Earthen Architecture: Past, Present and Future (2015); c) Vernacular Architecture: Towards a Sustainable Future (2015)]; and the present publication, a scientific and fundamental book, presenting the findings of the project.

Dissemination

Results were widely spread in European, Ibero-American and international networks. Worldwide, thousands of academics, university students and general public accessed results of the project and downloaded the VerSus booklet from the VerSus website, as well as from those of partner institutions.

The present publication is available on an open-access basis on the Internet, which favors an effective evaluation from the entire international scientific community. Besides, the possibility of accessing this publication in an unrestricted way will have a relevant impact on advancing knowledge among different audiences. Besides, the present publication will be distributed among the project's partners and authors, and further disseminated with the support of the ICOMOS Documentation Centre and the UNESCO Documentation Centre, as well as of faculties and schools of architecture throughout Europe.

Several presentations and publication of articles, regarding the VerSus project and its contribution were presented in International Conferences and Seminars, such as: Learning from the Past - Aarhus 2013, in Aarhus (Denmark); UNESCO Chair and UNITWIN European Conference 2013, in Istanbul (Turkey); Culture Mediterranee dell'Abitare 2014, in Naples (Italy); Festival ArchiTerre 2013 and 2014, in Algiers (Algeria); 14° SIACOT Seminario Iberoamericano de Arquitectura y Construcción con Tierra 2014, in San Salvador (El Salvador).

CIAV2013 | 7ºATP | VerSus conference
VerSus exposition and VerSus International Student Competition exposition
VerSus2014 | 2º MEDITERRA | 2º ResTAPIA conference

Support

In order to increase the project's outcomes and the dissemination of results, the institutional support of the following four international entities was fundamental: ICOMOS-CIAV (International Council on Monuments and Sites-International Scientific Committee of Vernacular Architecture); ICOMOS-ISCEAH (International Scientific Committee on Earthen Architectural Heritage); UNESCO Chair - Earthen Architecture, Constructive Cultures and Sustainable Development; and PROTERRA (Iberian-American Network on Earthen Architecture). This support was increased especially through networking, the dissemination of the conferences and their international impact.

Partnership

The VerSus project followed up the work, the contacts and the network previously established by the partnership team, in order to identify strategies and solutions that could be adapted and applied to sustainable architecture. All of the outcomes of the project were developed with a balanced management between partners, each entity assuming different activities and roles, according to their expertise and task responsibility in the project. This was possible due to the fact that the team members have a strong partnership, international vocation and have already demonstrated to be able to produce high quality outcomes and relevant results with an international impact.

The partnership of the VerSus project was built as a network of excellence, including leading institutions from the concerned fields, with complementary profiles and a traceable record of achievement. This expertise can be considered one of the pillars that guaranteed the project's quality, proper implementation and high level of results.

The impact of the project on a long-term basis

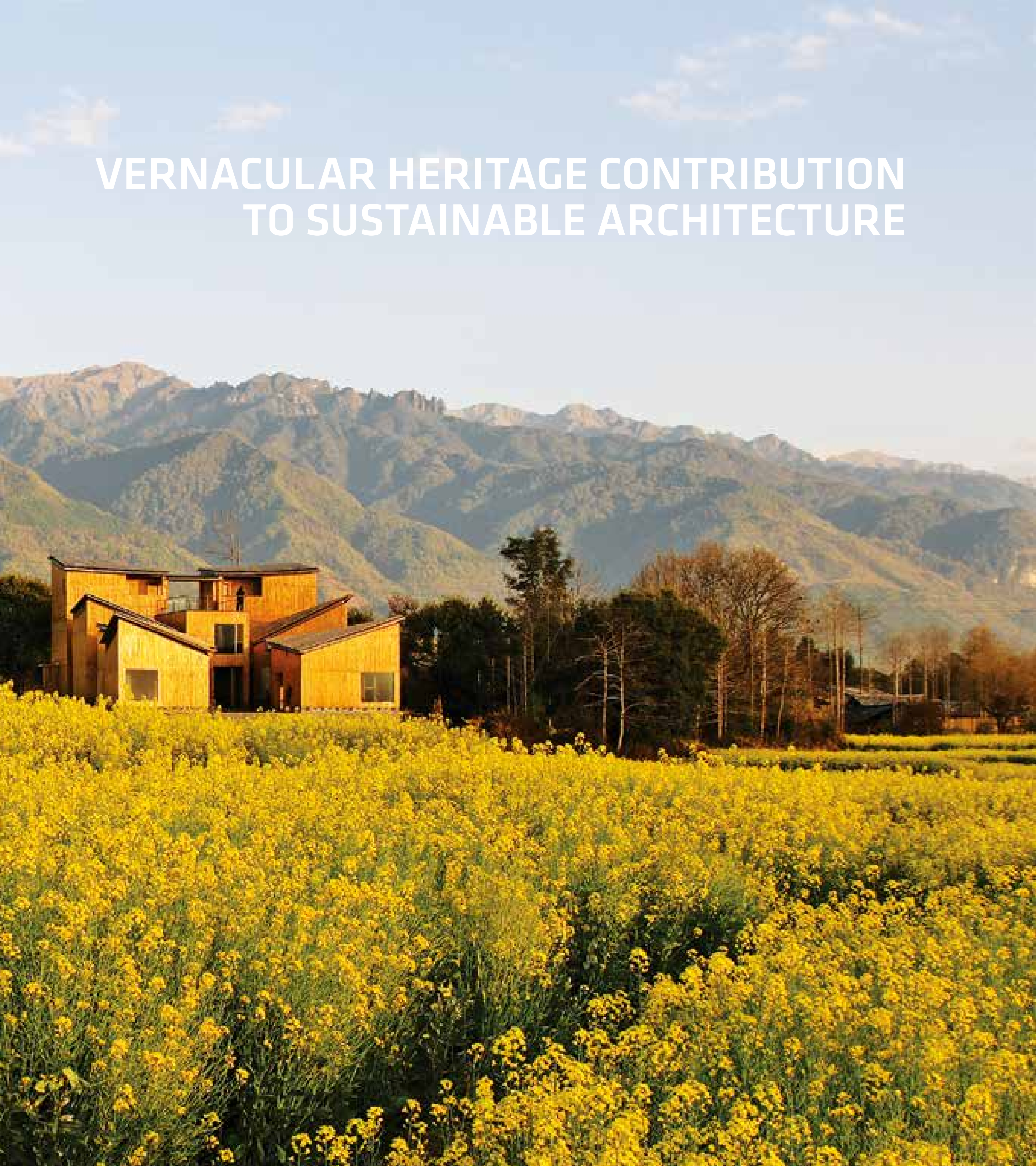
There is the strong conviction that the impact of the project will extend through a significant period of time. Understanding the theme potential, several Universities are using the publications that emerged from this project as pedagogic tools in the education of future architects and engineers. The methodology of the VerSus project is also being referenced in several articles and presentations, as an encouraging and relevant approach to follow.

Several Master of Arts students are exploring the VerSus method as an operative approach for future research, which is producing relevant outcomes from their study. Professionals, such as architects and engineers, are also beginning to apply VerSus principles as a reference in their professional work.

The global aim of the project was to achieve knowledge from the study of sustainability, as well as acknowledgement regarding its components and principles, which are identified in the vernacular built heritage, and to contribute to their recognition and cultural diffusion. These were the main aims that were both established and fully accomplished, as well as disseminated during the project.

Yunnan's Museum of Handcraft Paper in Xinzhuang, China
(photo: S. He. Courtesy of the international prize for sustainable architecture Fassa Bartolo)

VERNACULAR HERITAGE CONTRIBUTION TO SUSTAINABLE ARCHITECTURE



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ORTO DEI MELOGRANI
ALBERATA

Analisys following the VerSus approach elaborated during the Scientific Workshop in Cagliari, Italy, April 2013 (photo: M. Correia).

Research method and operative approach

Gilberto D. Carlos, Mariana Correia, Letizia Dipasquale, Hubert Guillaud, Saverio Mecca, Camilla Mileto, Fernando Vegas, Maddalena Achenza, David Viana, Leonardo Cannas

The conceptual outline of Project VerSus

The developed Research method and its consequent Operative approach aim to contribute to the awareness of the value of vernacular heritage, especially when it is considered for contemporary sustainable architecture. Going beyond conventional quantitative parameters, VerSus enhances solutions that concern transversal sustainable purposes.

As vernacular heritage addresses distinctive contexts, it was decided to establish a conceptual framework in order to survey, compare and interpret the collected data. The conceptual process should not be understood as a rigid format classification, but rather as an open approach, to be extended and further detailed, if needed, according to the nature of the input, or the perspective of the author. The principle aim is to give a more heterogenic knowledge with a wider possible impact and application. This simple, but rather ambitious premise, defines the development of a conceptual outline that should constitute the main guideline for data collection, and perhaps a preliminary orientation to identify contributions, within a structured and reliable system of analysis.

After several endeavours, the project adopted a four level conceptual structure, with one variable responding to the specific geographical location. Vernacular case studies could be integrated into this conceptual outline, which is based on: *Sustainable scope, Principles, Strategy; Specific needs determined by the geographic context;* and *Vernacular solution/ Contemporary adaptation*.

The conceptual structure constitutes the inventory layout of the project's database. It was designed, not only as methodological tool, but also as a communication device. It allows a reverse interpretation, working from the basics, to a selection of representative vernacular examples; or the other way around, guiding the reader from any specific vernacular solution to the factors that originated and influenced them. The apparently simple diagram provides a common ground for interconnection of different scientific areas (fig. 1).

The progressive development of the VerSus operative approach

VerSus project intends to outreach society, not only through the dissemination of the accomplished indicators, but also by showing the sustainable qualities of the identified examples, through the establishment of an operative approach that can be adjusted to different contexts. The selected approach was initially created, as an intrinsic component to develop VerSus research, stimulated by the definition of a specific systematic process, with scientific interest.

One of the fundamental objectives of the 'VerSus operative approach' is to constitute an instrument to assess the sustainability of built interventions. Despite its relation with the Vernacular heritage - a relation based on its essence and not on an application dependence - the intention was to present an outcome that could provide autonomous and diverse implementation possibilities.

Its premise was to propose a strategic guideline to provide an evaluation for existing interventions, but also to better plan future interventions for sustainable built environments. Another important intention was to provide a guideline that could be easy to interpret and simple to apply, without compromising the technical-scientific features of the related subjects. The operative approach never drifted from the ethical goals of the Project that consisted on creating a reliable technical tool with a high dissemination potential. Therefore, the present result seeks to achieve a balance between the 'fundamental level of technical characterisation' and its 'effective communication opportunities'. This required a significant effort of synthesis, in order to accommodate the input emerging from more than 1.000 documentary revised references from technical books, scientific articles, conference proceedings, expert interviews, building legislation and assessment programmes.

The lack of articulation of different scientific areas on the subject, and the evolution of the 'sustainable' concept itself (Correia 2009, p.70), constituted the critical limitation in the groundwork of the operative methodological proposal. The recent superficial and careless use of the term 'sustainability' in the architectural and urban spheres shows the lack of scientific accuracy concerning the theme. This largely contributes to the discredit of the concept, and most of all, to the unawareness of its potential and outreach, especially when considered as an architectural requirement.

Besides, the review of the literature allowed inducing that close to 70% were descriptive inventories linked to a national vernacular architecture literature. Their sustainable features related mostly to cultural values and ethnographic aspects. Only in a most recent trend of publications, mainly after the year 2000 which saw an in-

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crease in articles from the proceedings of conferences, was there a significant corpus of literature addressing the relation between the Vernacular Heritage and its sustainable potential. It was clear that after this period, relevant knowledge based on bioclimatic/ passive solutions was established, capturing the attention of the Vernacular Architecture specialists (Correia et al., 2014).

The operative approach draft was set after a careful revision of the literature regarding the collected theme bibliography of the most important references within the area. The selection of a multi-criteria perspective emerged following the crossing reference of vernacular heritage bibliography that mainly consider isolated sustainable features, and the documentation related to the impact evaluation of contemporary architectural projects. During the literature review process, studies were identified (Sánchez-Montañés Macías, 2007; Neila Gonzalez, 2004) relating vernacular features to geographical contexts, but also focusing the strategy behind the interpreted vernacular solution, which reinforced the research method perspective entailed by the project.

The revision of literature also addressed the specific evolution of concepts regarding building sustainability. The recent developments on the meaning of 'building culture' and its socio-cultural implications upon the living conditions of the local communities were integrated as part of the conceptual concerns.

After the conclusion of the project's conceptual and methodological framework, it was clear that the first difficulty was to develop an approach that could establish a comparable parameter between quantitative and qualitative features. Another important aim was to study the possibility to extend the analysis to different scale interventions, from the territorial dynamics to the material detail, allowing the integration of landscape, urban design, architectonic typologies or isolate architectural components within the analytic system.

It was also necessary to consider the importance of combining the distinctive implications of all the built intervention phases, from the territorial interpretation to the building process, the construction performance, the management and the maintenance. To test the efficiency and operability of the VerSus approach, several scientific workshops were undertaken during the partner's plenary meetings. These were specially adjusted to MA and PhD students, who were developing their dissertations and theses on the same field. The workshops were programmed within a progressive hierarchy, following the Project's main activities and their distinctive objectives. The debate generated between the researchers' established concepts and the targeted audience enabled the possibility of a direct observation of the application of the approach, allowing an awareness of its main constrictions and potentials.

Four main workshops, coordinated by the Project VerSus researchers, were developed in Italy, Portugal and France, focusing on the communication expression of the methodological approach, the quality of the student's work and the level of satisfaction of the participants. Although the aims, the given contents and the expected results were the same, the tested procedures were significantly different, in order also to evaluate the implication of the workshop format within the expectations.

The first scientific workshop was organised along with the project's start up meeting, in the Escola Superior Gallaecia, in Vila Nova de Cerveira, Portugal. The workshop was divided into a presentation session and a wide audience debate. All the research coordinators were challenged to expose their own field experiences, presenting clear cases of vernacular examples, where the sustainable features could be explicitly depicted. Naturally, the material was diverse and the contents were not systematised between them, producing isolated points of interest, according to the personal affinities of each participant. The 200 people that attended the event - professors, researchers, students and municipality technicians – were motivated to reflect upon the possibility of transferring this kind of knowledge to actual design studio processes. This was possible, once its main implications and eventual difficulties were considered. In addition to the dissemination of the project, the workshop was mainly driven to identify different strategies of outreach, according to the distinctive perspectives. Considering the intensity of the debate, and the increasing discussion on the actual overvalue of the aesthetic components in architecture, the pedagogical potential of such an interactive method of sharing contents gained significant importance, which in turn confirmed the pertinence of the VerSus educational objectives.

The second scientific workshop was organised at the Università degli Studi di Cagliari, in Sardinia, Italy. The workshop had the intention to clarify the scopes of the sustainable features and to classi-

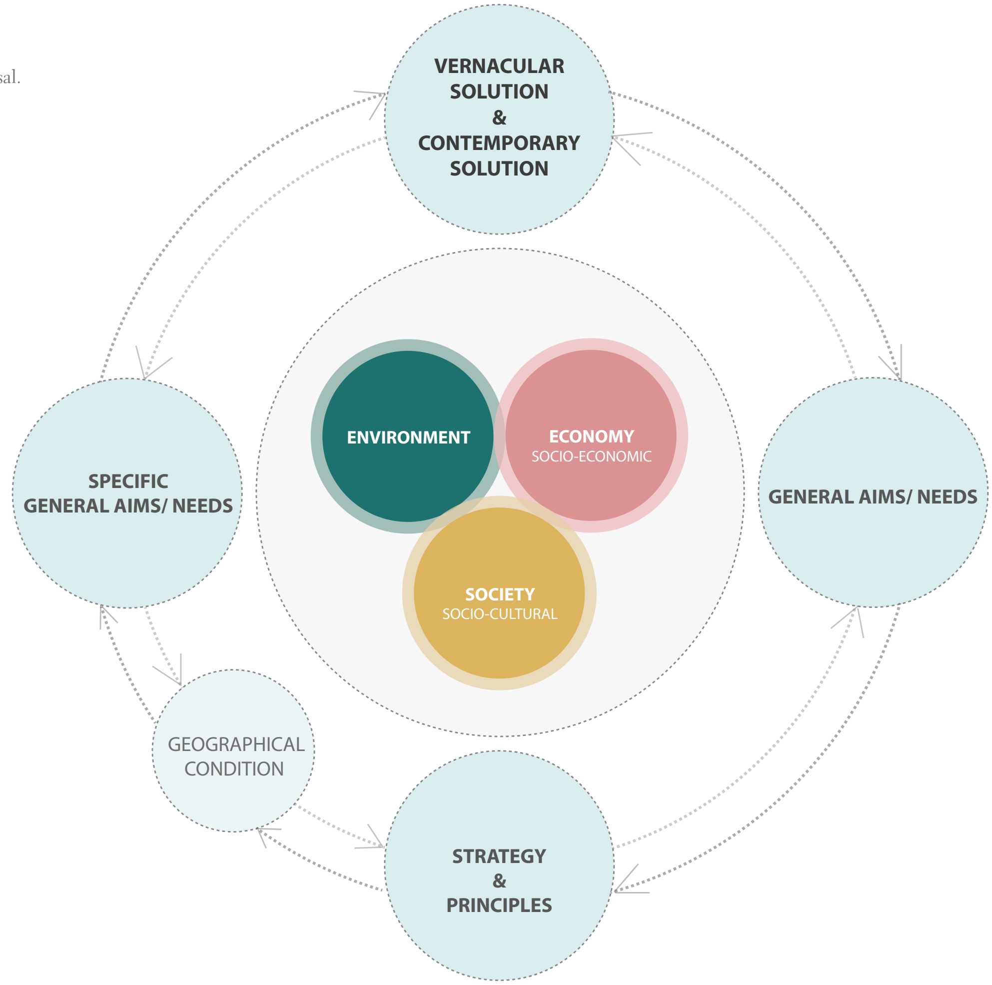


Fig 1 VerSus Project Research Methods Proposal.

fy them into different theme groups that could be isolated to address specific analyses. To allow a reliable monitoring of activities, the post-graduate students were distributed into groups, monitored by the VerSus researchers. A pre-established schematic layout was applied and students chose vernacular examples to relate to this first draft of the operative method. The proposed layout established more than 100 isolated strategies grouped in 8 distinctive sustainable areas, that concerned all the acknowledged scopes of the literature reviewed. Although ambitious for a two day working session, the main objective of the workshop was to understand the limits of the response capacity of the participants, to observe the average level of technical deepness in their analysis and to identify the spontaneous tendencies to value, or ignore, certain specific features or areas. The extension and the flexibility of the layout approach, although promoting the diversity of the results, required an intensive and permanent orientation by the coordinators, therefore overlapping with the autonomy of the analytic development of the participants. The interpretation of the structure had definitely to be more intuitive. In order to achieve this, the project's coordinators rapidly engaged on a process of conceptual synthesis and graphical expression improvement. The thematic redundancies were eliminated and all features were related throughout the most elemental sustainable classification. The hierarchic relation between principle and strategy was reinforced by the transversal nature of the identified solutions. It was also relevant to avoid unclear and vague generalisations without any perceptible advantage of application. Therefore, it was established that all the defined sustainable scopes had to present an interpretation of the results through the study of an architectural indicator. In order to obtain an intuitive and flexible data management, and to avoid conflicts with the terminology, the contents were classified into three preliminary sustainable scopes that could be reasoned into any built intervention type:

Fig. 2-3 Scientific Workshop in Cagliari, Italy, April 2013 (photos: M. Correia).

Fig. 4 Scientific Workshop in Vila Nova de Cerveira, Portugal, October 2013 (photo: G. D. Carlos).

Environmental: This scope addresses the human capacity of intervention, in order to decrease and even avoid negative impacts on the environment. It also implies the ability to compensate the consequences of any artificial action, and the recognition of the overall necessity to nurture the territorial regeneration (Neila, 2004).

Socio-cultural: This scope should be considered as a milestone of relations, sense of belonging, identity, personal and communitarian development. It tries to gather all the Social and Cultural positive impacts observable on the vernacular solutions (Oliver, 2006). The related features are usually more linked to the processes than to the physic reality itself.

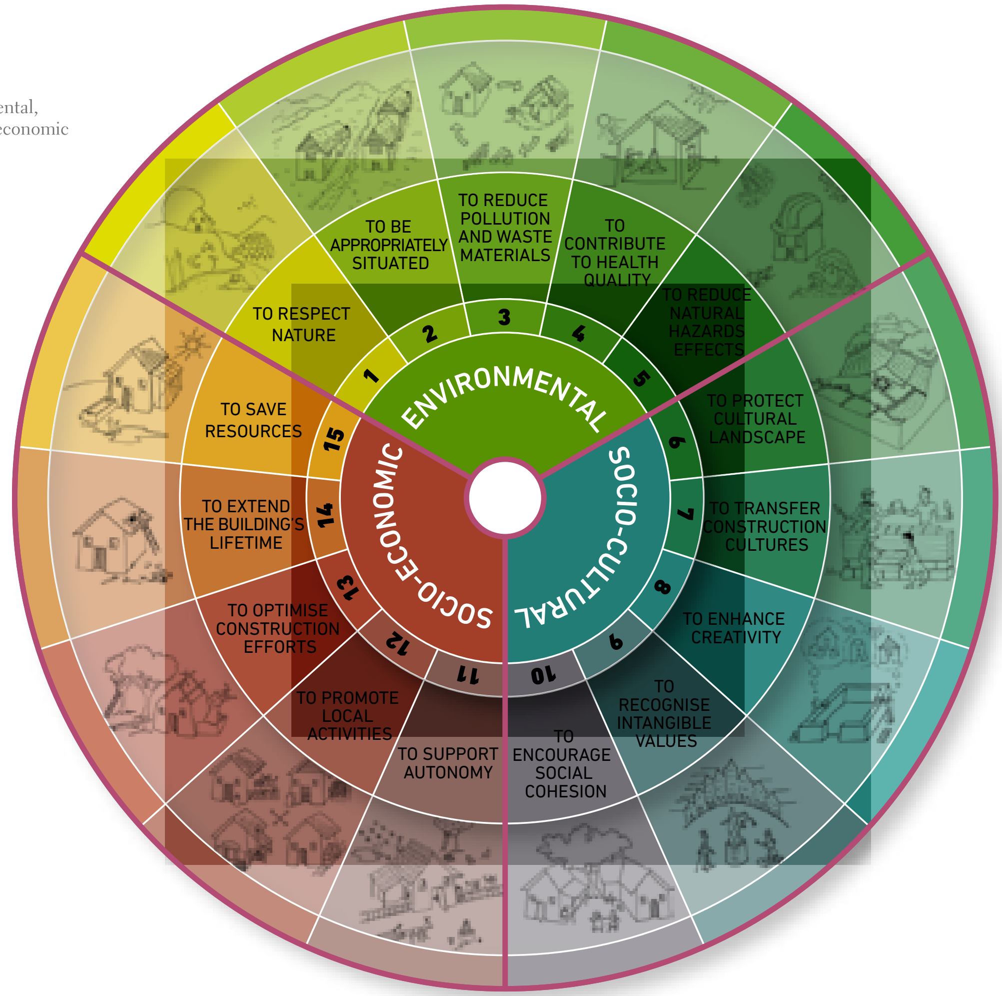
Socio-economy: This scope constitutes the most quantitative scope of the sustainable sphere, conventionally adopting financial and monetary values as basic indicators. Due to the vernacular conceptual implications, the idea of cost is related to the concept of effort, which can be more adequate, when applied to circumstances, where no capital-intensive system exist (Zupančič, 2009).

The third workshop took place once again at Vila Nova de Cerveira, Portugal, during the CIAV2013 Conference, in October 2013. In the framework of the event, organised within the VerSus project, the scientific workshop was zdirected to post-graduate students from the module of *Heritage-Design Studio*, from the MA in Architecture and Urban Design, at the Escola Superior Gallaecia. Several international students also expressed their interest to participate in the session and took part in the scientific workshop.

In a more restrictive format the participants were challenged to apply a grid of approximately 70 strategies, structured under 16 objective/needs, and distributed within the three sustainable scopes. The workshop was divided in two parts: one session, to analyse a vernacular example; and another session to interpret a contemporary project. While the first session produced a set of consistent results, the second session had a very heterogenic outcome. This was mainly due to the diverse information available regarding the contemporary examples that we analysed by the teams. When there was a profound knowledge of the selected contemporary intervention, the results were very interesting and they fulfilled entirely the requirements of the operative approach.

In this workshop the participants were also required to measure the intensity of the sustainable features of every developed case. The

Fig 5 Wheel of environmental, socio-cultural and socio-economic sustainable principles.



aim was to consider a possible rating system, through which it would be possible to observe the balance between sustainable scopes. Although there was an initial theoretical resistance, it was extremely interesting to observe the satisfaction of the participants with the achieved outcome. This entailed a need for a quantitative interpretation of the analysed features, but also of the visual impact they could produce.

The fourth and final workshop, which took place at CRAterre - École Nationale Supérieure d'Architecture de Grenoble, France, in April 2014, embraced a class format for MA students already engaged in similar practical exercises. The coordinators of the workshop benefit from the graphical tools produced within the booklet (fig. 5) to communicate the procedures and the potential results. Combining CRAterre's experience with similar pedagogical tools and the improvements arising from the past workshops, the scientific workshop had very interesting outcomes. The exercise consisted on the direct application and interpretation as a rating tool, of different pre-established case studies, enhancing their most significant features within the sustainable scopes. In this particular case, the examples were previously tested, and a set of materials, organised by the sustainable feature topic, was provided for consultation during the activities. Once more, the operative approach endured a process of synthesis. The objective was to produce a user-friendlier instrument that would allow a more practical interpretation, aiming at a broader audience. Based on the GNSH background (*Sustainable Housing Rating Tool* by CRAterre) within the same area, the operative approach was restrained to a two level circle structured upon the direct relation between principles and strategies. In this last phase, the representative solutions were of the exclusive responsibility of the user. The outline also adopted a more graphical equilibrium, which supposed a terminological update of the subject, allowing a more direct interpretation of the contents.

In the scientific workshop in Grenoble, almost 50 students were engaged in different work teams (fig. 6). These students were expected

pp. 29, 30, 31
Final definition of the 15 principles of environmental, socio-cultural and socio-economic sustainaibility embedded in vernacular architecture.

Fig. 6 Scientific Workshop in Grenoble, France, May 2013 (photo: M. Correia).

to analyse a contemporary project, after the project's researchers exemplified the procedure with a vernacular example. The final phase of the session consisted in a general presentation, where every team had to explain to all participants how their examples embraced all the operative approach strategies originally presented. The overall understanding led to less questions during the application of the operative approach, and a faster resolution of the outcomes. The quality of the consequent analysis and the exceptional level of the student's satisfaction confirmed the evolution process of the operative approach. The interaction of such methods contributed significantly to the quality of the project outcomes, proving that it is possible to overcome the generic prejudice of engaging Research and Development activities within the external community, and to obtain explicit benefits for every evolved part. The VerSus operative approach is currently being applied in MA dissertations and PhD theses, as a recognized methodological tool. Its application is also part of Curricular Units assessment exercises within the teaching programs of partner Universities. It is also important to state that one of the most gratifying indicators of the VerSus contribution, considering the short period of its dissemination, is to observe how external experts advocate it at international conferences.

There is certainly a strong conviction that the impact of the VerSus project will increase significantly over time. Outcomes can already be seen, which proves that the original aim of the VerSus Research Project, which is to have an impact on students and their architectural education, has already started. VerSus will certainly have a long-term impact, subject to constant institutional support, and encouraged by future socio-economical challenges.

ENVIRONMENTAL SUSTAINABILITY

addresses the human capacity of intervention in order to decrease and even avoid negative impacts on the environment.

PRINCIPLES

1	2	3	4	5
to **respect environmental context and landscape**	to **benefit of natural and climatic resources**	to **reduce pollution and waste materials**	to **contribute to human health and welfare**	to **reduce natural hazards effects**

STRATEGIES

1	2	3	4	5
• Assuring an approppriate choice of site • Minimising the impact of interventions • Ensuring conditions for site's regeneration • Integrating with the environmental morphology • Understanding the features of the site	• Choosing appropriate building orientation • Considering the hydrography of the place and managing the water resources • Location buildings to take advantage of the natural landform • Incorporating solar energy into the overall design • Taking advantage of soil thermal inertia	• Consuming local available materials • Using recyclable and recycled materials • Reducing loss of thermal energy • Using available energy resources • Planning maintanence and extending the durability of the buildings	• Enhancing indoor temperature and humidity levels within acceptable values • Ensuring adequate natural ventilation • Guaranteeing adequate natural lighting and sun radiation • Improving natural and passive heating • Avoiding toxic materials	• Providing practical guidance to anticipate and mitigate risks • Developing strong and flexible construction systems • Considering the specific characteristics of local risks • Integrating technical and behavioural measures for reducing vulnerability • Incorporating strategies for post-disaster recovery

SOCIO-CULTURAL SUSTAINABILITY

is like a milestone of relations, sense of belonging, identity, personal and communitarian development.

PRINCIPLES

6	7	8	9	10
to **protect the cultural landscape**	to **transfer construction cultures**	to **enhance innovative and creative solutions**	to **recognise intangible values**	to **encourage social cohesion**

STRATEGIES

6	7	8	9	10
• Understanding the value of the place and its dynamics • Enhancing techniques of land use that guarantee and sustain biological diversity • Articulating spatial organization with productive needs • Optimising soil features and micro-climates through sustainable crop planting and land management • Regulating productive activities by environmental features, as well as by seasonal and economic cycles	• Allowing practical constructive experiences to facilitate empirical know-how • Recognising the value of mastery and constructive memory • Involving younger generations in constructive processes • Acknowledging the value of roles in traditional activities and knowledge • Facilitating the participation of local communities in decision-making processes	• Developing collective intelligence • Encouraging diversity in building system solutions • Integrating influences from other building cultures • Allowing in experimentation in building techniques and processes • Evolving building techniques from experience, through processes of trial and error	• Transmitting cultural values and history • Incorporating social rituals • Building community character and sense of place • Recognising local symbolical expressions • Enhancing of building and productive processes as cultural values	• Promoting inter-generational relations • Ascribing value to the development of collective welfare • Enhancing community engagement and participation • Encouraging places for community meetings • Building common infrastructures and market places

SOCIO-ECONOMIC SUSTAINABILITY

"Due to the vernacular conceptual implications, the idea of cost is related to the concept of effort, which can be more adequate, when applied to circumstances, where no capital-intensive system exist"(Zupančič, 2009).

PRINCIPLES

11	12	13	14	15
to **support autonomy**	to **promote local activities**	to **optimise construction efforts**	to **extend building's lifetime**	to **save resources**

STRATEGIES

11	12	13	14	15
• Sharing resources • Using local and accessible materials and resources • Promoting indigenous workmanship • Encouraging local production • Enhancing community empowerment	• Reinforcing urban farming and local production of food • Enhancing short circuits and local trades • Promoting collective use of spaces • Including spaces for productive activities at urban and architectural scale • Developing handicraft products made with local materials	• Optimising the use of materials • Assuring appropriate scale of the building • Enhancing technical simplicity in building processes • Reducing transportation efforts • Encouraging the use of low-transformed materials	• Predicting regular substitution of building components • Preventing erosion of building elements • Planning maintenance of the building • Designing flexible buildings for possible changes and extensions • Building strong and durable structures	• Using recyclable materials • Promoting building densification and compactness • Assuring supply of renewable energy • Developing construction systems adequate to local conditions • Enhancing natural ventilation, heating and lighting systems

Peillon, Provence Côte d'Azur, Alpes - Maritimes, France (photo: S. Moriset).

Defining vernacular architecture

Hubert Guillaud
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According to the etymological approach and to the Historical Dictionary of the French Language (Robert, 1985), the notion of vernacular architecture refers to the house of verna, which in Latin means 'slave born in the house', while vernaculus means 'indigenous', or 'domestic'. This definition is derived from Roman law, codified in the fourth century by Emperor Theodosius the Great (347-395). Quoting Ivan Illich (2005), Pierre Frey (2010, p. 13) reminds us that the 'vernacular kind' means "Everything that was crafted, woven or reared at home and not for sale, but for domestic use. Therefore, what is 'vernacular' has no market value. By extension, this definition includes the architecture of a territory and/or a human group, or of an ethnic group, who lives there. Vernacular architecture commonly uses local materials (AA.VV., 1993, p. 4).

This is a 'contextualised' architecture which belongs to a particular 'country' or to a regional/geographical area, and which was built for a given time. This architecture emerging from the 'genius loci' is the sense of the 'being of the place' and of the 'being to the place' as noted by Christian Norberg-Schulz (1981).

The term 'vernacular architecture' in use (last half of the twentieth century) is derived from the English and arises as a reference to the work of prominent figures such as Bernard Rudofsky (1964), Eric Mercer (1975)[1] and Paul Oliver (1997). It most commonly refers to 'traditional' or 'popular' architecture, as opposed to 'scholarly' architecture. From a theoretical point of view, Paul Oliver (Ibid.) refers to Rudofsky in his definition of vernacular architecture and retains the notion of popular architecture, architecture without architects, or even 'people's' architecture (Oliver, 2003), expression of an "indigenous science of construction"(Oliver, 2006). This contrasts with 'learned' architecture that is produced by "trustees of the Art of Building", individuals, trades or institutions that break away from the contingencies of place as mentioned by Jean-Paul Loubes (2000, p. 40-41). One seminal definition given by Eric Mercer in the introduction to his study of English vernacular houses (Ibid.) focuses on the concept of shared type with regard to the number of buildings, on a geographical area and for a given time. Lastly, in this brief definition, we cannot ignore the importance of the anthropological and cultural parameters to which Amos Rapoport (1969) gave so much importance in his definition of vernacular architecture.

[1] Mercer, E. 1975, *English Vernacular Houses. A Study of Traditional Farmhouses and Cottages*, Royal Commission on Historical Monuments, Her Majesty's Stationery Office, London. "*Vernacular buildings are those which belong to a type that is common in a given area at a given time. It follows that a kind of building may at any one time be 'vernacular' in one area, and 'non-vernacular' in another and in any one area may change in the course of time from 'non-vernacular' to 'vernacular'. In other words, no building is or is not vernacular for its own qualities but is so by virtue of those which it shares with many others, and the identification of vernacular buildings is very much a matter of relative numbers*"(Introduction).

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Yunnan's Museum of Handcraft Paper by Hua Li and TAO, Xinzhuang, China (photo: Shu He*).

Defining sustainable architecture

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The term 'sustainable' has come so much to the fore in recent decades in the field of architecture that it has become indispensable, a label that seems to guarantee the excellence of the projects that refer to it. On many occasions, contemporary architecture is thought to be heading towards sustainability, meaning that the new paradigm is believed to have defined a new course for an architecture that has lost its way, marked by the stigma of artificiality as opposed to naturalness. However, the history of architecture tells us that architecture has been sustainable from birth and that since its very origin it has satisfied many of the needs that today are no longer met, due to other priorities of the global world, as a result of which we resort to technology in an attempt to provide a counterbalance. The fact is that architecture implies a transforming process and, as such, affects to a greater or lesser degree the natural milieu in which it is inserted. The architect may be aware of this process of metamorphosis and cultivate a sensibility that will minimise the effects of a widespread maxim that stigmatises the profession today, according to which construction is the main enemy of the environment. Vindication of sustainability in architecture attempts to equilibrate this dialogue between the natural and the artificial and define architecture as "a fragment of built responsibility"(Disch, 2008) (fig. 1-4).

Variations and related terms

In the wide range of possibilities between natural architectures and the architecture of an industry that devours nature, we can find endless nuances referring to sustainability, that include meanings or variations related with the term: 'kilometre zero', 'low-tech, bioclimatic', 'passive ecological', 'eco-tech', 'bio architecture', 'bio construction', 'permaculture', etc. It is worthwhile to clarify the terms used today to identify certain architectures that are considered to be responsible in their relationship with the environment.

The 'kilometre zero' concept originated in the world of gastronomy and has been adapted to architecture. The demand for a healthy increase in production and consumption times (*slow food*) as opposed to the hegemony of 'fast food' leads to the promotion of 'local products'. Just like in gastronomy, 'kilometre zero architecture' vouches for local materials, techniques and industries. Similarly, 'kilometre zero restoration' endorses the repair, consolidation or reinforcement of a building with local materials, techniques and crafts. This avoids transport and commuting, which favours local economies and reduces the ecological impact of the work by decreasing transport energy and favouring the adaptation of the material to its location. Related to this concept are 'slow cities', cities with fewer than 50, 000 inhabitants, which apply environment-friendly policies, encourage autochthonous production and seek a compromise between modernity and tradition that improves the quality of life of its citizens.

'Low-tech' or low technology architecture promotes certain production and transformation processes, minimising mechanical aspects and leaning towards craftsmanship, in the belief that these processes reduce the impact of mass production. The concept of 'low-tech' also addresses the sociology of construction and defends organising systems that call for individual craftsmen or artisan cooperation. The idea has a direct repercussion on the economic aspects of the production process, for, although it tends to make production more expensive, the money goes directly to local producers.

'Bioclimatic architecture' is connected exclusively with energy issues and favours the use of available climatic resources such as the sun, rain, or wind. It focuses on the optimisation of energy in architecture while safeguarding the comfort of its spaces. To this end the decisions of the project are made taking into consideration the insertion on the site, sunlight, ventilation, typological issues, the choice of materials or resorting to auxiliary technologies that save energy. Putting this concept into practice, the concept of 'passive architecture', which was based on Edward Mazria's *Passive Solar Energy Book* became popular in schools of architecture in the early eighties. With an energy component, 'passive architecture' addressed the collection, storage and distribution of solar energy without any external supply or according to simple techniques and infrastructures that permitted an architecture with an independent energy supply[1].

The concept of 'bio architecture' or the closely related one of 'bio construction' see architecture as a biological unit that interacts with the environment, but not only with the natural environment but also with the social, cultural, economic, and other milieus, which means that the architecture is designed to satisfy the occupier's demands. In this way, the prefix 'bio' involves taking into account new parameters that affect the architecture's dweller.

*Courtesy of the international prize for sustainable architecture Fassa Bartolo

[1] *Arquitectura Bajo Consumo* (1) y (2). No 2/2007 3/2007. Información del Consejo Superior de los Colegios de Arquitectos de España CSCAE.

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Fig. 1 Environmental sustainability. Mapungubwe Interpretation Centre designed by Peter Rich Architects in 2009. Limpopo, South Africa (photo: P. Rich).
Fig. 2 Experimental house with a strawbale dome in Hrubý Šúr, Senec, Slovakia (photo: Bjorn Kierulf, courtesy of Zuzana Kierulfonva)

The concept of 'ecological' is a term linked to the science of the same name and is used to arouse sensibility towards the protection of the environment. From a purely ecological standpoint, priority lies with the *oikos*, the etymological origin of the prefix 'eco', which refers to the home. In other words, the preservation of the biological home and of all species has priority over any individual or component of any species. Since the ecological stance is formulated by human reasoning, the result is a specific interpretation of environmentalism that aims to achieve a balance between showing respect for the environment and satisfying human needs[2]. Related to this term are the concepts of 'green architecture', 'green building' or 'green design', which strive to minimise any possible adverse effects of architecture on human health and the environment by choosing suitable materials and techniques. 'Ecologic architecture' and/or 'green architecture' would belong in a broader category: *permaculture*, which embraces the same philosophy of self-sufficient life, architecture and agriculture in harmony with the natural ecosystem.

Other concepts related with sustainability to take into account in this context are the 'ecological footprint', which is an environmental measure of the impact of a human community on its surroundings, the LCA or *Life Cycle Assessment* of a material, which allows us to estimate the environmental impact produced throughout all the stages of the product's lifespan (extraction of the raw material, processing, transport, conversion into waste matter), and the *deconstruction* or group of coordinated operations to manage waste in order to minimise the volume that ends up in a landfill[3].

Misinterpretations of sustainability

The application of the principles of sustainability affecting vernacular construction in contemporary architecture requires some investigation into the context, form, constructive materials and techniques, and their value as tradition, along with its potential for design. Nevertheless, in this pursuit of sustainable contemporary architecture, we find frequent distortions in design and construction that are worth mentioning.

1. *Sustainability and design*

In the first place, we must point out that architecture built with traditional materials and techniques does not imply a lack of attention, conscientiousness or quality in the architectonic design or an a *priori* choice of a certain type of architecture. Understood from a material viewpoint, sustainability does not necessarily involve a non-critical reproduction of the formal models of historic architecture in the post-modern sense of the word, nor does it involve opting for very *naïve* organic architecture.

Without renouncing the abstraction proper to its condition, sustainable contemporary architecture, in its process of reinterpreting the context with the prevalent use of locally produced materials and techniques, may decide to either use the forms of local vernacular architecture constructed by trial and error methods over the centuries or to have recourse to an organic language or to a project based on Cartesian geometry. It is true, for example, that sustainable bio-architecture often resorts to bio-morphism as the apparently most coherent choice of project, as though rebelling against widespread systems of squandering money also implied a rebellion against the most common parallelepiped shapes. But the adjective 'sustainable' in architecture need not involve a predetermined formal option or carelessness in its elaborate design. Therefore there is no such thing as a predetermined eco-aesthetic of architecture[4].

2. *Globalised sustainability*

On the other hand, trends and growing sensibility regarding the subject have generated a sort of unsystematic globalisation of sustainable constructive solutions which are indiscriminately applied in a myriad of contexts, without taking into account specific local conditions and materials. In this way, one runs the risk of ignoring the lessons of sustainability of the local vernacular architecture in question to acritically apply solutions which are indeed sustainable but stem from a principle based on other vernacular architectures from faraway lands, in other environments and with other basic conditions.

Logs or wooden planks, for example, are probably a sustainable material near the place where they are produced, in forested regions or countries, as is demonstrated by the vernacular architecture of

[2] There are also variants of the former two. See: AA.VV. 1992, *Architettura bioecologica. Atti del primo convegno nazionale sul costruire bioecologico, Pradamano:* Associazione Nazionale per l'Architettura Bioecologica.

[3] *Guia d´aplicació del Decret 201/1994, regulador dels enderrocs i altres residus de la construcció. Capítulo 3.3, pág. 27. Barcelona, ITEC i Junta de Residus, 1995.*

[4] 2005, *Guía Básica de la Sostenibilidad,* Editorial Gustavo Gili, Barcelona.

these places, and therefore the most logical thing is to use it in its contemporary architecture, but it is probably not sustainable in dry regions or areas, where vernacular architecture uses other options better suited to their natural environment.

3. *Decorative sustainability*

In some cases, contemporary architecture uses the materials of traditional vernacular architecture to make the building look sustainable, as a decorative device. We find examples of concrete walls lined with real or false adobe or stone, or else roofs made of metal plaques covered with a layer of vegetation not to make them transpire better or add thermal insulation but for an exclusively mercenary aesthetic purpose with the intention that the new building will be considered 'sustainable'. This kind of approach cannot be given the name of sustainability, although it may fit in superficially in its natural or built surroundings, either as a deliberate action or as a secondary consequence of that decorative sustainability (López Osorio, 2007).

4. *Momentary sustainability*

The term sustainability is often applied to a barely constructed building, especially within the scope of some architectures that call themselves passive, often in reference to the reduced use of energy employed and the economic saving that such buildings involve for the environment and its inhabitants, but they do not take into account the cost in energy and carbon footprints generated in constructing them, and still less the cost arising from medium- and long-term maintenance as well as that resulting from its destruction, waste or recycling at the end of its lifespan, i.e., the LCA (Life Cycle Assessment) previously described. Contemplating the whole ecological cycle of the building may cause more than one surprise, for in some buildings the personal and environmental cost generated by the production of the materials and the construction of the building does not counterbalance the posterior energy saving in the building's complete lifespan. In the same way, possible recycling is jeopardised, since materials are used that require a great deal of energy to be reprocessed.

Furthermore, the importation of materials from more or less distant places not only tends to have an aesthetic impact, but it generates the energy cost of transport, which is quite absurd when there are other materials available near the site. It is worth considering the re-

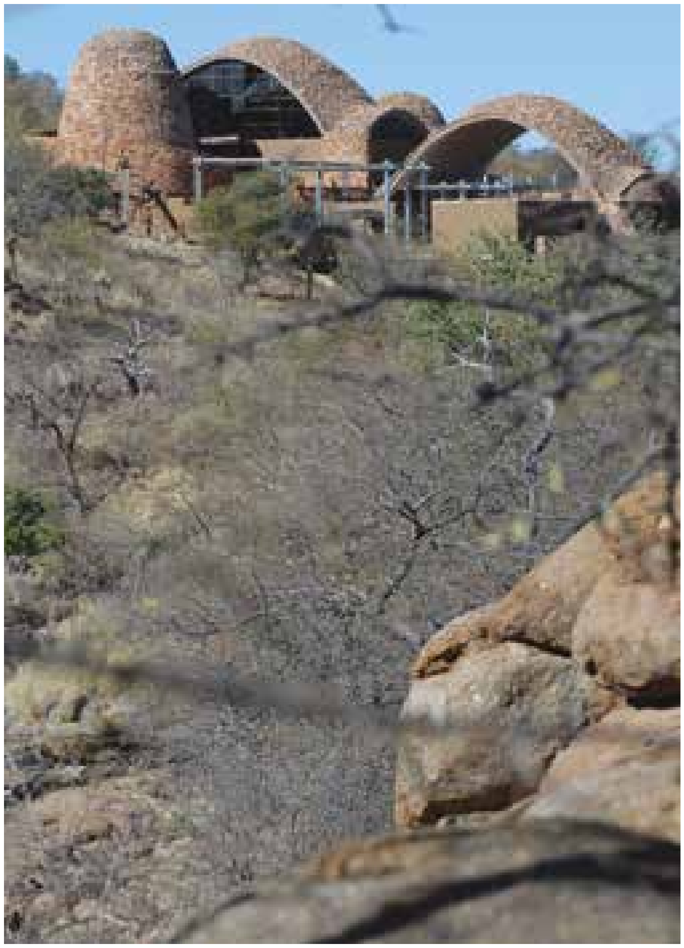

Fig. 3 Kids playing in the fields besides the Yunnan's Museum of Handcraft Paper by Hua Li and TAO, Xinzhuang, China. (photo: Shu He, courtesy of the international prize for sustainable architecture Fassa Bartolo).

al cost –or 'cosmic cost', as Eladio Dieste called it (Dieste, 1996, p.221-242), including all these factors. In the same way, the possible recycling of materials is usually called into question, because reprocessing requires a great deal of energy.

A typical example is the 'ecolabel' often applied to high technology architecture, which permitted –and still permits– master 'high-tech' architects to preserve their poetics of technological exaltation with an ecological 'lifting treatment' that disguises the product. This energetic sensibility based on an alleged saving of consumption masks a waste of materials or in fact does not compensate for the energy consumption required for the production processes. In many cases, this mask is real, and covers up the ecological deficiencies by resorting to supposedly efficient technologies or formal evocation of the vernacular tradition.

5. *The sustainability of recycling*

Recycling seems to have become a byword for efficiency, a sacred term for any contemporary architecture that wishes to aspire to sustainability, whether sincerely or merely following the trends of the time and the most popular labels in the construction market. However, recycling is not always the panacea of sustainability. Furthermore, the concept of recycling would be the last option from a group of variants implying greater sustainability such as repairs, restoration, rehabilitation, recuperation, reuse, etc. (Carroon, 2010). This is the case of aluminium, among other materials, for its production cost is so high that it would require dozens of recycling periods to make it worthwhile. Other popular materials in the recycling sphere like used tyres, either as they are or converted into EPDM rubber (Ethylene Propylene Diene Monomer *M-class* rubber), are used with freedom and ease of mind because they are recycled, but the fact that it does not allow steam to transpire often makes it incompatible with the rest of the materials used in sustainable building, sometimes creating potentially pathological constructive aberrations.

Finally, experience shows us that resorting frequently to demolition materials from old buildings generates a market that causes more demolitions in the historic city centres, as occurred in the early 20th Century in the United States with neo-colonial architecture and the fashion of creating period rooms in museums and stately homes.

Fig. 4 Interior view of the Yunnan's museum of handcraft paper by Hua Li and TAO, Xinzhuang, China. (photo: Shu He, courtesy of the international prize for sustainable architecture Fassa Bartolo).

6. *Partial sustainability*

The concept of sustainability in contemporary architecture is often confused or deliberately mixed up with other hackneyed notions that we defined briefly at the beginning of the text, although they are not the exact equivalent and the adjective used has nothing to do with what is actually built. Besides, above all in the realm of schools of architecture and the most widespread journals, sustainability in architecture is often seen as a purely environmental factor, mainly related to the production of construction materials or the energy cost of maintaining a building, unmindful of social, cultural and economic implications, which have to do with other factors such as durability, tradition, the cultural scene, immaterial values and human relations.

Dammusi in Pantelleria, Italy
(photo: Bisi, CC BY-SA 4.0).

Environmental sustainability in vernacular architecture

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Beginning in the late 80's, the acknowledgement of severe global environmental conditions has forced humankind to reconsider the misleading notion of an unlimited availability of natural resources in favour of a new development model based on the idea of 'sustainability'. The need to provide for ourselves and future generations has led to an approach seeking the correct use of resources, in balance with the laws of nature; this in turn has led to humankind identifying buildings and their aggregation as one of the main reasons for high energy consumption and pollutant emissions (Steemers, 2010; Hegger M., 2008; Sánchez-Montañés Macías, 2007). The impact of buildings on environmental concerns (Ingersoll, 2009) such as the ozone layer, climate change and the greenhouse effect has led to the implementation of important actions and policies in favour of environmental sustainability. The application of this concept to the construction sector has led experts to rethinking current construction processes and techniques in favour of new sustainable approaches that are able to use natural resources in a renewable manner and apply the bioclimatic features available in the specific area, thereby avoiding irreversible environmental impacts.

According to Goodland, the definition of environmental sustainability was embodied in T.R. Malthus (1836-1878) and J.S. Mill's (1900) writings on economy (Goodland, 1995). Both authors linked the problem of limited natural resources to 'unfettered growth' and the need to protect the environment in order to preserve human welfare (Goodland, 1995).

Beginning in 1987, the expression 'environmental sustainability' has attained worldwide significance thanks to the Report of the Brundtland Commission, *Our Common Future* (1987). The report became a turning point in future international actions and policies aimed at sustainable development. It recognized most of the issues that had already been addressed at the UN Conference on Human Environment in Stockholm in 1972, such as the frailty of the global environment and the safeguarding of the planet for future generations. Since then, environmental issues have played a central role in European strategies and policies (Rio de Janeiro, 1992; Kyoto, 1997; Copenhagen, 2009, etc.). The main reason for environmental sustainability concerns the protection and safeguarding of human habitats (Goodland, 1996). According to the Brundtland Commission: "The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities". Human life depends on the global life-support system for water, food, waste assimilation, etc. Many past environmental policies have been damaging to this system because they have not considered the limit and non-renewable character of many resources. Among these, the burning of fossil fuels, soil sealing (urban sprawl), the increasing living standard of developed countries and unsustainable transport systems include some of the most damaging. Their consequences are obvious in the climatic and environmental changes the planet is currently experiencing, such as the melting of polar ice caps, an increase in global temperatures, the rising of sea levels, and high pollution. These conditions require an urgent transition toward environmentally-friendly sustainable strategies, the main goal of which is to preserve the planet's life-support system and restore the appropriate balance between human and natural habitats.

Following the energy crisis of the 70's, a renewed interested in the environment led researchers to apply ecological and thermodynamic concepts to human habitats (Magnaghi, 1994; Droege, 2006). The development of a new holistic model has modified the way in which we conceive of the city's behaviour as an open and complex ecosystem that depends on the surrounding environment for energy and matter exchange (Earth carrying capacity) (Bettini et al., 2001).

In the history of architecture, this condition had been reached, for example, in pre-industrial communities. People used to depend on local bioclimatic and environmental resources for food, energy sources and building materials (Mumford, 1967; Oliver, 1999; Memba Ikuga and Murray, 2012) (fig. 1). These were produced, processed and consumed directly on site, using processes that were consistent with the environmental period in question and supported the regeneration of these materials. Constructive techniques took advantage of local climates and topographical conditions: the habitat was able to exploit bioclimatic factors (such as the sun, wind, water) and geographic morphology in order to guarantee human comfort for inner and outer spaces (Memba Ikuga and Murray, 2012; Lloyd Jones, 2002; Coch, 1998) (fig. 2).

With the advent of the Industrial Revolution, the link between human habitat and its surrounding supplying basin was broken. Tech-

M. Correia, L. Dipasquale, S. Mecca (edited by), *VERSUS: Heritage for Tomorrow. Vernacular Knowledge for Sustainable Architecture*, ISBN (online) 978-88-6655-742-5, ISBN (print) 978-88-6655-741-8, CC BY-SA 4.0, 2014 Firenze University Press

nological progress significantly modified the construction sector, as it introduced new building materials (concrete, steel, glass) and techniques, and at the same time launched highly polluting and energy-expensive production processes based on industry (Fernandes et al., 2014). From this point forward, "economic development represents the development of more intensive exploitation techniques of natural environment"(Wilkinson, 1973).

Architectural environmental sustainability

Sustainable architecture must engage with all aspects of architecture, its surroundings, and human needs, as well as with the relationships that exist between them (Memba Ikuga and Murray, 2012). In particular, in architecture, the goal of environmental sustainability is to guarantee satisfactory human comfort, avoiding or limiting environmental impacts such as high resource consumption (e.g., fuels, land, materials) and pollution.

This goal produces a set of project actions that enable exploiting local bioclimatic conditions and materials, in accordance with lessons from vernacular or pre-industrial examples.

Among the main areas of intervention are (Lloyd Jones, 2002):

Energy – refers both to energy-saving strategies and energy sources in all parts of the construction process and considers: "the extraction of materials, the manufacture of these materials into components, the construction process itself, a lifetime's use and maintenance, and then the eventual demolition and decay or recycling of parts"(Memba Ikuga and Murray, 2012). Today, the building sector mainly uses industrially produced materials. These are characterized by high embodied energy, high carbon emissions and high energy intensive production processes. Because of globalization, they are extracted, processed and distributed globally with considerable transport costs and environmental impact. Their applications usually do not maintain a close relationship with local traditions or the environmental characteristics of a site. The lack of attention toward to local climate concerns has also led to creating constructive solutions, such as thinner masonry and wide glass surfaces, increasing in building management costs as it relates to heating and cooling systems, as well as maintenance operations (Fernandes et al., 2014). Finally, the prevalent use of fossil fuels in the construction industry impacts heavily on CO_2 emissions into the atmosphere.

Health and comfort – carelessness in the design process regarding the comfort of building spaces can affect inhabitants' physical and psychological health. A bad choice in building materials can impact on the health of the building and its inhabitants. Examples include asbestos or the use of chlorofluorocarbons (CFCs), which can have an

Fig. 1 Windmills, Holland (photo: E. Bracco, CC BY 2.0).

Fig. 2 Trulli, Alberobello, Italy (photo: Monika, CC BY-SA 2.0).

1 to **respect environmental context and landscape**

2 to **benefit of natural and climatic resources**

3 to **reduce pollution and waste materials**

4 to **ensure human indoor comfort**

5 to **mitigate the effects of natural hazards**

ENVIRONMENTAL PRINCIPLES *The habitat is a result of a virtuous integration into its natural environment*

affect not only on human health but on the entire planet (ozone layer) (Lloyd Jones, 2002). Inadequate architectural design does not assure proper attention to climatic factors such as solar radiation, ventilation, lighting, and poor internal living conditions. Additionally, a lack of attention to the topography of the building site impacts both on the dwelling's health, thermal comfort, and its safety. Frequent environmental disasters due to extreme weather events such as flooding or landslides are often linked to human actions (the overbuilding of soil, the closure of riverbeds, excessive deforestation, etc.).

Environmental sustainability in vernacular architecture

Vernacular lessons, partially recovered today within bioclimatic design, interprets human habitat and architecture as a dynamic system able to adapt itself to continuous environmental changes. Local climate and natural resources are the starting point from which to conceive the architectural organism (Oliver, 1999) (fig. 3).

Referring to the existing research on vernacular architecture, the VerSus research project indicates environmental sustainability as "the capacity of the human intervention in decreasing or avoiding a building's adverse environmental impacts, reacting to every change in the environment understood as the set of conditions in which life is possible, and regarding the whole biological quality (Neila González, 2004). It is widely interconnected with the scope of the economy scope especially pertaining to the aspects regarding energy consumption and building life cycles" (Correia et al., 2014).

In order to respond to the environmental requirements, five main strategies have been identified from the literature.

1. To Respect Nature

According to Oliver (1999), the literature establishes that every building exists within an environmental context. A site's features and local culture influences local building types and techniques (Oliver, 1999). In addition, owner-builders who used natural, renewable, recyclable and organic materials within the immediate proximity of the selected location obtained deep harmonization with site surroundings and had a minimal environmental im-

Fig. 3 Traditional houses of Asir Province, Saudi Arabia (C. Roffey, CC BY-NC-SA 2.0).

Fig. 4 Seaweed farmhouses of Læsø Island, Denmark. (photo: SEIER+SEIER, CC BY 4.0).

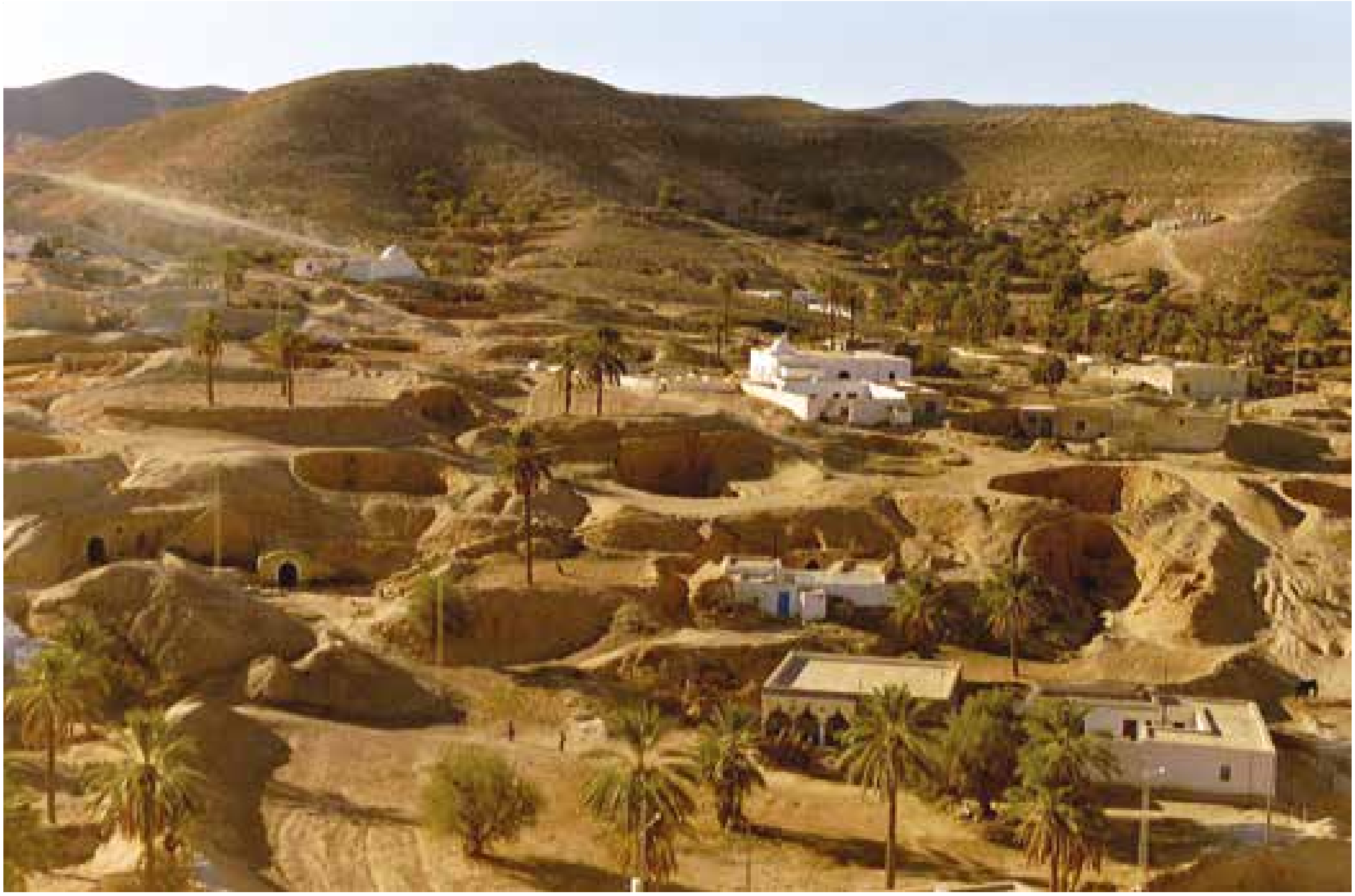


Fig. 5 Below-ground dwellings in Matmata, Tunisia (photo: A. Zwegers, CC BY 4.0).

pact (Fernandes et al., 2014). The vernacular habitat is integrated into the environment and does not harm other elements of the ecosystem. Usually, terrain features (morphology) define building characteristics in accordance with the *genius loci* of the site (Sánchez-Montañés Macías B., 2007) (fig. 4). Examples are the below-ground dwellings, such as Matmata (Tunisia) and Tajuña valley (Spain). These provide protection and shelter to people through the soil which behaves at the same time as site and building envelope (Oliver, 1999; Sánchez-Montañés Macías B., 2007) (fig. 5).

2. To Be Appropriately Situated

As stated above, climate and terrain qualities are the starting point from which to conceive architecture. Due to a lack of energy resources and current plant systems, vernacular communities have assured the liveability and comfort of their homes by taking advantage of the site's bioclimatic features (solar radiation, ventilation, orientation, building type, etc.).

Diverse global climate conditions have caused numerous solutions whose strengths 'lie in the flexibility and adaptability' of building elements to the seasonal or daily variability of climatic factors (Coch, 1998). In a temperate climate such as the Mediterranean, for example, buildings might be equipped with devices useful for absorbing sun-rays during winter or to provide shelter against them during summer (courtyard, porches, shutters, deciduous vegetation, 'dual housing', etc.) (fig. 6). Device type and position depend on building location (valley, slope, coastal or marine location, etc.) and orientation (Oliver, 1999).

3. To Reduce Pollution and Waste Materials

The vernacular habitat optimizes resources in order to avoid pollution and other environmental impacts. In the vernacular tradition: "the materials used were obtained from the geographical area where the buildings were erected" (Fernandes et al., 2014). Materials had artisanal production; they were extracted, slightly processed and used directly on site (or a short distance away), reducing the energy and environmental costs linked to transport. According to Oliver, the vernacular building techniques 'usually enable the use and re-use of renewable resources' (Oliver, 1999) by recycling waste and converting these into new resources. On the basis of the research by Fernandes et al.: "Generally, the most rel-

Fig. 6 The loggia (*lolla*) in Samassi, Sardinia, Italy (photo: Associazione Nazionale Città della Terra Cruda).

Fig. 7 Leanach Cottage Culloden Moor, Scotland (photo: Sammydavisdog, CC BY 4.0).

evant environmental advantage related to local materials are: no need of transportation; less energy intensive production process and consequently lower embodied energy and CO2 emissions; they are natural materials, often organic, renewable and biodegradable, with a life cycle from 'cradle to cradle'; low environmental impact during maintenance operations" (fig. 7).

4. To Contribute To Health Quality

The habitat offers inhabitants the opportunity to live in a healthy environment. "Heat, radiation, pressure, humidity, and wind, among other factors, interact mutually to establish [continuously changing, editor's note] climate conditions" (Fathy, 1986) to which buildings have to deal with in order to assure human comfort. Thermal comfort depends on the interaction between environmental and human factors. It is defined by the heat exchanges between man and its immediate surrounding. Architecture interposes itself between man and the external space with the purpose of alleviating extreme weather conditions and improving man's health and well-being.

Although buildings have fixed structures that are unable to vary with the climate and man's sensibility, they are provided with a wide range of 'devices' which fit with different and variable climatic conditions and human body sensations (cold, hot, etc.). Particularly, vernacular architectures include several examples of architectural and technical solutions to cool or warm the inner space through the exploitation of local natural resources and physical phenomena in harmony with the environment. It also determines the dwelling's health through adequate control of solar radiation, natural lighting and ventilation, as well as the humidity of inner spaces (Lloyd Jones, 2002). Examples concern building orientation and spatial configurations as façade porosity, buffer zones (courtyard, verandas, porches, loggias, etc.), openings size, form and location, window screens (venetians, trellis, *mashrabiya*, etc.), ventilation systems (wind-catch as *malqaf, badgir* and wind-escape system, etc.), roof shape and colour, etc. (fig. 8). In addition, also material characteristics (non-toxic, breathable, acting as moisture regulator, albedo, etc.) can have a positive impact on human well-being.

Fig. 8 Beehive homes in Jinshan, China (PRC) (photo: A. Synaptic, CC BY 2.0).
Fig. 9 Embankments. Ouroux-sur-Saône, Bourgogne, France (photo: N. Sanchez).
Fig. 10-11 Stone houses in Forio, Ischia Island, Italy (photo: A. Picone).

5. To Mitigate the Effects of Natural Hazards

The habitat should provide a safe and protective environment for all its inhabitants. In hazard-prone areas, vernacular builders have implemented constructive strategies for coping with local natural risks. These techniques have primarily been empirically developed throughout centuries in relation to each particular environment and usually employ local natural materials (timber, bamboo, stone, etc.) (Oliver, 1999). Technical solutions change according to the prospective hazard, local culture and environmental resources, and range 'from constructive details to territorial planning' (Caimi and Hoffmann, 2014) such as vegetative barriers, breakwaters, embankments, etc. (fig. 9). Construction technical measures can be permanent or temporary. The former are integrated in building shape and/or constructive details (joints, masonry wall type, buttress, etc.), whereas temporary ones are easily implemented by inhabitants at the moment it is needed (nets, ropes, ground anchoring systems, moving shelters, etc.) (Caimi and Hoffmann, 2014).

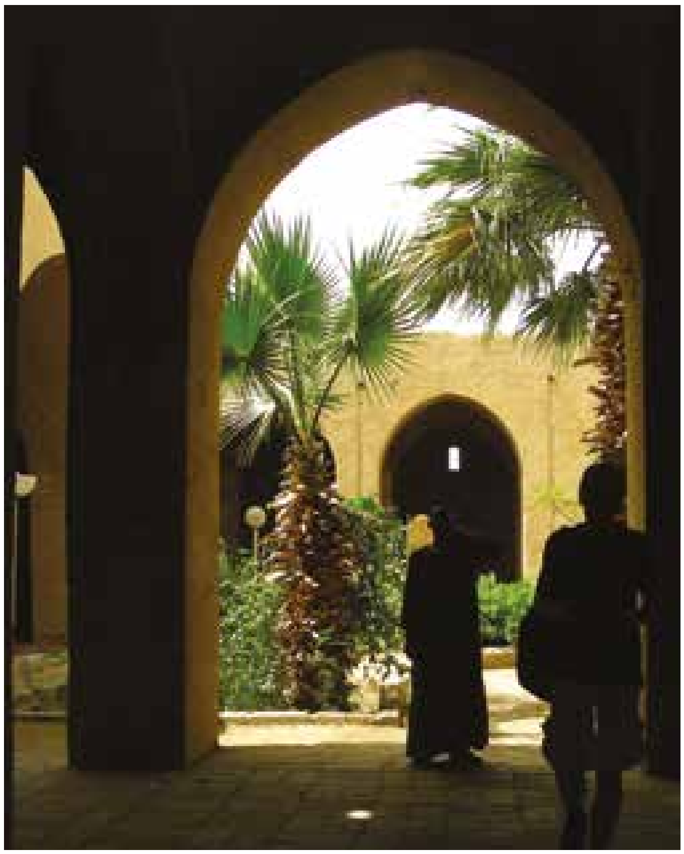
Principles of environmental sustainability in vernacular and contemporary architecture

Among the vernacular examples, the 'stone house' of Ischia (Phlegraean Islands, Gulf of Naples) includes most of the environmental strategies illustrated previously. In regard to the first principle, local community occupied the rocks through minimum interventions on environment. Outwardly, the boulders have retained their original shape (the few added elements, like stairs and rain water channels, have been adapted to the rocks' natural configuration), whereas the domestic space had been dug into the boulders, getting from the rock both the living space and the furniture (fig. 10).

Such deep integration of humankind within the environment has also affected the surrounding rural land: people dug connections (mule track, steep stairs and path) and terracing for viticulture (*parracine*), using dry stone walls made of local green tufa (principle n.3). Architectural and technical solutions exploit the local bioclimatic features to ensure the health and well being of inhabitants (principles n.2 and n.4). These include:

- The thermo-hygrometric behaviour of tufa and wall thickness (up to 2m) provide excellent thermal insulation throughout the year and prevents heat dispersion.

Fig. 12-14 New Gourna Village of Hassan Fathy, Egypt (photos: M. Achenza).



- The openings are arranged along the main direction of the wind. These are small in size to prevent heat dispersion and rainwater seepage. To achieve this, the opening design has marked splays with a trapezoidal geometry outward and elliptical inwards.
- A channelling system dug into the rock conveys rainwater into a water tank, which is placed under the storage (fig. 11).
- The inner walls are usually whitewashed with lime in order to improve lighting.
- A wood oven or fireplace provides an efficient heating system.

Concerning contemporary examples, also the village of New Gourna (Egypt) designed and built by H. Fathy in the 1940s, incorporates most of the previous strategies. Concerning the harmonization between the man-made and natural environments (principle n.1), this was achieved through the use of traditional materials and building techniques inherent to Egyptian heritage and still preserved in the skills of local craftsman (mud bricks). As stated by Fathy: "I had to try to give my new designs that appearance of having grown out of the landscape that the trees of the district have" (fig. 12). Beyond an economic necessity, this material was necessary for use in the particular climate and served the well-being requirement due to its thermal properties (low heat conductivity) and the thickness of the walls (principle n.4). The bricks were produced in a brickyard in the village, reducing transport emissions and fostering a low-energy productive system (principle n.3) (fig. 13).

The hot and dry Egyptian climate required the shading of building spaces from solar radiation and a cooling system which used moving fresh air in order to guarantee satisfactory human comfort. For this aim, in continuity with traditional techniques, Fathy's project paid attention to the exploitation of local bioclimatic resources: sun and wind (principles n.2 and n.4) (fig. 14). These factors influenced the building orientation and architectural solutions (the *madyafa* (north facing loggia), the courtyard, the *dorka'a* (central square), the *malkaf* (wind catch), the *mashrabiya* (wooden screen), etc.).

In addition, the village also provides solutions for the safety and health of inhabitants (principles n.4 and n.5). These concern the protection of mud bricks from damp, the cooking and heating system (the *Kachelofen* system) from polluting fumes and dirt and safeguarding of the water supply (public pumps).

A neighbourhood in Coaraze, Provence, Alpes-Côte d'Azur, France (photo: E. Sevillano).

Socio-cultural sustainability in vernacular architecture

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"Housing should also be the space of good life, which embodies material well-being but must also include [...] a system of mutual assistance and solidarity, at the scale of the block of flats or of the city". **Edgar Morin (2011, p. 197)**

Architecture is a social and cultural reality

This text by Edgar Morin makes us think about what housing should be if it was to reclaim the dimensions of material and immaterial values and if it was to contribute to generating more social cohesion in the space we live in. Lessons learnt from vernacular architectures put us back at the centre of this issue, through their legacy of social and cultural significance. Today, with an increasingly global society that tends to trivialize culture, is there not a space for recreating social bonds and for turning our social and cultural differences into a wealth of significance to be reintegrated into the production of our habitats?

The question of sustainable habitat in such a new global world, through the prism of social and human sciences, and according to spatial approaches suggested by researchers such as Alberto Magnaghi (the local project) or Augustin Berque and his studies of *human milieu*, his *écoumène*[1], and his *poetics of living*, encourages us to re-establish the anthropological and social dimensions of habitat. Moreover, and as pointed out by Jean-Paul Loubes (2010, p. 24), "we should reintroduce in housing the dimensions which were evacuated by functionalism (...): the symbolic and cultural dimensions (...). Cultural in the sense that architecture and the city are cultural realities, 'artefacts'. Housing should be 'situated', in other words localised and informed by place. This information cannot be limited to the impact of geophysical or climatic factors. It should also draw on social and cultural dimensions that nourish the richness of significance of our habitat, by valorising housing cultures, place, and being in the world. For it is the 'essences' as defined by Merleau-Ponty, and the *Lebenswelt* as defined by Husserl, that we search for in the lessons we learn from vernacular architecture – this 'architecture without architects' (Rudofsky, 1964) that is humanity's common good which we have inherited and which expresses the widest social and cultural diversity anchored in the specificities of territories. This renewed interest in vernacular architecture may then reflect the rebirth of a desire of reconciliation with the material and immaterial values and with forms of expressions of the Beautiful, the Good, the Genuine that we feel when looking at the homes of ancestors that were so harmoniously integrated in the landscape as a geographic and cultural space and as the mirror of man's history and life. A connected, non-arrogant, peaceful, human-scale architecture, that fits into sites, topographies, mineral and vegetal environments. An architecture which accounts for the diversity of cultures and economies. An architecture which reflects the knowledge and 'know-how', the 'building cultures' that have been passed on from one generation to the next, by anonymous builders, masters of an art of building that developed in the margins of scholarly construction and architecture, borrowing from or owing it very little – if anything.

In *La maison rustique*, Jean Cuisinier (1991) quotes these few words from Eugène Viollet-le-Duc's book on modern housing: "if any work of man reflects the state of a civilization, it is housing, for sure". In similar vein, Pierre Frey (2010, p. 22) argues that "architecture reflects the state and values of a society". It is this social and cultural dimension of civilization, which is embodied in vernacular architecture, that we are interested in, at a time when this architecture is analysed in order to produce a sustainable contemporary architecture which would reintegrate the power of genius loci Christian Norberg Schultz referred to. A new vernacular architecture which would reunite drawing and building, the pencil that draws and the hand that builds, the space that is designed and the way it is used.

[1] The word *écoumène* refers to human-made environments, lived in and used by man.

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Fig. 1 Culture landscape of terracing in Les Beaumettes, France (photo: S. Moriset).

Free thinking on the sociocultural meaning of vernacular architecture

The meaning of vernacular architecture is both ordinary (for it is popular) and extraordinary because of its many qualities. Here, this meaning is revisited through the prism of some social, cultural, geographic, anthropological, architectural and building-related codes.

The fact that we are increasingly mobile from a spatial point of view (work, holidays, travel) means that we are inevitably in contact with architectural heritage, whether it be vernacular architecture in the countryside or historic buildings in the cities. From an emotional point of view, we often associate a dimension of beauty with these buildings, since they are a testimony of the past, traces in our memories that enrich the way we consider the world. It is 'our' heritage and common good, a 'collective good' that belongs to a social group, to a region, to a nation, and even beyond, with the development of international cultural tourism. There is often a risk that this built heritage will end up in ruins, that it will be destroyed and will disappear. This collective bond means that we are 'all' invited to safeguard it in order to pass it onto future generations. This collective responsibility is increasingly compromised as heritage falls within the remit of the history of man, of spaces, of art, of architecture, of aesthetics, of sciences and techniques. This means that analysing it is very complex, particularly from social and cultural points of view.

Renewed interest for vernacular architecture is based on the motivation of enlightened people who authored many regional monographs on 'peasant architecture' and of non-profit associations that worked for its inventory and conservation. This commitment was tangible in the middle of the 20th Century[2]. In the past few decades, these studies, which were mostly functionalist and typo-morphological in their approach, opened up to anthropological and ethnological analyses which embodied the social and cultural dimensions of built heritage. Today, this infatuation with vernacular architecture seems once again to be nourished by society's attachment to peasant cultures, of which the richness of expression has been widely brought to light by the dissemination of published studies and by ethnographic or museological actions that have ascribed renewed value to the history of the peasant world. The global world also seems to revive the desire to take root in the cultural identities of territories, in the context of a dissatisfaction fuelled by the mediocrity of housing design since

[2] The study of the French rural architecture corpus was initiated during the Second World War. It is said this was to 'keep architects busy' during those dark times.

Fig. 2 Cultural landscape of vineyards, Chignin, Rhone-Alps, France (photo: S. Moriset).

the thirty year boom period that occurred between 1945 and 1975, a tendency which is perceived as generating trivialization and dehumanization in housing as many projects of that time – designated in France under the appellation of *grands ensembles* – have shown, several of which have been recently destroyed.

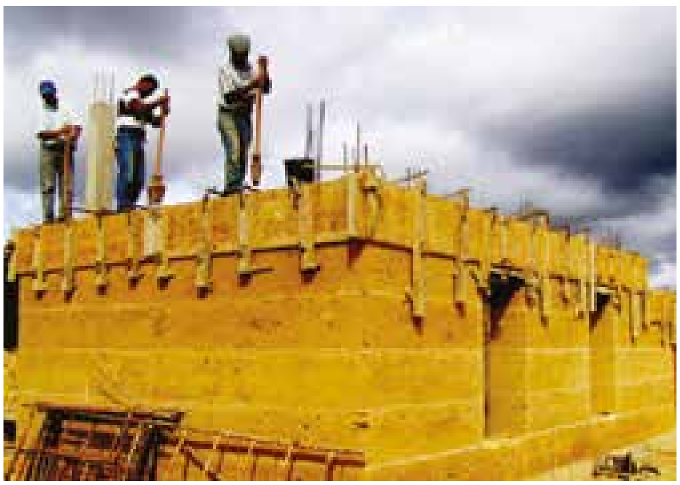
In the past few years, the mobility of populations between cities and rural areas has increased and has contributed to the spread of detached housing and to the restoration or refurbishment of part of the vernacular building stock[3]. These interventions are sometimes for the better, sometimes for the worse, and reflect a wide scale sociocultural movement. Some have referred to a 'back to the land' trend found amongst *neo-rural*[4] populations moving to rural areas that had lost their social, economic and cultural roots and part of their density. This trend is supported by local elected members since it contributes to the development of local economies (and in particular of tourism) and to the preservation of cultural identity. It can also be seen as a will to preserve the traces of history, associated with the quest for social and cultural values of which the meaning has dwindled in the face of a world that is increasingly dominated by economic and financial interests. Moreover, the work crisis generates unemployment, tensions and stress, and as a consequence of this people are increasingly unable to buy a home in urban areas due to the price of land and building, and are thus seeking other solutions in rural areas. This movement is also generated by a quest for peace, calm and slowness, as a reaction to hasty lifestyles that cause health problems. This need to seek refuge appears to be linked with the strength of vernacular architecture and with its'noble', natural and ecological materials, as opposed to industrial materials and other low quality artefacts found on the dominant market and that are built according to the principles of planned obsolescence. Compared with housing that appears to be fragile, degradable and built for one generation, vernacular architecture proclaims the reassuring evidence of its sturdiness, and of its environmental sustainability – an increasingly widespread preoccupation.

Recognizing the 'intelligence' of vernacular architecture is a way of paying tribute to the capacity of successive generations of builders

[3] Sabattini, B. 2008: A report published in 2006 by the Economic and Social Council stated that of the 6 million rural buildings that remained in France (there were 11 million of them in 1966), only 1, 5 million had changed use and had been converted into main or secondary residences or rural guest houses and many others were falling into ruins.

[4] Ibid. Between 1999 and 2004, over two million French people left urban areas, and moved to communes with fewer than 2000 inhabitants.

Fig. 3 Traditional granary, Soajo, Norte, Portugal (photo: M. Correia).
Fig. 4 Restoration of a traditional masonry roof; Nonza, Upper-Corsica, France (photo: N. Sánchez).
Fig. 5 Building a rammmed earth wall; Alentejo, Portugal (photo: M. Correia).



to adapt to the diversity of environments, to overcome constraints, to make best use of available resources. It is a way of recognizing the 'meaning' rendered by this architecture that has been at the basis of a surprising cultural and social creativity developed and transmitted by craftsmen, bricklayers, carpenters and others, but also and above all by the inhabitants themselves – anonymous builders. This architecture is spatially anchored in territories shaped by man, where nature, space, society and culture intertwine to generate shapes that are perceived to be those of happiness. Its meaning is also strengthened by its relation with uses and exchanges, and encourages new types of relationships between inhabitants and their physical, social, cultural and economic environment, thus expressing a need for renewed social cohesion to allow new forms of creative sociability and improved community life to emerge.

Socio-cultural lessons learned from vernacular architecture

Our European vernacular architecture embodies tangible as well as intangible values that are a testimony to mankind's capability of adaptation in its living contexts, and of its deep respect of nature, whatever the specific features of its environment are. Nature and culture, identity of the local society, ability for creating the best living conditions as far as possible, knowledge and know-how, are intimately linked. All this constitutes a socio-cultural heritage of great importance that offers us today inspiring lessons. Several major aspects of these lessons can be raised:

- Vernacular built heritage is part of the space of cultural landscapes which have been shaped by man, whether by peasants or craftsmen, prior to the industrial era which changed the course of history. More than the built objects themselves, it is the entire space of cultural landscapes which also gives a patrimonial value to flora (forests, various wood varieties), fauna, and to the landscaping made for specific cultivation in wide valleys, wine-making terraces or fields separated by walls. Water is also an element of cultural value. It has often been domesticated through canals and ponds inland, or salt marshes, dikes and ports along the coast line. Vernacular architecture and cultural landscapes are one and the same space which links nature and culture and which must be conserved and passed on to future generations (fig. 1-2).

6 to **protect the cultural landscape**

7 to **transfer construction cultures**

8 to **enhance innovative and creative solutions**

9 to **recognise intangible values**

10 to **encourage social cohesion**

SOCIO-CULTURAL PRINCIPLES *The habitat helps to preserve and transfer inherited values.*

- Vernacular architecture is a testimony of the knowledge and know-how of craftsmen or anonymous builders who erected it. These 'traces' of vernacular building cultures live in the landscape through the visual aspect of materials, earth, stone, wood, plants, farmhouses and outbuildings (barns, stables, washhouses, dovecotes), roofs, building and decoration details, relationships between buildings and their surroundings (paths, ponds, streams). All these elements demonstrate man's capacity to adapt to a place, to meet their needs and to address the social and cultural identity of territories (fig. 3). The transmission of all these dimensions of the vernacular heritage and its reinvention is a challenge for the future (fig. 4-5).
- Vernacular architecture expresses a surprising creativity which reflects a high degree of collective intelligence and a process of building experimentation that gradually turned into experience. This social and cultural heritage demonstrates a high level of ingenuity in terms of adapting to resources and using them wisely. It takes many forms, that are useful, creative, aesthetic (coloured coatings, frescos, plantations) and artistic. These expressions of creativity should be an inspiration for tomorrow (fig. 6-7).

Fig. 6 Recognize the intangible values; Rennes, Bretagne, France (photo: E. Sevillano).

Fig. 7 Symbolic representation; Montsoreau, Loire River, France (photo: E. Sevillano).

- The social and cultural dimensions of vernacular architecture are also reflected in a building language which expresses the immaterial values of those who built and lived in the space. This collective memory expresses place attachment, shown by the varied forms of sacredness (religious or agnostic, myths and legends), expressions of symbolism and identity associated with the construction systems, apotropaic protection devices. These values are also expressed in collective rites or in intimate spaces (awnings, galleries, courtyards, gardens) that are pleasant to live in (fig. 8-9).

- More than the mere architecture of buildings, the vernacular human settlements, hamlets and villages, reflect inhabitant's desire and capacity to exchange and live together, and to maintain the conditions of social cohesion so as to live as peacefully as possible despite conflicts of interest. This is shown by washhouses and fountains, squares and covered markets where markets are found, frontages embellished through the use of flower planters, galleries and awnings that offer shaded spaces that can be shared and other spaces that can be used collectively for revelries. This community intelligence must be favoured in the built environment of the future, through squares, covered markets, fountains, etc. (fig. 9-10-11).

Fig. 8 Intangible values; stele of devotion at Annot, Hautes-Alpes, France (photo: E. Sevillano).

Fig. 9 Wash-house and public fountain at Vergons, Hautes-Alpes, France (photo: S. Moriset).

Fig. 10 Places for social activities; Les Marches, Rhône-Alpes, France (photo: S. Moriset).

Fig. 11 Central square in Vila Nova de Cerveira, Portugal (photo: L. Dipasquale).

Ksar de Ouled Saïd, Wilaya d'Adrar, Algeria (photo: Kays Djilali © Ministère de la Culture, Algérie, 2011).

Socio-Economic Sustainability in Vernacular Architecture

Mariana Correia, Borut Juvanec, Camilla Mileto, Fernando Vegas, Filipa Gomes, Monica Alcindor, Ana Lima

Vernacular architecture is a wide area of study, with singular researches and complementary studies. According to the *Encyclopedia of Vernacular Architecture of the World*, it comprises all dwellings and buildings, either private or community-owned, which were built using traditional technologies (Oliver, 1997). This can reveal how vernacular architecture is an unlimited source of conceptual solutions, through which sustainability can be rediscovered. In vernacular architecture today, there are still examples that can be observed where there is a balance between energy saving, tradition, the environment, and the social parameter. This is particularly observed in rural and isolated areas. It is not the case in urban areas, where the pressure of fast growth, both of the population and of its habitat, undermines any possibility of a balanced approach.

When addressing the revision of literature regarding sustainability and its impact on vernacular architecture, it is observed how there is a persistent tendency to privilege the study of environment issues, in detriment of the social, cultural and economic parameters. This is reasonable regarding a first observation of vernacular architecture, since environmental issues tend to be physically evident, and therefore easily observed. Thus, Vellinga (2015) underlines the fact that restricting the focus to environmental issues will not only show a partial picture of the challenges faced by vernacular architecture, but also offer a partial understanding of the lessons that can emerge from its study.

It is therefore essential to approach socio-economic sustainability as a broad area of study with different dimensions. In this article, the dimensions under analysis will relate to the identification of socio-economical principles; to the economy: its needs and values; to collective values being economical values; to the efficient management of local resources; to a self-management economy; to the impact of the economic factor on local development; to assessing the economic value of vernacular architecture**;** to the impact of conservation in economic terms; to the conservation of traditional architecture; and other relevant reflexions.

Socio-economical principles

To value with relevant significance are the socio-economical principles, which empower the community to optimise their local resources, contributing towards the development of effective strategies for sustainable development. This is possible to achieve by supporting local communities to be more self-sufficient, by sustaining local production, by optimising local materials and by choosing to work with communal efforts. Furthermore, community development is valued when evidence is considered, regarding the fact that the extension of the life span of a building and of its parts has a direct impact on the local economy. Maintenance, conservation and adaptability of the dwellings can be reached through balanced efforts, directed towards a more inclusive and integrated approach. Additionally, preventing the waste of local resources can contribute towards a more steady and efficient sharing of resources, energy, the environment, infrastructures, systems, and communal life.

Economy: needs and values

Economy is very closely bound to the use of resources and the more modest the use, the closer it is to the economic function (fig. 1). In Mali, several settlements have cereal storage granaries (*'greniers'*) built for the conservation of the cereal. The number of granaries and their building culture varies according to the cultural zone. Their number can also increase, if there is an abundant harvest (fig. 2). In general, each family builds their own individual granary. However, during periods of drought, communal granaries are built for food security. In modest communities, families try to do the most with the least possible resources. Economics is therefore, according to Ost (2010), a way to satisfy the needs, by managing scarcity and non-renewable resources.

Fig. 1 Modest constructions between Segou and Mopti, in Mali (photo: M. Correia).

M. Correia, L. Dipasquale, S. Mecca (edited by), *VERSUS: Heritage for Tomorrow. Vernacular Knowledge for Sustainable Architecture*, ISBN (online) 978-88-6655-742-5, ISBN (print) 978-88-6655-741-8,

Fig. 2 Granaries between Segou and Mopti, in Mali.
Fig. 3 *Qanats* in the cultural landscape of Bam, in Iran.
Fig. 4 *Khettaras* in the Oasis of Figuig, Eastern Morocco.
Fig. 5 *Foggaras* from the Ksar Ouled Said, near Timimoun, in Algeria.
(photos: M. Correia)

However, Juvanec (2009) adds that the economic parameter can be wider, as it can involve the sum of the material availability, the technical circumstances, the possibilities and abilities of the builders, as well as the needs of the family. Also to consider are the values of the community, associated with their culture and beliefs.

It is these needs and values that were reinforced by Oliver (1987), when he mentioned that all forms of vernacular architecture are built to meet specific needs, accommodating the values, the economy and the ways of life of the cultures that produce them. Also stressing the importance of values, Zupančič (2013) underlines the fact that the economy in vernacular architecture relates to the identification of living environmental values, through the function of spatial structures in vernacular architecture. Therefore, the analysis of the values and the concern for the needs have a decisive contribution on the study of vernacular architecture economy. It is also essential to understand how economic issues have been understood and undertaken by local communities.

Efficient management of local resources

Isolated communities spend energy and resources looking for a more efficient management. This can be observed by the use of communal ways to develop more efficient use of resources. For instance, through the opening of water floodgates to periodically clean the village paths, as in Vilarinho da Furna, in Portugal (Calado, 1999); or by using the water cycle efficiently: through a resourceful flow of water, which continuously passes by drinking fountains, runs to water mills, then to water for animals, through washing tanks, and finally to be used on the crop fields. This is common usage in different rural parts of the world, especially in mountainous regions in the Iberian Peninsula. Important to mention, in socio-economic terms, and still in use nowadays, is the existence of rotation practices, among several communities, regarding the efficient management of local resources. This can be observed for instance with the sharing of the water in desert regions, which has an important role in the survival of populations in hard climates. The hydraulic system is composed by underground tunnels created by man for the passage and management of subterranean water. These tunnels have a slight slope with the water flowing by gravity from below the water table, in general located near mountains. The water is transported through the de-

11 to **support autonomy**

12 to **promote local activities**

13 to **optimise construction efforts**

14 to **extend building's lifetime**

15 to **save resources**

SOCIO-ECONOMIC PRINCIPLES *The habitat empowers communities and optimizes local resources.*

sert, for hundreds of kilometres until it reaches the soil surface, creating oases, where populations settle. On the surface, the community shares the water in a very efficient way. The water is supplied as drinking water and for irrigation in agriculture. The system is known as *qanat* in Iran (fig. 3), *falaj* in the United Arab Emirates, *khettara* in Morocco (fig. 4), or *foggara* in Algeria (fig. 5).

Collective values are economical values

In several regions of the world, traditional homesteads are organised in sustainable economic systems which avoid waste and save energy, through an efficient management of resources, including people, land, animals, equipment, outbuildings, main house, materials, resources, etc. These sustainable systems are even applied by several communities, which work together to produce, distribute, and consume wealth. They aim to create a restrained and efficient use of available materials, techniques, goods, food, etc., and to share resources to help the community. Doing so local people also obtain benefits for themselves. Therefore, these collective values can be considered economic values, and according to Ost (2010) cannot be attributed to any individual.

Worthy of mention is the community self-help present in different moments of the daily life, as is the case of the communal construction of rural facilities for common use. For instance, in the North of Portugal and the Northeast of Spain there are communal facilities in several villages; this includes communal threshing floors – where the straw and seed are separated, corn cribs – for the storing of corn cobs, or communal ovens where the fire was traditionally kept burning day and night, in order to cook bread for all the community and provide as well, a source of warmth for the poorest.

In traditional villages, it is still a reality that local populations unite for collective purposes and to build their spaces of work. Communal efforts create spaces to produce materials needed by families to trade or sell, contributing to the survival of local economies. Traditional tanneries are a fine example and can be observed in several Medinas, as is the case of the Medina of Fez (fig. 6) and the Medina of Tetouan (fig. 7), in Morocco. The leather resulting from the skin of animals such as lamb, ox, camel or goat is cleaned and coloured with natural dyes. The animal skin is immersed in vats filled with lime and dove excrement, where they remain for days to get clean. The acid mixture removes flesh and hair from the skin and makes the leath-

Fig. 6 Traditional tannery in the el-Bali, Medina of Fez, in Morocco (photo: A. Lima).

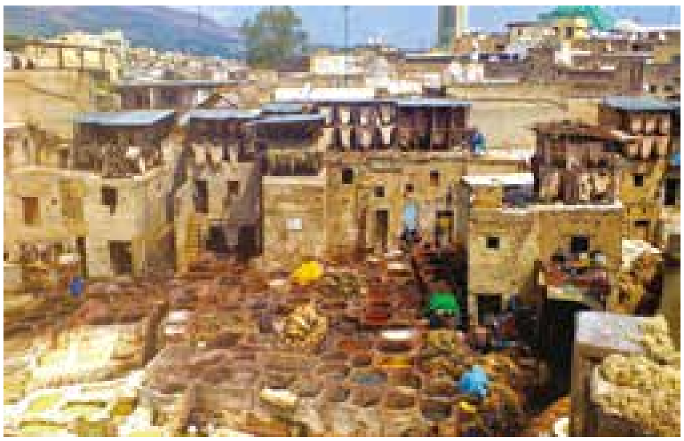
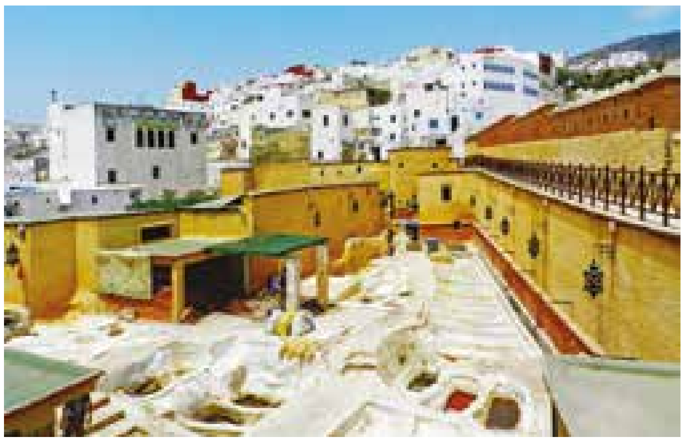


Fig. 7 Traditional tannery in the Dar Dbagh, Medina of Tetouan, in Morocco (photo: A. Lima).



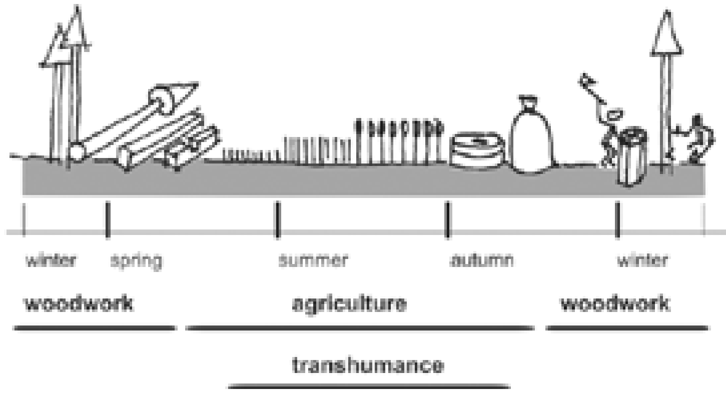


Fig. 8 Cycle of the woodwork: in the mountains of Slovenia, peasants work throughout the whole year, as agriculture runs from the middle of spring to the middle of the autumn. Colder seasons provide work in the forests (drawing: B. Juvanec).

er more malleable and smooth. Then, the tanners pass the knife to trim the fur and reintroduce the skins in vats to traditionally colour them. The skins are then set to dry on the numerous terraces and roofs that surround the tanneries. Once dried, the artisans create with the produced leather bags, shoes, clothes and accessories. In the medina, the different shops, where the manufactured products are sold are located near the entrances of buildings, with direct accesses to the terraces, where the tanners (*debbaguim*) and the dyers (*sebbaguim*) can be observed working. The complex has a plumbing system that usually is connected to natural water sources that clean the vats. The collective values associated to the common effort developed by the community to build the tanneries and to produce and colour the leather products, resulted in a self-sufficient economy for the common survival of the whole community. As mentioned by Oliver (1987), the advantage of exchange, trade and even barter, offers the opportunity to produce, to sell and to purchase, which are incentives to use the village and, for many, to be a part of it. This approach creates sustainable economies capable of being more self-sufficient.

Self-management economy

In the mountains, in several European countries, communities were integrated in a context characterized by strict geographical and topographical features. There were, and in some places there still are, isolated communities that autonomously implement a self-management economy. Subsistence was barely possible through simple economic activities, such as agriculture and livestock. Both concepts were based on different ways of using the territory by identifying its values and characteristics, and thereby leading to the creation of different housing clusters, adapted to a mild summer climate and to demanding winters, in response to the needs of economic exploitation (Gomes, 2014). This argument was previously revealed by Oliver (1987), when emphasising that the economics of settlements relate to time-distance factors, which affect the ability of a population to work its lands.

This issue also relates directly, to the economy and the livelihood in the settlement, as with the occupation of the territory. The village of *Strojna na Koroskem*, in Slovenia, addresses this matter. The village is located in the Alpine region of narrow valleys with livestock pens. In the past, the region was inaccessible for a good part of the year, due to the snow. The farm buildings comprised a dwelling, with residences for the owners and sometimes for the workers too, as well as the rural equipment and auxiliary structures needed for life and production. The main residential dwelling could be attached to the working part, or could be autonomous. Required for the development of the farm economy, the outbuildings were composed by stables, animal barn and other auxiliary buildings. The animal barn required more attention; therefore it was located near the dwelling; while the other structures could be distant from the main house. The farm was totally functional (Juvanec, 2009).

Economically speaking, the farmstead is a rural economic unit based upon agricultural work, and livestock. The members of the family and other hired workers carry out the work. The farm community is technically and economically efficient, basing its self-economy in various principles: mainly the possibility of managing the work beforehand, which allows having the work spread-out throughout the year for all the workers involved, and therefore providing not only regular work, but also self-subsistence at home (fig. 8).

The impact of economic factors on local development

The current abandonment of several vernacular structures leads to the need to define a conservation and enhancement strategy for rural heritage, through sustained intervention, considering that natural and cultural resources are based on economic and social reorganisation. According to Barão, Valente and Reimão Costa (2014), any conservation strategy and promotion of cultural heritage in rural areas, corresponds to a deliberate intention to safeguard cultural natural resources for the future. This would be possible through sustainable development which would ensure an ecological balance, in terms of management related to the economic, social and functional reorganisation of cultural heritage, at different levels.

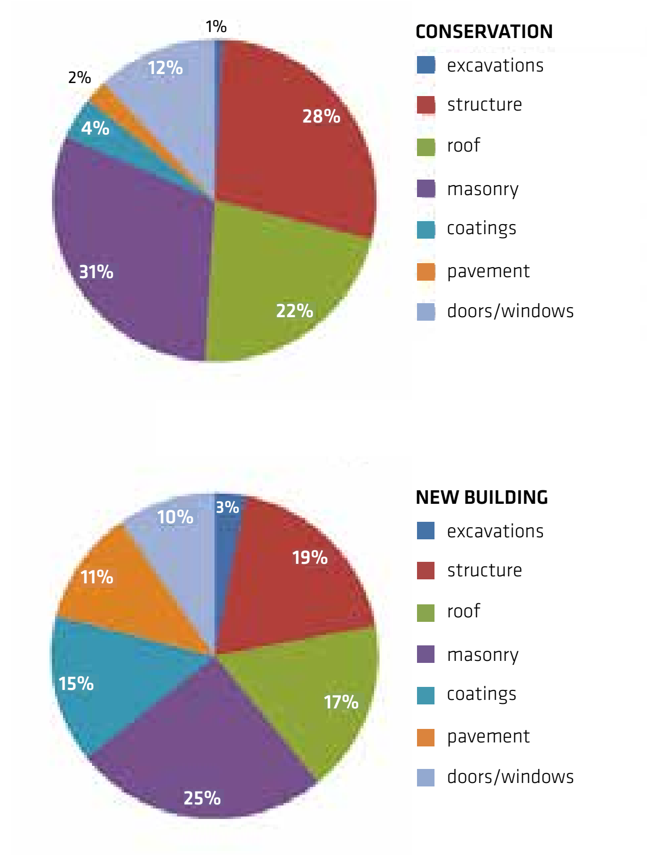


Fig. 9 Economic value assessment table of vernacular architecture conservation versus new building, in Rincón de Ademuz, Valencia, Spain (credits: F. Vegas, C. Mileto).

Several authors also argue that a deeper study of economic factors could have a relevant impact on local development, as a key issue to give significance to the local community and its protection. According to Fernandes and Mateus (2012), research, professional training in traditional techniques, conservation actions or adaptation of existing vernacular heritage could also contribute to boost local economies. The spread and success of these actions could even promote the revival of small industries of traditional local materials, reducing energy needs in the production and transportation of building materials. This could definitely have a positive impact on local development.

Assessing the economic value of vernacular architecture

Some authors, such as Giannakopoulou and Kaliampakos (2014), support the idea that vernacular architecture itself holds the key for the development of vernacular heritage in isolated regions (i.e. in mountainous regions). The only way to assure that maintenance and conservation is cheaper than new building is to reveal the potential benefits of vernacular architecture in monetary terms. According to Giannakopoulou et al. (2011), 'several authors (such as Coller and Harrison, 1995; Bateman and Willis, 1996; Carson, 2004) already applied this cost evaluation through a well-known and widely stated preference technique, the *Contingent Valuation Method*. The preliminary findings indicate that vernacular architecture holds a significant value, which could justify its protection. However, regarding this matter, more quantitative analyses should be undertaken, comparing different regions and criteria of intervention.

Impact of conservation in economic terms

As a result of the workshop dedicated to *Heritage Economics and Conservation Funding* organised in Syria, Ost emphasised that conservation is "an economic process of allocating resources today, in order to maintain and/or obtain higher economic values tomorrow" (2010, p.90). This is generally accepted when referring to monumental architecture and world heritage sites, due to the impact of tourism. The uncertainty arises from the conservation of traditional architecture. The fact is that conservation of traditional architecture may also prove to be a powerful motor for economic development and the promotion of handicrafts, building trades and small industry in rural areas.

Economic assessments developed in Rincón de Ademuz, in Valencia, Spain (Mileto and Vegas, 2005), demonstrated that the conservation cost of existing buildings did not exceed the cost of erecting new structures. The comparative analysis began with the rehabilitation of a single building and was subsequently extended to twenty buildings in the region. In all, costs and performance of conservation were studied, both in project and on site construction (fig. 9).
The study demonstrated that the conservation cost of an existing building did not exceed the cost of erecting a new structure. This was possible, as the overall aim was to stop the demolition and the substitution of the traditional houses that constitute the vernacular built heritage by new houses that increasingly alter the built landscape, eliminating its value, content and identity. Therefore, conservation practice was complete on twenty vernacular buildings, in a poor state of conservation. The performance of every project was measured and the cost of all units was estimated. The partial costs of recovering each element of the building were compared with the equivalent replacement costs that would entail its new construction, in the case of demolition, and substitution by a newly built house.
Furthermore, this study also demonstrated that conserving and reusing an existent building requires much more local handcrafts than

COMPONENTS	NEW BUILDING / CONSERVATION COSTS VERNACULAR ARCHITECTURE
Excavations	333, 33%
Structure	-14, 74%
Roof	-1, 35%
Masonry	7, 92%
Renderings	350, 00%
Pavement	531, 58%
Doors/Windows	5, 00%

Fig. 10-11 Costs comparison of vernacular architecture conservation versus new building, in Rincón de Ademuz, Valencia, Spain (credits: F. Vegas, C. Mileto).

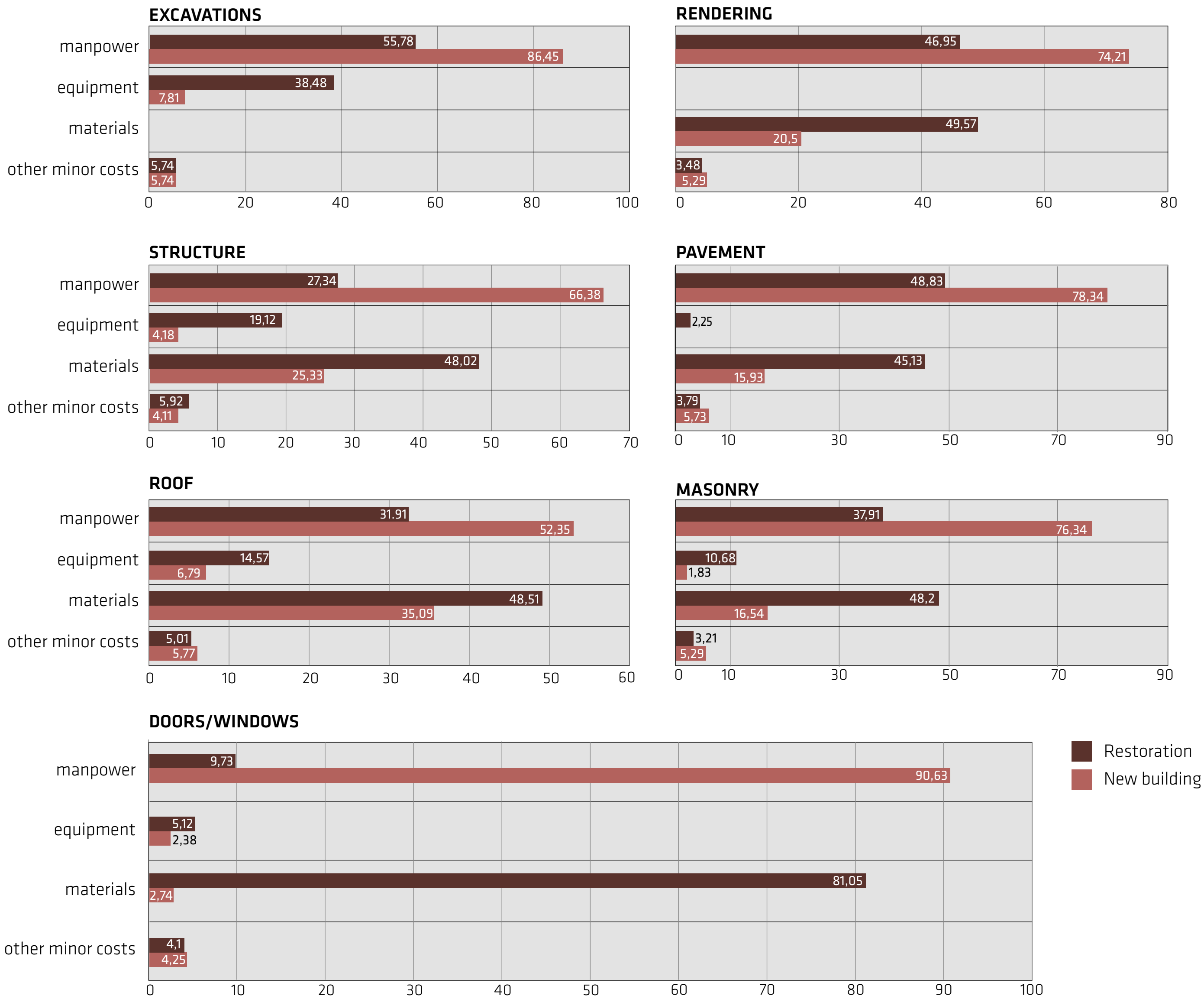


Fig. 12 Communitarian maintenance of vernacular buildings in Romania (photo: M. Correia).

erectind a new structure, thus promoting the survival of traditional building trades, generating labor demand on site and benefitting local economy (fig. 10, 11).

Conservation and partial or total rehabilitation of the built heritage represents a sensible and sustainable attitude (Doglioni, 2008), as it allows the existing resources to be reused.

Careful rehabilitation of this rural heritage consumes much less resources and energy, and generates less carbon dioxide during the construction. This not only provides savings in the transport of demolition debris, but also proves to be less expensive in the delivery of the materials for new building, and avoids the use of large equipment during construction. The use of traditional techniques and local materials in the conservation of vernacular architecture is the result of the advantageous use of means and resources available in the vicinity with nearly no transformation. This also allows important savings that help decrease the pollution of the environment.

Conservation of traditional architecture

Conservation of traditional architecture, independent of its absolute cost has in general terms, a very positive influence on the development of the local economy, as it generates labour demand, and preserves the building handicrafts and trades. It also allows the safeguarding of the cultural identity of traditional architecture in rural settlements, which constitutes an attraction for cultural tourism and encourages the development of the local economy. The fact that many international institutions recognise the importance of vernacular heritage conservation supports the relevancy of this legacy, in terms both of economy and identity (MEDA-CORPUS, 2011). The conservation of traditional architecture is an excellent field to redirect community-oriented economic activities.

Conclusions

The traditional production system ensures the management of tangible and intangible assets, confirming the sustainability of the method, under the basic rule of closing cycles and with the restriction of a pattern that governs it: the economy.

The steps to achieve this balance have to be the essential ones, which are possible through minimum effort, reduced movement, efficient work, effective management of the available resources, and collaborative efforts to ensure maintenance over time (fig. 12). However, the re-adoption of these ways to operate and to face the challenges presented by sustainability is not as self-evident, as it may seem at a first approach. With the introduction of modernity, major differences appeared within traditional models. Nowadays, the challenge brought by contemporary society is to regulate traditional ways of life and to justify, both in economic and energy-efficiency terms, the importance for the need of conserving vernacular settlements and structures.

The rapid transformation of the world is having a great impact on the socio-economics of vernacular architecture, which is also changing with great speed. The response could emerge from the regeneration of rural areas in regions that are under change and the preservation of vernacular ways of life in original habitats. As mentioned by Oliver (2006), the discourse on sustainability is too city-oriented. The implementation of decentralized policies in rural economies could contribute to the regeneration of these rural areas, a relevant and needed approach. The conservation and redevelopment of these areas could be a way to discontinue the expansion of cities and to contribute to the preservation of balanced habitats that are still alive nowadays and that support the diversity and the quality of life in this world.

Socio-cultural resilience; *lakou* layout in post-disaster tent encampments, Haiti (photo: United Nations Development Program).

Resilience of vernacular architecture

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Pınar Kısa Ovalı Trakya University, Institute of Science and Technology, Edirne, Turkey

"It is not the strongest or the most intelligent who will survive but those who can best manage change". **Charles Darwin (*The Origin of Species*, 1859)**

In recent years the evidence of human-initiated climate change has already began to transform human habitats. The most pronounced changes occur in cities under the negative outcomes of rapid urbanisation, consumption of natural resources and demographic changes. Mitigating the impacts of changing environmental conditions is one of the major urban challenges of today's cities. In this context resilience has been introduced in the field of urban planning and architecture as an integral concept for increasing the ability of adaptation of human settlements in the face of changes.

The notion of 'resilience' in urban science, describes the capacity of human habitats to absorb shocks and perturbations without undergoing major alterations in its functional, physical, social and economic systems. A crucial feature of a resilient urban system is having the ability to survive the potential risks and threats as well as taking advantage of the positive outcomes that the disturbances bring. Vernacular architecture, which is in continuous evolution, constitutes a substantial research field with its immense adapting capacity to the changing external circumstances. The understanding of resilience sees the environment in constant transformation; therefore resilient architecture presupposes a dynamic architecture, which is primarily characterised by *flexibility* and *adaptability*. In this case, vernacular architecture, which includes in its origins a series of responses to the changing dynamic factors such as micro-climate, local materials and local living cultures, can meet the requirements of resilience.

What is resilience?

The word resilience was first used as a term in psychology in the 1950s to describe the tolerance abilities of children. The term was also used within a conglomerate of qualities that allow people to remain psychologically balanced and mentally healthy in the presence of negative life circumstances and crises (Petzold et al., 2002).

Subsequently the term 'resilience' has gained significance in different disciplines and scientific contexts (Burkner, 2010): from approaches to human ecology and taxonomy to studies on developing countries. The resilience of an ecosystem has firstly defined by Hollings (1973) as "the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes" (Van et al., 2012, p. 310). Hollings also underlined the fact that a resilient ecosystem can withstand shocks and rebuild itself when necessary. The Resilience Alliance (2002) further define the characteristics of resilience in natural environment, which can also be used as a measuring system of the resilience of an ecosystem. These characteristics refer mainly to the amount of change that the system can endure under crisis, the level of self-organization capacity of the system and the ability of a system to adapt itself to the new conditions and learn from the experienced disturbances.

In 2007, Ward described resilience stating: "change is constant and unpredictable in a complex and dynamic world" (Ward, 2007). Afterwards, two definitions which specifically relate to urban resilience have been formulated: the first one belongs to Walker (2004) who defines resilience in these words: "resilience is a capacity of a system to absorb disturbance and reorganize itself while undergoing change, so as to still remain essentially the same function, structure, identity and feedbacks". A second, similar definition, in terms of urban resilience, was given by the 'Resilience Alliance' (2002) who defined it as "the ability to absorb disturbances to be changed and then to re-organise and still have the same identity (retain the same basic structure and ways of functioning)"[1]. This definition further emphasizes the ability of a resilient system to learn from disturbances and crisis.

In the framework of 'sustainability', which deals with the scarcity of natural resources and economic crisis, 'resilience' emerges as a 'complementary' key approach in urban planning and architec-

[1] The notion of resilience is defined here by the 'Resilience Alliance' as a series of key concepts, available at www.resalliance.org/index.php/key_concepts.

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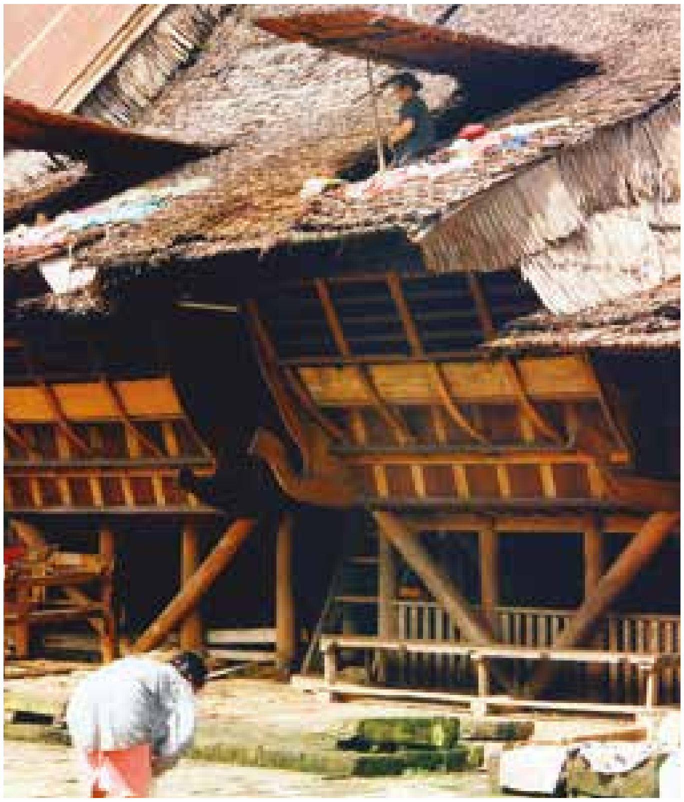

Fig. 1 Resilience through local construction systems. Traditional timber framed houses of Nias Island, Sumatra, Indonesia (photo: Ouicoude).

ture. The relation between 'sustainability' and 'resilience' has been discussed in the Resilient Communities and Cities Partnership Program (ICLEI) in 2004: "How can a city be truly 'sustainable' if it lacks the capacity to reduce vulnerability to crisis and to respond creatively to change? This essential capacity can be described as 'local resilience'. Therefore, a new agenda must be introduced in the sustainable cities movement. A sustainable city must be a resilient city. a sustainable community must be a resilient community" (Otto-Zimmermann,2012, p.3). According to this consideration, a sustainable city must also have the ability to respond to environmental shocks and reduce its 'vulnerabilities' beyond simply optimizing its energy requirements. In comparison with the concept of 'sustainability', 'resilience' is a more dynamic notion as it refers to 'transformation', 'flexibility' and 'adaptation' of the systems through changing circumstances while 'sustainability' is mostly concerned with sustaining the 'stability' without requiring re-adaptation. However resilience seems to have an opposite sense in this respect to sustainability, and although they both focus on maintaining the system's *equilibrium*, they do it in different ways.

A human habitat can be truly sustainable only if it can manage to establish a balance between the changing conditions while maintaining its indigenous characteristics by rebuilding new systems in order to respond to forthcoming changes. The features of a sustainable habitat substantially coincide with the requirements of a resilient system in environmental, socio-cultural and socio-economic terms. Therefore the two concepts, 'sustainability' and 'resilience', are inseparable and vital for the survival of human settlements in changing environments. Responding to the requirements of both sustainability and resilience will strengthen our cities in the face of forthcoming climatic, environmental, socio-cultural and socio-economic changes.

Role of indigenous cultures in the context of resilience

The close relationship between vernacular architecture and resilience was first noticed in the definition by Paul Oliver (1997): "vernacular dwellings and buildings are related to their environmental context and available resources, they are customarily owner or community built, utilizing traditional technologies. All forms of vernacular architecture are built to meet specific needs, accommodating the values, economies and ways of living of the cultures that produce them". Oliver's description points out the existence of numerous parameters in the constitution of a local building culture, above all the role of the 'micro-climate' and various environmental conditions. Therefore, indigenous knowledge and vernacular culture become very specific and localized and can represent the specific responses given in the pre-industrialization age by human beings to environmental, socio-cultural and economic challenges by processing available natural resources for their survival.

Indigenous knowledge refers to the methods and experiences selected and established by local communities from a progressive understanding of the local resources, constraints, values and risks over the years. The most relevant character of indigenous knowledge, which distinguishes it from other categories of culture, is that of being diffused informally and developed/transmitted collectively over generations: accumulated practices have not been experimented in a systematic and scientific way over the years, since they are mostly a series of social and shared values that are transmitted from one generation to the next. Looking for sustainable design paths for future architecture and human settlements, we can rely on past findings for developing resilient planning strategies, analysing, selecting, testing and verifying the intangible heritage of vernacular archi-

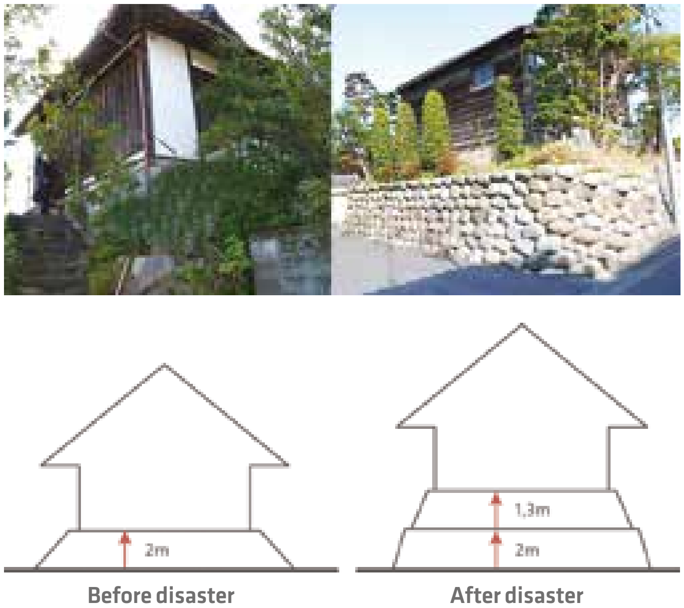

Fig. 2
Initially, *mizuya* was built as a storage room to protect household assets. When a severe flood disaster occurred in 1896, the *mizuya*'s plinth height was only 2 m. After the flood destroyed *mizuya*, the householders reconstructed it by raising the plinth level 1.3 m higher than the previous level. Gifu, Japan (photo: NIED-KU, 2007 after Shaw et al. 2008).

tecture. In this way the heritage of vernacular architecture can provide a rich field of research concerned with developing new strategies of resilience, meant as the shock-absorbing capacity of systems aiming towards sustainability in a world of changes and transformations (Berkes, 2004).

Vernacular architecture heritage is characterized by three specific factors that are relevant for resilience:

- interaction with climate change and changing socio-cultural conditions;
- interaction with a certain environment after a certain time frame;
- being a socially shared knowledge.

Vernacular building culture has been established through centuries by many civilizations across the world through a process of trial and error. Accordingly, vernacular architecture is in a continuous evolution and shows different features and shapes which are based upon local climatic conditions, materials and living cultures.

In a given society, the existence of a local culture implies a favourable development of awareness that arises from diffused cultures. Indigenous knowledge plays an important role in the way communities deal with crises, disasters and profound changes. In this case the concept of 'resilience' becomes important for developing an approach to adaptation through a series of strategies by which the inhabitants use available resources to cope with adverse conditions that can occur due to the disasters. Resilience attributes to an ecosystem the ability to repair damages after a disaster, as well as to absorb impacts and manage emergencies together with the capacity to adapt and innovate in socio-territorial organization. Strengthening the resilience enables communities to develop a great capacity to mitigate the effects of natural hazards.

Traditional knowledge, which is achieved through experiences and intergenerational transmission, strengthens social-ecological systems as a result of its ability to deal with complexity and uncertainty (Berkes et al., 2000). Therefore it is natural to assume that indigenous knowledge is a source of resilience as has been proven for example in the case of Nias Island in 2004 when it was hit by a series of earthquakes which caused the death of 900 people (fig. 1).

The local building culture of the Nias Island has demonstrated an outstanding capacity to withstand strong seismic shocks. While 80% of the 'western style' concrete buildings, which were mainly built under the influence of 'modernism', collapsed, few of the vernacular buildings were damaged and ultimately caused less harm to the inhabitants due to the relative lightness of the wooden structures. In the indigenous culture of Nias, appropriate construction systems have been developed over years that adapt to the specific environmental conditions.

Indigenous knowledge has been proven also in the field of flood mitigation in Japan, in the flood-prone Gifu region. This experience elucidates the fact that when the traditional knowledge is well integrated with the technological systems, it facilitates handling catastrophic events in a better way. In Gifu, a dynamic strategy has been developed by building additional elevated houses called *mizuya* (fig. 2). Commonly the families build *mizuya* next to their main houses where they keep household assets. In the case of flood, *mizuya* serves as a protection room from the rising water level. Inhabitants of these houses are continuously adapting their *mizuya* to the changing flood level; when the water level tends to exceed the plinth level, *mizuya* can be reconstructed by raising its height to adapt it to future floods.

Vernacular building culture has a close relationship with environmental factors and is conscious of the fact that natural changes and alterations are normal and nothing new; in many cases vernacular architecture of a specific site is the result of a selection of an architectural culture which is able to prevent changes (mostly climatic, but also social and cultural) and to mitigate their consequences and effects in order to adapt itself to the new established conditions.

The building principles of vernacular architecture incorporate var-

Fig. 3 General view of Kayaköy village, province of Mugla, Turkey (photo: P. Kısa Ovalı).
Fig. 4 Section of the settlement morphology of Kayaköy village, province of Mugla, Turkey (credits: P. Kısa Ovalı).
Fig. 5 Streets of Kayaköy village as a drainage system, province of Mugla, Turkey (photo: P. Kısa Ovalı).

ious strategies to enhance resilience through three main actions: *prevention*, *resistance* and *adaptation*. While *prevention* and *resistance* are related to the management of risks and threats, *adaptation* concerns itself with the recovery capabilities of an ecosystem after shocks and disturbances which in our case are changing circumstances. Adaptive capacity relates to the preconditions that enable actions and adjustments in response to changes in order to establish a new state of equilibrium within current post-change conditions.

Environmental dimensions of resilience in vernacular architecture

Environmental resilience reflects the effectiveness and capacity of an ecosystem to deal with changing environmental conditions by reducing its physical vulnerabilities. The degree of a community's vulnerability depends on its physical exposure to natural hazards and on its capacity to absorb the negative effects of changes and re-organise itself.

In pre-industrial societies, climatic variability and the uncertain presence of water and other resources lead local communities to develop adaptive practices in order to respond to variability and change, making up in this way for the lack of modern technology, transports, and global market economy. Therefore traditional knowledge played a central role in responding to environmental crises: through processes of trial and error, practices and institutions have been developed to cope with changes and unpredictable events (Gómez-Baggethun et al., 2012).

The preconditions of environmental resilience are enhanced through three stages of strategies related to *pre-crisis* and *post-crisis*.

- Strategies of *prevention* of environmental crises enable communities to interact with environmental changes of a specific site in order to avoid or reduce risks and threats. These strategies consist of several actions such as: land use management, assuring appropriate choice of site, considering the hydrography of the place and the management of water resources, comprehension of meteorological and biological systems, use of locally available materials, and considering the specific characteristics of local risks;
- Strategies for building *resistance* to environmental crises are based on the use of climate-adapted and durable materials, appropriate architectural and structural conformation (in terms of seismic resistance) and natural hazard management.
- Strategies of *adaptation* to post-crisis conditions are concerned with the flexibility of design, the sharing of building cultures and the development of self-construction systems in order to facilitate fast recovery after natural disasters.

The most prevalent indicators of an adequate coexistence with environmental conditions are: the settlement morphology, the spatial layout of vernacular buildings and their relation with natu-

Fig. 6 Interior views of the courtyards in Tissergat and in Chefchaouen, Morocco (photo: L. Dipasquale).
Fig. 7 Patio with its reduced dimensions work as a filter during sand storms. The Ksar of Tissergat, Draa Valley, Morocco (photo: B. Aguilar).
Fig 8-9 Internal view of a patio in Tissergat, Draa Valley, Morocco (photos: L. Dipasquale).

ral resources. As it is seen in the case of Kayaköy, a former Anatolian-Greek settlement situated in the South-west of Turkey, a virtuous land use strategy has been developed. Kayaköy and other five neighbour settlements are founded on the slopes that surround the unique cultivable lowland of the region, which is situated 62 meters below (fig. 3). The choice of settling on the slopes and leaving the plain area for farming activities demonstrates the presence of environmental knowledge that is accumulated over the years (Kısa Ovalı, 2009). Placing the settlement on the high levels helps also to protect it from floods. In Kayaköy, all streets are planned in such a way that they could act as a drainage system by working as water canals in order to discharge excessive rain water down to the lowland (Kısa Ovalı, 2009) (fig. 4-5).

In terms of adaptation to the changing external temperature of daily and seasonal cycles, specific strategies have been developed related to the specific features of the site such as water collecting systems, natural ventilation, passive heating and cooling systems. In this context, a winning morphological model, adopted in all the Mediterranean area, which provides resilience against changing extreme climate conditions, is the 'courtyard house' (fig. 6-7): the central courtyard acts in the night as a natural cooling and ventilation system thanks to the air convention property that is based upon the principle of rising of warm air which is replaced by cool air. In addition to the chimney effect of the courtyard, the thermal inertia of the walls of the courtyard house contributes considerably to keeping the interior spaces cool. Whereas in the evening time the air of the *patio*, which has been heated directly by the sun and indirectly by the walls, rises up while nocturnal cool air gradually replaces it (Aguilar et al., 2013). According to this case it is clear that the adaptation is achieved through the courtyard, which has a shifting function according to the daily changing climatic conditions in order to provide indoor comfort in a totally passive and ecological way. The formal features of the courtyard show diversities according to the specific climatic conditions and living cultures; in desert areas, the courtyard presents very reduced dimensions in order to function as a filter during sand storms (fig. 8-9), while in warm and cold climate areas the courtyard has an extensive shape to capture more sunlight. As seen in both cases, the courtyard with its locally adapted design provides resilience against changing extreme conditions.

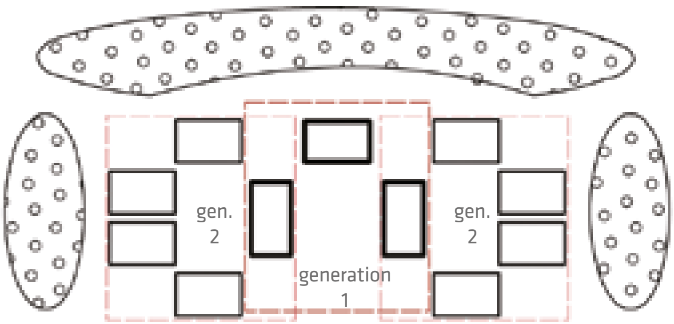

Fig. 10 Organization scheme of traditional dwellings according to 'Lakou' culture (credits: J. Miller).
Fig. 11 Proximity of cultivation terraces to the dwellings. The vineyards in Corniglia, region of Liguria, Italy (photo: B. Özel).
Fig. 12 Close relationship between the living and production areas. Traditional dwellings in Greve in Chianti, Tuscany, Italy (photo: B. Özel).

Socio-cultural dimensions of resilience in vernacular communities

The socio-cultural dimensions of vernacular heritage include intangible values such as beliefs, social behaviours, knowledge, building cultures and social cohesion that give the communities their identities. Consequently socio-cultural identities play a crucial role in terms of reducing vulnerabilities and strengthening the resilience of the communities: indigenous culture is important since it includes the knowledge of management of the territory in an appropriate way, which is indispensable to prevent natural disasters.

Socio-cultural resilience is acquired through three stages of strategies that regard *pre-crisis* and *post-crisis* phases.

- Socio-cultural strategies for crisis *prevention*, which aim to avoid risks and reduce social vulnerabilities by using local living cultures and traditions, consist of understanding the value of the place and its dynamics and disseminating local knowledge regarding practices and actions to cope with disruptions.
- Socio-cultural *resistance* is achieved through various strategies such as: community preparation for emergency, knowledge of alerting systems, strengthening the network of relationships and trust, facilitating the participation of local communities in decision-making and constructive processes, transmitting cultural values and history, ascribing value to the development of collective welfare, building common infrastructures and shared spaces, as well as integrating new technologies to indigenous cultures.
- Socio-cultural *adaptation* to post-crisis conditions is concerned with strategies based on sharing activities such as: swapping know-how on change management, maintaining the psychological health of communities, activating mutual reciprocal actions and sharing of wealth, food, labour and knowledge, sharing early warning systems, planning and activating mobility of people or goods according to climatic changes, and incorporating strategies for fast post-disaster recovery including temporary structures.

There are many practices for the oral transmission of knowledge regarding change adaptation: tales, songs and proverbs were used to store the collective memory of communities (Gómez-Baggethun, 2012). The transmission of living cultures from generation to generation and an increase in the acknowledgement of basic needs such as agriculture, or construction cultures (the so-called 'know-how') makes communities capable of recovering their living systems in case of perturbations.

The identity inherent in the cultural heritage also helps survivors to recover from the negative psychological impacts of disasters. The evidence of the power of socio-cultural values on post disaster recovery has been seen in Haiti after the devastating earthquake in 2010. The *lakou*, which historically means a large extended family, headed by the oldest male and grouped spatially in a cluster of houses, represents the space where a family grows and socializes by creating nucleus of urban texture (fig. 10). More than a pattern of set-

Fig. 13 Traditional *hórreo* in Galicia, Spain (photo: B. Juvanec).

Fig. 14 Typical nort-west Asturian *hórreo*, Spain (photo: R. Piñeiro).

Fig. 15 The 'serender', typical granaries in the Black Sea Region of Turkey (photo: R. Jackson).

tlement, the clustering symbolizes the family's unity and solidarity against the challenges of maintaining the property (Miller, 2012). The *lakou* culture also develops a social structure through reciprocal food sharing and helping each other in difficult times and during work. It is really interesting that the Haitians created a *lakou* layout in post-disaster tent encampments, which were supposed to be temporary settlements. According to the observation of researchers, most people do not want to leave their temporary settlements and have established a sense of community in their current environment (Miller, 2012). As mentioned previously, the notion of 'resilience' means not only surviving crises and perturbations but also re-establishing equilibrium through adaptation to the post-disaster conditions. Therefore in the terms of resilience, the culture of *lakou* works and helps to maintain the psychological health and vibrancy of the community.

Socio-economic dimensions of resilience in vernacular settlements

The economy of vernacular settlements is closely linked to the environment, or else to the locally available physical and human resources. Being based on natural conditions, the traditional productivity is closely influenced by the climatic and biological characteristics. Therefore the loss of a global economy makes the traditional productive activities strongly dependent on local changes. The linkage of economic and social welfare in local dimensions requires, for a good coexistence, a deep knowledge of seasonal cycles, natural disasters and social crisis management. Regarding building production, the participation of local communities in decision-making and in the productive process can reduce costs.

'Self-sufficiency' is the most essential precondition for a community to be socio-economically resilient. A 'self-sustaining' or 'self-sufficient' ecosystem has the capacity to maintain itself by independent effort without external support in case of crisis. In terms of urbanism, 'self-sufficiency' refers to the productive dimension of the cities which have the capacity of producing sufficient food, energy, building materials and services (Özel et al. 2014). The 'proximity' of productive areas to the dwellings, as well as shared cultivation and construction cultures, promotes the 'self-sufficiency' of vernacular settlements. Even when the land presents difficult morphological conditions, the 'proximity' of cultivated fields is ensured in creative ways, as can be seen in the Cinqueterre (Italy). The localities in this region are situated on top of hills, at a high of about 100 meters, and they are all surrounded by vineyards on terraces. The agricultural activities are managed thanks to the typical Ligurian terrace system (fig. 11).

The preconditions for socio-economic resilience regard three stages of strategies related to *pre-crisis* and *post-crisis* periods.

- Strategies for the *prevention* of socio-economic crises, which aim to avoid and reduce economic crisis and scarcity threats, consist of: using local and accessible resources, optimising the use of materials and promoting indigenous workmanship, selecting productions adapted to the local conditions, reinforcing local production of food, and including spaces for productive activities at housing scale.
- Strategies for building socio-economic *resistance* to crises based on sharing goods, integrating production, recognising the value of local products, transmitting production knowledge, enhancing local economy empowerment, promoting collective use of spaces, and transportation efforts.
- Strategies for developing socio-economic *adaptation* to the post-crisis economic conditions focuses on the storing and pooling

Fig. 16 Ice house in Monte Arcibessi, province of Ragusa, Sicily, Italy. (photo: S. Cultrera)

Tab. 1 Resilience approaches from vernacular heritage. (L. Dipasquale, S. Mecca, B. Özel)

of resources, sharing infrastructures and facilities, planning mobility according to human and physical resources availability, enhancing technical simplicity in building process, and optimizing construction efforts.

The food production and tending of livestock are part of daily activities, therefore vernacular houses are built in such a way that the production facilities can be included in the living areas (fig. 12). Vernacular dwellings are equipped with storages, domestic workshops, ovens and wells in order to carry out a series of productive activities in order to make the food accessible in all seasons. These spaces, especially the storages, have a major importance for achieving 'food security' as they are built to keep wheat and other essential substances for 'food production' during the difficult periods of the year with extreme climate conditions. The 'granaries' have particular architectural features, since they need to provide an appropriate structure in order to avoid humidity and the presence of rodents. The *hórreo*, the typical granary of the North-west of the Iberian Peninsula, is built in wood or stone, raised from the ground by pillars (fig. 13-14). The same is true in the Black Sea region of Turkey; the granaries, called *serender*, are a fundamental part of traditional houses (fig. 15). The *serender* shows the same morphological features as the *hórreo* since it is built on wooden pillars, raised from the ground for the same reasons. Storages show different features according to the needs. While 'granaries' are built raised on pillars, 'ice-houses', which act like a natural fridge to preserve food during the hot months, are built underground in order to offer more thermal insulation (fig. 16). As it is seen in both cases, indigenous people improved local cultures both by taking advantage of natural benefits and by protecting their socio-economic situation in the face of crises.

Resilience lessons from vernacular heritage for contemporary architecture

Strategies for resilience are intrinsic to traditional cultures. Moreover, they are highly reliable since they have had a long evolution over the years. Indigenous people have developed an immense knowledge, as well as useful disaster prevention strategies over generations thanks to the accumulated experiences of survivals during numerous crises; the experiences and lessons learned from previous disturbances have a crucial role in shaping resilient dwellings and habitats.

Today the traditional knowledge system is difficult to identify, since it is usually embedded in local cultures, rituals and symbols (Gomez-Baggethin, 2012), or else it is orally transmitted from generation to generation. Codifying this traditional knowledge that has not been registered in written form (material and immaterial heritage) could become a strategy to safeguard the heritage at risk, for example by identifying new solution for contemporary resilient architectures. A comprehensive inventory and multidisciplinary analysis of local resilient solutions could generate local practice codes, such as standards and quality controls, to be used for preventing, conserving and designing buildings (Dipasquale et al, 2011).

Practices of prevention and adaptation that come from vernacular architecture should be integrated with technological information and technical skills, in order to validate these practices as well as to educate the communities about potential hazard and risks. Participation of the community in decision-making regarding the site, building design, and construction details is decisive to consolidate their knowledge and sense of belonging and fellowship.

Local communities can reduce their vulnerability in the face of natural hazards and improve their resilience through locally managed and also small-scale mitigation activities; however, vulnerabilities can also be reduced through education, raising awareness, and fostering the conscious capacity of building and planning. These non-structural methods are often as important over the long term as structural mitigation, in a sustainable way of living.

	PRE-CRISIS PHASE **PREVENTION + MITIGATION** APPROACHES	**CRISIS** PHASE **RESPONSE + RESISTANCE** APPROACHES	**POST-CRISIS** PHASE **RECOVERY + ADAPTATION** APPROACHES
ENVIRONMENTAL	• Land use management • Assuring appropriate choice of site • Considering the hydrography of the place • Comprehension of meteorological and biological systems • Use of locally available materials • Considering the specific characteristics of local risks	• Use of climate-adapted and durable materials • Appropriate architectural and structural conformation • Natural hazard management	• Flexible design • Sharing of building cultures • Development of self-construction systems in order to facilitate fast recovery
SOCIO-CULTURAL	• Recognising local living cultures and traditions • Understanding the value of the place and its dynamics • Disseminating local knowledge regarding practices and actions to cope with disruptions	• Knowledge of alerting systems • Strengthening the network of relationships and trust • Transmitting cultural values and history • Ascribing value to the development of collective welfare • Building common infrastructures and shared spaces	• Swapping know-how on change management • Maintaining the psychological health of communities • Activating mutual reciprocal actions and sharing of food, labour and knowledge • Incorporating strategies for fast post-disaster recovery including temporary structures
SOCIO-ECONOMIC	• Using local and accessible resources • Optimising the use of materials and promoting indigenous workmanship • Selecting productions adapted to the local conditions • Reinforcing local production of food • including spaces for productive activities at domestic scale	• Sharing goods • Integrated production • Recognising the value of local products • Enhancing local economy empowerment • Promoting collective use of spaces	• Storing and pooling of resources • Sharing infrastructures and facilities • Planning mobility according to human and physical resources availability • Enhancing technical simplicity and self-building activities in building process • Optimizing construction efforts

Contemporary rammed earth wall of 'La Raia' Winery, Novi Ligure, Piedmont, Italy (photo: B. Özel).

Parameters of vernacular sustainability throughout the 20th Century architecture

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Three basic pillars of sustainability have been defined in this research project, namely environmental, sociocultural and socioeconomic issues, divided into fifteen principles that are explained and illustrated in this book (Guillaud et al, 2014). In general terms, the contemporary architecture best known or most publicised in specialised journals, including the architecture labelled sustainable, finds it very hard to comply with a large enough number of parameters to be deemed sustainable. Considering the schism from the past caused by the advent of the Modern Movement in the history of project-conceived, not vernacular, architecture, we think it is worth having a quick look as the fifteenz sustainability parameters in the period between their appearance and the present day.

The examples that illustrate the beginning and evolution of sensibility regarding each individual parameter have been chosen because they constituted a landmark in the last century. These examples do not pretend to be exhaustive, nor could they be, but they do strive to stimulate the view of modern architecture on the sometimes clumsy and partial but steady path to sustainability. Some of these examples comply with other parameters too, but they usually attract our attention fundamentally regarding one of them rather than the others. At the end of this historic review, we shall give some examples of contemporary architecture that manage to comply with most of the 15 sustainability parameters.

Environmental principles

1. *To respect nature, environmental context and landscape*

This parameter received special attention from the representatives of what is known as organic architecture, with many of the most outstanding examples built by Frank Lloyd Wright as a pioneer in using local materials and reinterpreting local building techniques throughout his professional career, apart from integrating nature into his projects. Other architects who have often taken this parameter into account in their works are Alvar Aalto and Jörn Utzon, among others, that is, architects with a special sensibility towards the nature of their native lands, and who often chose an organic design for their buildings. Among the more recent examples, we can mention the Tussols-Basil Track and Field Stadium in Olot, Spain (2002), by RCR Architects, which interblends and merges with the surrounding woods (El Croquis, 2003, 2003) (fig. 1), or Pachacamac Hill House, to the south of Lima, Peru (2010) by Longhi Architects, which illustrates the symbiosis between land and human activity while blending with its surroundings (Longhi Architects, 2010). Respect for nature is especially present also in architects who specialised in landscape architecture, like pioneer Frederick Law Olmstedt (Martin, 2011) and, more recently, Alfred Caldwell (Domer, 1997) or Shlomo Aronson (Aronson, 1998), among many others.

2. *To benefit natural and climatic resources*

The idea of a suitable location has been a parameter common to all architecture since olden times. As far as modern architecture is concerned, suitable location is one of the main concerns of the group of organic architects mentioned above. In this historic overview of the last hundred years, we can especially underscore the situation of Taliesin Villa (1911, 1914, 1928) by Frank Lloyd Wright in Spring Green, Wisconsin, USA (Levine 1996, pp. 74-111) (fig. 2) or Curzio Malaparte's house on the island of Capri by Adalberto Libera (Savi et al. 1989, pp. 6-31), among others. Appropriate situation on natural slopes has also been common practice in well-known architects with interesting results, like the housing estate in Kauttua in Finland (1938) by Alvar Aalto (Schildt, 1996), the apartments in the bay of Mazarrón, Spain (1968) by Miguel Fissac (AAVV., 2006) or the house in Moledo do Minho, Portugal (1998) by Eduardo Souto de Moura (El Croquis, 2005). Other more recent examples of buildings wisely located on their plot and fitting in with their surroundings not only from an environmental but also a formal point of view are the Fundación Miró at Palma de Mallorca (1992) by Rafael Moneo (El Croquis, 2004) and the Museo Domus (1995) in A Coruña by Arata Isozaki (AAVV., 2005), both in Spain.

3. *To reduce pollution and waste materials*

There are interesting examples in the architecture of the last century in which rough materials and vernacular techniques have been deliberately used, such as the retirement home in Karuizara, Japan by Antonin Raymond (1933) (Helfrich et al., 2006), the houses and furniture designed by Wharton Esherick (Bascom, 2010) or George Nakashima (Nakashima, 2003) or the several saunas made of logs and with a roof garden by Alvar Aalto or Reima and Raili Pietilä (Quantrill, 1985).

M. Correia, L. Dipasquale, S. Mecca (edited by), *VERSUS: Heritage for Tomorrow. Vernacular Knowledge for Sustainable Architecture*, ISBN (online) 978-88-6655-742-5, ISBN (print) 978-88-6655-741-8,

Fig. 1 Field Stadium of Olot, Spain, designed by RCR Architects in 2002 (photo: F. Vegas, C. Mileto).

Fig. 2 Taliesin Villa (1911, 1914, 1928) by Frank Lloyd Wright on top of a small hill in Helena Valley, Spring Green. Wisconsin, USA (photo: F. Vegas, C. Mileto).

The reuse of waste materials to reduce their impact on the environment is another interesting line copied from the vernacular logic of reusing materials that has always existed in traditional architecture and has been transmitted to the present in the neo-vernacular architecture typical of urban slums and shanty towns, which makes use of any kind of material to build their constructions.

In contemporary architecture there are examples of recycling (Daggonet, 1997; Huygen, 2008; Van Hinte et al., 2008; AA.VV. 2009, pp. 56-65) like Le Manable in Argentan, France, built in 2007 by NAC, Cucurbitahome in Caaguazçu, Paraguay, built in 2008 by Elsa Zaldívar, different buildings of Earthship Biotecture in Taos, USA by Michael Reynolds and his imitators in Argentina, bottle houses, Heineken WOBOs and many other initiatives; recycling with a creative bent like Frank O Gehry's own home in Santa Monica, USA, built in 1978 (Chollet, 2001), the Scraphouse in San Francisco, USA, built in 2005 by Anna Rich or the living ship containers by Clément Gillet, Jim Poteet or the Tower Hamlets Container Cities in London and other places, among many other examples; or a paragon of inventiveness in the design of new elements with reprocessed materials, especially cardboard, like Frank O Gehry's furniture or the emergency architecture of Shigeru Ban.

It is also worth mentioning the Ningbo History Museum or the campus of the Superior School of Fine Arts at Xiangshan (2002-08) by Wang Shu, a personal poetics on the recycling of salvage materials that at the same time denounces the accelerated loss of Chinese cultural built heritage (Shu, 2013).

4. *To ensure human indoor comfort*

The creation of a luminous, ventilated and healthy architecture in open, green, inhabitable urban spaces, was one of the motors that fuelled the architecture of the Modern Movement. German Siedlungen in the nineteen twenties and Le Corbusier's dwellings in general revolve around this concept to begin with. However, natural illumination and ventilation, with the incorporation of lighting control elements, the creation of terraces and the inclusion of thermal insulation or hygrothermal control devices are not enough to ensure that a building will be healthy. The abuse of technology together with an excessive use of chemical products in Germany in the seventies and eighties generated an ecological awareness that affected and inoculated popular culture when selecting homes and work places to pursue architectures with healthier materials and treatments.

Among the most outstanding architects in the international panorama today in this regard it is worth mentioning the Australian Glenn Murcutt (Fromonot, 2005), a specialist in the design of houses inspired by the vernacular tradition of 19th Century colonists, with a suitable layout that guarantees natural lighting and ventilation, sunlight, the creation of protected spaces connecting the interior with the exterior, the elimination of the need for central heating or air conditioning, etc. The studio of Troppo Architects, specialists in the design of equally sensible sustainable architecture for tropical climes, is also Australian.

The use of vegetation as a compositional element in general and vegetable shade in particular has an important precedent as far back

Fig. 3 Caixa Forum building in Madrid by Herzog and de Meuron, with its vertical garden designed by the French botanist Patrick Blanc (2008). Madrid, Spain (photo: L. Dipasquale).

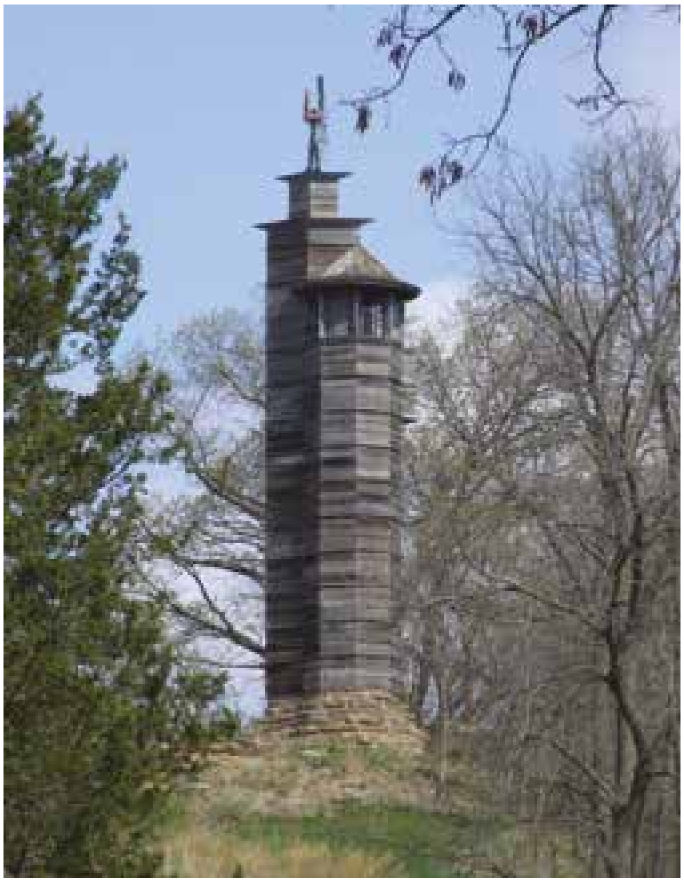
as Alvar Aalto's early work, which favoured the presence of vegetation inside and outside his buildings to counteract the coldness of technology, as well as creating trellises and espaliers for climbing plants whose design was partly influenced by Le Corbusier (Schildt, 1996). At the present time there are projects that have used vegetable shade as their main motif, with the creation of modern arbours, as in the case of Hedge by Atelier Kempe Thill Architects in Rostock, Germany, built in 2003 (2007, pp. 67-75); AlgaeBra (2012), with walls of water with photosensitive algae, by EcoLogic Studio (2006); the Japanese pavilion for the 11th Venice Biennale of Architecture (2008) by Junya Ishigami, or the vegetable cathedral by Giuliano Mauri in Bergamo (from 2010 on), surely inspired by the English and German 18th Century theories on the origin of Gothic architecture (Rykwert, 1981). In the last two decades vegetation has even taken on a vertical character, lining the walls and partition walls of buildings, like the Quai Branly Museum in Paris (2006) by Jean Nouvel or the Caixa Forum in Madrid (2008) by Herzog and de Meuron, both made in collaboration with the French botanist Patrick Blanc (fig. 3).

5. *To mitigate natural hazard effects*

Architecture projects that foresee the possible inclemency of nature, such as floods, earthquakes, hurricanes, unstable lands, etcetera, were created above all in environments with a serious and recurrent risk of these phenomena. As a pioneer, it is worth paying special attention to Frank Lloyd Wright's successful efforts in designing the Imperial Hotel in Tokyo to stand up to possible earthquakes, based on two parameters, the conception of a low centre of gravity for a symmetrical ensemble and laying the foundations on piles, with a view also to avoiding differential settlements on the very soft ground (Wright, 1992; Arnold et al., 1982; Arnold et al. 1980, pp. 42-46, 70). A well-known counterexample would be the famous magnificent Farnsworth House (1951) by Mies van der Rohe, built on the shores of the Fox River on small piles that are not sufficient to save the house from the frequent floods of the river, which have literally covered it on several occasions. In more recent architecture, we can mention the Sendai Mediatheque in Japan (2001) by the architect Toyo Ito (El Croquis, 2006; El Croquis, 2010) (fig. 4), whose extraordinary structural innovation with the visual non-existence of the vertical supports has not prevented it from withstanding the recent Tohoku earthquake in 2011, which reached 9 points in the Richter scale. In the sphere of restoration, in the last few decades, especially in Italy, an important corpus of knowledge is being generated regarding structural consolidation to resist frequent earthquakes, which, by the way, is now mandatory (Boarin et al. 2013, pp. 27-31), and it also takes into account respect for the built substance and the character of the building. In this sense, it is worth underscoring the exemplary delicate anti-seismic restoration and consolidation works carried out by Professor Francesco Doglioni, the introducer and promoter of alternative technical solutions like dry compression layers with planks and plywood panels, flat trussing bands on the roof of the buildings and different types of trusses inspired by tradition, etc. (Doglioni, 2008).

Fig. 4 Innovation in structural concept by the inspiration from surrounding trees. Sendai Mediatheque designed by Toyo Ito in 2001. Miyagi, Japan (photo: F. Vegas, C. Mileto).

Fig. 5 The Romeo and Juliet Windmill (1896) in Spring Green designed by Frank Lloyd Wright with modern forms covered with shingles following the local tradition. Wisconsin, USA (photo: F. Vegas, C. Mileto).



Sociocultural principles

6. *To protect cultural landscape*

Curiously enough, one of the first 20th Century architects to vindicate the value of the natural landscape and defend it from architectural projects alien to the context was Adolf Loos (1910, pp. 23-35). Throughout the 20th Century, greater sensibility towards the natural landscape often ran side by side with organicism in architecture, whose major representatives were Frank Lloyd Wright, Alvar Aalto and the landscape architects mentioned above. Today there are two exemplary cases that focus on the protection of the natural landscape that stemmed from a desire for the retrieval of beauty spots believed lost due to the poor treatment they had received in the past: the Vall d'en Joan in Garraf Park in Barcelona, Spain (2008) by Battle and Roig with Teresa Galí-Izard (AAVV., 2009a), which had been the city dump for 30 years; and Tudela-Culip at the Cap de Creus in Cadaqués, Spain (2010) by EMF Estudi and J/M Ardévol, which had been inappropriately urbanised in the nineteen sixties.

7. *To transfer building cultures*

There are precocious examples of the use of traditional techniques in architecture of the Modern Movement regarding a variety of materials, countries and contexts. We could mention the use of masonry fabrics in Henry Hobson Richardson's oeuvre and in several works by Frank Lloyd Wright, like Taliesin (from 1911 on) and shingle-covered wooden structures (Romeo and Juliet Windmill, 1896) (Levine 1996, pp. 80-83) (fig. 5.); the tradition in the use of timber in the work of Greene and Greene in California (Smith et al., 1998) and the use of log cabins in the first stages of Gropius' work (Sommerfeld House and the offices for the Sommerfeld Group, 1920-22) (Nerdinger 1988, pp. 69-72), or several works by Alvar Aalto under the influence of Karelian culture and even in the work of Le Corbusier in the Petit Cabanon (1952); the use of the thin-tile vault typical of the local tradition in the modern architecture of Josep Lluís Sert, Antonio Bonet and other members of the GATPAC (from 1930 on) (Álvarez et al., 1996); the reinterpretation of traditional brick fabric by the Wendingen Group in the nineteen twenties in Holland, especially in Michel de Klerk's work (Bock et al., 1997) (fig. 6); the use of shingle roofs in the Woodland Chapel of Stockholm cemetery by Gunnar Asplund (1920) (López-Peláez, 2002), etc.

Fig. 6 The whole work of Michel de Klerk and his fellows in the Wendingen Group is based on the local building tradition with bricks that gives continuity to the building culture in the modern buildings. Amsterdam, Holland (photo: F. Vegas, C. Mileto).

There are more and more architects today who resort to crafts and traditional vernacular techniques to design and construct contemporary buildings with roots in their local context. They use them as an aesthetic device, which at the same time helps maintain and transmit a constructive culture. Suffice it to recall as an example the interesting vegetable roofs in extremely contemporary projects like Pool House I (2001) and Pool House II (2009) in the south of England, by Kathryn Findlay, or the frequent use that Kengo Kuma makes in some of his projects of local materials and constructive traditions, as in the Yusuhara Marche Hotel in Yushihar-Cho, Japan (2010), where, as well as an interesting wooden arboreal structure, he uses bales of hay which serve as brise-soleils at the same time as they act as thermal insulation (Namias 2011, pp. 128-138); the stone in the Country House in Bijača, Bosnia (2011) by DVA Arhitekta; the cladding of the roof with shingles in the aerospatial shape of Chesa Futura in St Moritz, Switzerland (2004) by Norman Foster; the timber used in a newfangled way in the Wooden House (2008) by Shou Fujimoto; the Reindeer Spotting Pavilion, in the Dovrefjell National Park, Norway (2011) by Snohetta Architects (Károlyi 2012, p. 6); the Bubbletecture H (2010) by Shuhei Endo or the Haesley Nine Bridges Golf Club House in Seoul (2009) by Kyeong-Sik Yoon and Shigeru Ban (Balzani et al. 2010, pp. 188-195), and the reinterpreted tradition of Molly's Cabin at Georgian Bay, Ontario, Canada, (2009) by Agathom Co. Architects; or the use of local wicker in the cladding of the Spanish Pavilion for the Shanghai Expo (2009) by EMBT (*see book cover*).

8. *To enhance innovative and creative solutions*

Although creativity has always been present in 20th Century architecture, it is difficult to find examples of personal creativity not connected with academies, fashion trends and imported languages, simply inspired by local tradition combined with the architect's private universe. This personal creativity often, though not always, involves an organic architectural option. Among others, we could point out the work of the Catalan Antoni Gaudí (Bergós i Massó, 1999) (fig. 7), the Dutchman Michel de Klerk (Bock et al., 2001), the Japanese Seiichi Shirai (Shirai, 2011) and Kazuo Shinohara (Matsunaga, 1982) or the Hungarian Imre Makovec (Heathcote, 1997) and, with a greater predominance of their personal universe, the German Rudolf Steiner (Leti Messina, 1996), the Americans Val Agnoli (Kahn, 1973) and Bruce Goff (Cook, 1978), the Uruguayan Eladio Dieste (Dieste et al, 1998) with his pre-tensed reinforced ceramic, the mature work of the Japanese Toyo Ito[1], the studio of Ushida and Findlay, (Ushida, 1998) or the textures of Herzog and de Meuron[2], among others. On the other hand, the Austrian Friedrich Hundertwasser (Kotschatzky, 1996) was a veritable 20th Century apostle in fostering the creativity of the inhabitants of a building so that they could transform, extend or decorate it.

[1] See *El Croquis* n. 71. (1995); n. 123 (2006).
[2] AA.VV. 'Herzog and De Meuron'. *El Croquis* ns. 60 (1983-1993), 84 (1993-1997), 109/110 (1998-2002), 129/130 (2002-2006), 152/153 (2005-2010).

Fig. 7 Gaudi's buildings show that personal creativity and new architectural shapes are not at odds with using traditional techniques. Cripta Colonia Güell vault, Barcelona, Spain (photo: F. Vegas, C. Mileto).

9. *To recognise intangible values*

In the last century, acknowledgement of the intangible values inherent in cultural identity, the sacred or symbolic meaning, and the collective memory appear linked above all to the design of some monuments, museums and holy places. Thus the monument to Karl Liebknecht and Rosa Luxemburg (in Berlin, 1926), by Mies van der Rohe, is one of the first examples that combine the abstract character of the Modern Movement with the symbolism of an aborted revolution. The Chapel of the Holy Cross in Sedona, Arizona, built in 1956, by Richard Hein, is another interesting instance because of its symbolic value as it looms over the rocks that surround it.

Among museums, it is interesting to mention the Archaeological Museum in Maa in Cyprus (1989), by Andrea Bruno (Mastropiero, 1996), which fits into the site and makes interesting references to the venerable nature of the place, for it is the quay where the early settlers arrived on the island after the Trojan War. Other interesting examples are the Chapel of Reconciliation in Berlin (2000), by the architects Sassenroth and Reitermann with the collaboration of Martin Rauch, because it symbolises the reunification of Germany using local earth as its construction material, and the Bruder Klaus Field Chapel in Mechernich, Germany (2007) by Peter Zumthor (Bönsch, 2011), a blackened, texturised hollow concrete cone made from the combustion of 120 tree trunks that acted as the internal formwork.

10. *To encourage social cohesion*

Architecture can foster social cohesion by creating urban spaces with a suitable scale, which can become a place for the social interaction of the inhabitants. One of the first cases in the Modern Movement was the Spangen Quarter in Rotterdam (1919-21), by Michiel Brinkman (Sherwood 1983, pp. 100-103), a paradigmatic example in the design of low-rise blocks of flats, with common facilities and many spaces for communal gatherings in the form of garden patios, pedestrian areas and broad sunny communication galleries that can also be used as terraces for socialising. Quite the opposite is the anonymous Pruitt-Igoe housing project in St Louis (1955), by Minoru Yamasake, which was granted an award by the American Institute of Architecture, but demolished with explosives in 1972, just seventeen years after it had been built because of the social, racial and delinquency problems in this gloomy complex with no spaces for community gatherings.

The elegant urban planning of great monumental capital cities like New Delhi (fig. 8), Washington, Brasilia or Chandigahr in the first half of the 20th Century was also incapable of generating social cohesion in their open, mammoth, disproportionate spaces. In general, Team 10 and, in particular, the work of Aldo van Eyck (Van Eyck, 1999), who proposed that urban design should evolve to become an organised *kasbah*, or Herman Hertzberger (Continenza, 1988), who defended that the priority of the form should not exclude participation, vouched for the design of urban spaces and buildings that would be capable of furthering and promoting social relations. In the last few decades, there has been a revival of more pedestrian-friendly urban planning, with a residential and urban weft on a smaller scale, which aspires to generate spaces for gathering together, often inspired by the tradition of the local cities. The housing project known as 'Tête en l'air' (Paris, 2013), by the studio KOZ, is a good example of this, and furthermore uses timber both for the structure and walls of prefabricated dry-assembled modules (Gauzin-Müller 2013, pp. 84-89).

Socio-economic principles

11. *To support autonomy*

As far back as the Modern Movement there were interesting proposals for self-construction or self-management of a dwelling in Plan Obus for Algiers (1931), where Le Corbusier planned that every owner should fashion his dwelling on a curvilinear superstructure according to his own taste (Le Corbusier 1935, p. 247). Le Corbusier himself approved the brutal personal transformation carried out by each

Fig. 8 The disproportionate urban planning of cities like New Delhi was not thought to generate life and social cohesion. New Delhi, India (photo: F. Vegas, C. Mileto).

of the inhabitants of his buildings in Pessac on a visit he paid in the sixties. The SITE Group copied the idea of an urban superstructure with self-constructed or self-managed dwellings in the Highrise of Homes project in 1981 (Muschamp, 1989). On the other hand, with his *Mouldiness Manifesto against Rationalism in Architecture* in the sixties, Friedrich Hundertwasser also defended self-construction as an alternative option to the failure of contemporary dwellings due to the lack of communication between the dweller, the architect and the builder (Kotschatzky, 1996).

As a result of his experience as a child in shanty towns in Peru, for the last forty years the Englishman John F.C. Turner has been defending the greater efficacy of self-construction, as opposed to government construction programmes of social dwellings. The idea upheld by this English scholar is that the administration should look after the large scale, while promoting the dwellers' personal initiative regarding the small scale (Turner et al., 1972; Turner, 1977). Some samples of this line of thought put into practice are, for example, the self-constructed dwellings of Cité Ben Omar (Algeria, 1970), or the Campamento Nueva Habana (Chile, 1970-73), where the owners demanded that they themselves should build under the management of the state, rejecting private construction companies. Instead they organized self-construction cooperatives (Alvarado et al., 1973), and even set up a Department of Direct Execution.

12. *To promote local activities*

With regard to this parameter and the previous one, we could mention the figure of the German Leberecht Migge (1881-1935) (Haney, 2010), an innovating landscape architect who coined the concept of 'garden culture', designed parks, gardens and urban orchards in the German Siedlungen in order to make modern life more liveable and even defended the socioeconomic benefits of urban agriculture, pioneer concepts at the time that would seem to be more likely to have arisen in the early 21st Century than in the early 20th.

It is worth giving special mention here to the work of the architect Víctor Pelli from his chair of Management and Development of the Popular Dwelling, the Mexican architect Enrique Ortiz Flores, from the Habitat International Coalition, and the architect Joan McDonald, specialized in programmes of human settlements, with experience in small-scale technological transference.

Other examples of the promotion of local activity are the initiatives of collective construction and restoration of old facilities for social and collaborative ends, which arise especially in times of economic crisis, such as the rehabilitation of the San Fernando Market (Lavapiés, Madrid, 2013) by the interdisciplinary group PEC (Puesto En Construcción), who function according to a co-working self-construction philosophy among professionals from different fields and generate very interesting initiatives for the city.

13. *To optimise construction efforts*

In this parameter, it is worth mentioning the work that the Rural Studio of Auburn University in Alabama, USA (Freear et al., 2014) has been carrying out since 1993, which aspires to transmit to architecture students the social responsibility of the architect at the same time as they design and construct dwellings and buildings with a suitable scale, technical and material simplicity and an optimised use of resources for poor communities in the Black Belt. Another interesting case in this respect is the work done over the past forty years in Mauritania and Mali by the Italian architect Fabrizio Carola, who refuses to use in his buildings cement, concrete and timber and any other raw material extraneous to the context, and erects dwellings and public buildings with domes made of locally produced brick, making the best possible use of local materials. On the other hand, as regards progressive or time-expandable dwellings, we could mention the housing project in Quinta Monroy in Iquique, Chile (2007) by Alejandro Aravena (Balzani et al., 2010), who prepared the building to be expanded in an autonomous and self-constructed manner, so that the built ensemble has attained in time the character and personality that its inhabitants have given it. In this section, we must not fail to mention the initiative of Carlos González Lobo from Mexico with his Seed House, or the different programmes of the CYTED network, like *a roof over one's head* (Gálligo, 2005), coordinated by the Spanish architect Pedro Lorenzo, with the participation of Raquel Barrionuevo from Peru, Máximo Bocalandro from Cuba and Antonio Conti from Venezuela, among others.

14. *To extend the building's lifetime*

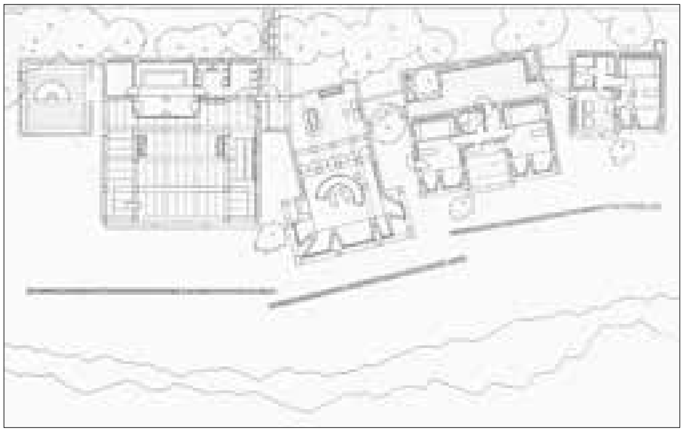
Solid, stable construction with long-lasting building methods and materials that do not require too much maintenance involves traditional construction materials like stone, brick and even earth, as long as it is protected against capillary and meteoric damp. Concrete, steel and even double-glazing have a relatively short life span. Regarding this point, we can mention, among many other projects that strive for durability, the work of Nader Khalili (Kiffmeyer, 2004) and the California Institute of Earth Art and Architecture and their buildings with super adobe domes, that is, corbelling domes of sandbags full of pressed earth held together with barbed wire.

15. *To save resources and reduce resource consumption*

An interesting, primitive example of compactness and reduction of energy loss in the slow but progressive path towards passive architecture would be Herbert Jacobs House II in Middleton, Wisconsin, (1940) by Frank Lloyd Wright (Ryley et al., 2003), also known as So-

Fig. 9 New sustainable architecture based on tradition. New Gourna by Hassan Fathy (1948), Egypt (photo: F. Vegas, C. Mileto).

Fig. 10 The house at Porto Petro by Jörn Utzon (1971). Majorca, Spagna (credits: Weston, 2002).



lar Hemicycle House. The north side of the house, with a curved floor plan, is buried to protect it from the cold and wind and made of glass on the south side, with a corbel that lets the sun in during the winter and provides shade in the summer.

Another outstanding example that complies to perfection with this and other parameters is the work of the Italian Paolo Soleri (2006), a disciple of Wright who designed the Arcosanti Community in Arizona (1970 on), a constructed demonstration of his concept of arcology, a portmanteau word made up of architecture and ecology. Arcology conceives a hyper dense city to promote human interactivity, provide ready access to common assets and infrastructures, make a rational use of water, reduce waste and environmental pollution and minimise the use of energy, earth and raw materials.

Regarding this parameter we must also mention the work of Steve Baer (Kahn, 1973, pp. 122-123) over the last fifty years, from the first polyhedral houses known as zomes in Drop City to his energy-saving inventions like beadwall (double glazing with an inner vacuum where air can be blown in or out as required), the Track Rack, a solar tracker or easily assembled dynamic photovoltaic modules that turns with the sun, or the Skylight Tracker, a skylight with a photovoltaic sheet that filters the sunlight while generating energy.

On a more technological line, we could mention, among many others, two representatives of the architecture that seeks to reduce losses of energy, namely the German Thomas Herzog (Revedin, 2010), who has spent the last forty years working on technologically architectural skins, efficient especially in cold climates or, at the other extreme, Ken Yeang (1994), whose skyscrapers have a bioclimatic green design that avoids using air conditioning despite his country's tropical clime.

Sustainable contemporary architecture

After this systematic overview of how the sustainability parameters defined in this project were applied in some examples of modern architecture in the last century, illustrating how they complied with one, or at times several of them, this chapter shows some cases that fulfil most of the established parameters.

A paradigm for many of the parameters, including the socioeconomic principles that most modern architecture finds it difficult to comply with, is the work of Hassan Fathy in New Gourna (1948) (fig. 9) or New Bariz (1967), both in Egypt (Fathy, 1973), partly continued in other countries in the Persian Gulf by his disciple Salma Samar Damluji, from her home in England. Within this section about pioneers of past decades, a well-known building that fulfils most of the fifteen sustainability parameters must be mentioned: it is the dwelling that the Danish architect Jörn Utzon designed for his own use in Porto Petro in Majorca, Spain (1971) (Weston, 2002) (fig. 10), with special emphasis on the situation, respect for nature and the cultural landscape, health quality, the use of local materials and construction techniques, creativity, the symbolism of night and day, etc.

Today, innovation and experimentation in sustainable architecture find fertile ground in developing countries, which in some cases has even generated a certain style for cooperation architecture. In this section, it is important to distinguish between the work performed by autochthonous architects and by Western architects alien to the context. In the sustainable work carried out by autochthonous architects, such as the case of the Hatigaon Elephant Village (2010) in India by Rahul Mehrotha, (Rossato 2013, pp. 16-29) and the school buildings in Burkina Faso by Diébédo Francis Kéré (Lepik, 2011; Balzani et al. 2010, pp. 86-88), a readier use is made of imported materials, like cement, concrete or metal, which are used alongside traditional techniques. On the contrary, in the cooperation architecture of Western architects in developing countries, like the Soe Ker Tie House (Thailand, 2008), by the Norwegian architects TYIN Tegnestue (Balzani et al. 2010, pp. 90-93), the vocational training college in Oudong (Cambodia, 2010), by the Finnish architects Hilla Rudanko and Anssi Kankkunen (Gauzin-Müller 2010, pp. 108-116), the buildings in Bangladesh by the German Anna Heringer (Balzani et al. 2010, p. 262; AAVV, 2009b, pp. 40-49), or the work by the Dutchman Anne Feenstra (Feenstra, 2009) in Afghanistan, among others, there seems to be a more sensitive approach in their creativity regarding local raw materials, techniques and traditions.

Fig. 11 Mapungubwe Intepretation Centre while being erected with local craft and materials. Limpopo, South Africa. (photo: J. Bellamy)

Fig. 12 Mapungubwe Interpretation Centre by Peter Rich Architects (2009). Limpopo, South Africa. (photo: P. Rich)

Exceptions to this classification are two buildings extraordinarily sensitive to the material culture and means available in the places where they were designed and built by local architects, which have won many international awards and have not gone unnoticed by many journals. The first of these is the Mapungubwe Interpretation Centre in South Africa (2009) by Peter Rich with the collaboration of Michael Ramage and John Ochsendorf (AA.VV. 2010, pp. 98-197) (fig. 11-12), a fascinating ensemble covered with thin-tile vaults clad with local stone, with pressed soil cement tiles built on site by local workers.

The second is Yunnan's Museum of Handcraft Paper by Hua Li and TAO (Trace Architecture Office) in Xinzhuang, Yunnan, China (2010) (Rossato 2013, pp. 52-59) (fig. 13-14), a contemporary building with an abstract design, with a punth of local volcanic stone, wooden structure and walls, a bamboo roof and paper panels, which retrieves and interprets local materials and constructive traditions, respects scale, takes inspiration freely from traditional forms, and creates patios and spaces for workshops, meetings and the exchange of ideas, as well as lodgings for visitors. The museum not only extols the old Chinese art of paper production, it was also built by local farmers.

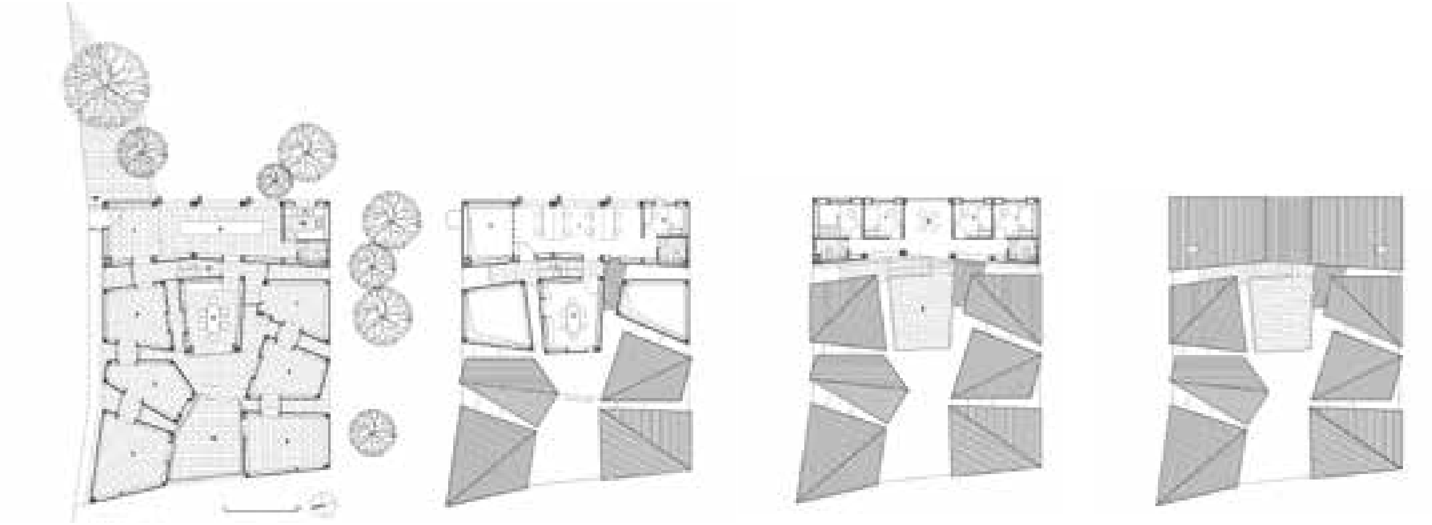
In Europe the era of mismanagement and the disproportionate generation of waste is giving way little by little to a more and more sustainable attitude in architecture. Many initiatives have been put into practice in this direction. Worth mentioning, among others, are the experimental house in Hrubý Šúr in Slovakia (2010), designed and constructed by Björn Kierulf and the German Gernot Minke, a pioneer with experience in the construction and the promotion of ecological architecture (fig. 15); the new contemporary earthen architecture in Alentejo (Portugal) by the architects João Alberto Correia and Bartolomeu Costa Cabral, among others; the work of Gabi Barbeta and Lluís Auquer in Catalonia (Spain) (Guillaud et al., 2014, pp. 62-65); the farm in Sassenage (2011) by Caracol Écoconstruction or the Interpretation Centre in Dahlingen (2013) by Nunc Architects, both in France; the work of Hermann Kaufmann in Austria; the Parco dei Suoni in Sardinia in Italy (2007) by Pierpaolo Perra and Alberto Antioco Loche; the eco-sustainable rehabilitation work by Christian Kaiser (2012) in the south of Germany, linked to the Institut für Baubiologie in Switzerland; or the Pines Calyx Building in St Margaret's Bay, Dover in United Kingdom (2006) by Helionix Designs, with the collaboration of Michael Ramage and John Ochsendorf (2012, pp. 309-318), a rammed earth construction with a thin-tile vault and a garden on the roof kept tidy by a flock of sheep, that the client asked the architects to put there when he commissioned a building that could last for the next five hundred years (fig. 16). Regarding the furtherance of the culture of sustainability in architecture it is important to mention the work carried out by the International Award for Sustainable Architecture (Balzani et al., 2010) granted by the Facoltà di Architettura of Ferrara (2003 on) and the Fassa Bartolo Company and the Global Award for Sustainable Architecture (2006 on) granted by the Locus Foundation based in Paris.

Fig. 13 Layouts of the Yunnan's Museum of Handcraft Paper in Xinzhuang, China (© Hua Li and TAO. Courtesy of the international prize for sustainable architecture Fassa Bartolo) .

Fig. 14 Yunnan's Museum of Handcraft Paper by Hua Li and TAO (Trace Architecture Office)(2009) Xinzhuang, China (photo: Shu He. Courtesy of the international prize for sustainable architecture Fassa Bartolo).

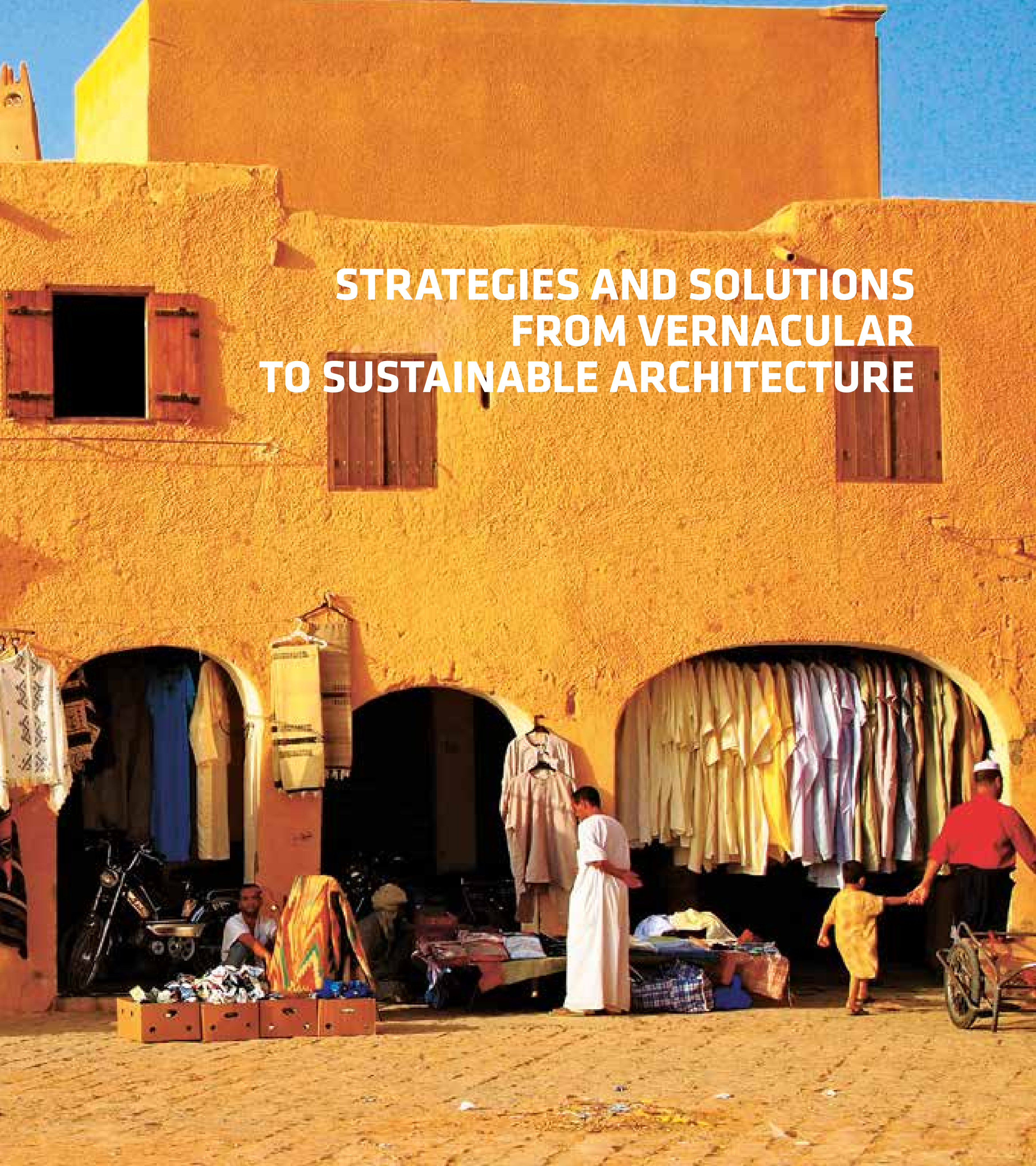
Fig. 15 Experimental house in Hrubý Šúr (Senec, Slovakia), vaulted with curved straw bales and with a gardened roof on top of it (Photo: Daniel Marinica. Courtesy of Zuzana Kierulfova).

Fig. 16 Pines Calyx Building in St. Margaret's Bay, Dover (United Kingdom, 2006), a rammed earth construction with timbrel vault and a gardened roof kept tidy by a flock of sheep, was born when the client commissioned the architect a building that could last for the next five hundred years (Courtesy of M. Ramage).



Ghardaia, Algeria (photo: L. Dipasquale)

STRATEGIES AND SOLUTIONS FROM VERNACULAR TO SUSTAINABLE ARCHITECTURE



Urban and territorial strategies and solutions

Village of Azenhas do Mar, Portugal
(photo: C. Scarpa de Medeiros).

Settlements morphology

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The vernacular settlement can be interpreted as a pragmatic response to how territorial interventions, on a community scale, are directly conditioned by its geographical features. The settlement is developed in specific models according to its particular climate, geomorphology, geology and available resources, which are materialised through formal solutions adapted to specific socio-cultural perspectives.Therefore, it should be noted that this item could adapt several distinctive morphological types, some of them with a strong identity, which can become formal paradigms of vernacular settlements (Lefaivre & Tzonis, 2003). This is the case, for instance, of riverside villages built on piles, or underground mountain dwellings (fig. 2-3).

This text addresses the sustainable contribution of vernacular settlements as a particuwlar formal unit, and how this contribution can be applied to urban design interventions. The strategies were identified throughout the analysis of the representative morphological elements, their relations and organisational characteristics.

It is relevant to emphasise the need to interpret vernacular elements beyond conventional models and patterns. The variety and flexibility of vernacular settlements can produce singular characterisation results that sometimes are not compliant with generic systematisation methods. It is implied, in its own essence, that the context can become more significant than any apparent rule or principle. This last condition should not be considered mandatory for the recognition of the intervention's quality. In several cases, it is this uniqueness that confers its architectural richness and even its most sustainable qualities (Adolphe, 2003).

To attain this aim the project's research team developed several studies based on the interpretation of the fundamental features of the settlements, focusing on the geographical displacement, the communications structure, the productive and exploitation logics, the consolidation of the built form, and its conflicts and/or compatibilities with the natural systems.

In all the studied examples this last feature reveals itself as a fundamental condition to judge its sustainable qualities. One can say that it highly depends on the cultural and technological capability of a specific social structure to recognise an existing natural system constrained to specific limits; and to provide a recurrent articulation with a new artificial system, optimising and increasing its potential on behalf of the subsistence of the community (Girardet, 1997).

The implantation of the settlement on the territory and the consolidation of its morphology are usually constrained by three main concerns:

1. To control the sun and the wind exposure of the buildings (improving or avoiding it, according to the local climate) considering the original relief and the autochthonous vegetation, while managing particular aggregation systems of built units as the primary instrument to attenuate the relation between the inhabitants and the natural elements. The attained solution is usually an expression of the compromise between the individual and the collective needs of the community;

2. To minimise the occupancy of fertile soil, and to avoid conflicts with water lines, within a reasonable proximity. To respond to it, the most common strategies resort to the use of typological models, which can be integrated to the landscape following the same logic of aggregation, and adapted to the most convenient orientation and to the original topography of the territory (fig. 1). The second premise is attained taking into consideration the geological quality of the soil, continuously trying to preserve non-edificandi areas, the best agriculture soils, even when the local community no longer depends on their exploitation. This also validates the integrity of the settlement impact on the larger natural environment and the necessity of its long-term management;

Fig. 1 Roccacasale, Abruzzo, Italy (photo: A. Pace).

M. Correia, L. Dipasquale, S. Mecca (edited by), *VERSUS: Heritage for Tomorrow. Vernacular Knowledge for Sustainable Architecture*, ISBN (online) 978-88-6655-742-5, ISBN (print) 978-88-6655-741-8, CC BY-SA 4.0, 2014 Firenze University Press

Fig.2 Ortahisar, Cappadocia, Turkey (photo: A. De Pascale).

Fig. 3 Fishermen floating village, Ecas, Indonesia (photo: G. D. Carlos).

3. To facilitate the direct access to resources and to optimise the circulation network. The mobility and communication features are extremely important components in the development of all vernacular settlements. They intend, generally, to reduce the displacement efforts using as little floor area as possible, controlling the inclination of the paths, and reducing, as much as possible, the land movement for its implementation (fig. 4-5). The itineraries are primarily determined by the major productive activities, but they also contribute to the strengthening of the agrarian system organisation and its subsequent land registration. Therefore, most of the times, plots of land and communication networks conform intricate solutions, and the collective and shared spaces are extremely connected to them, or even overlap the private plots (Bouhier, 2001).

The vernacular settlements morphology is usually adapted to the rural mosaic. Its configuration is determined by the way the agrarian system appropriates the territory on a large scale, also considering the balance between the wild and the humanised. Its articulation to the surroundings is far beyond the built core. The settlement, more than being integrated, becomes itself part of the wide cultural landscape (fig. 7). The village's spatial configuration plays a role in the characterisation of the territory appropriation. It contributes to the physical articulation with gardens, fields, forest or harsh areas, setting these diverse elements in a coherent hierarchy that has to be perceived from an inside-out interpretation, from the perspective of the inhabitants; and only afterwards from a regional approach, which is usually an ecological, 'romantic', yet misleading procedure.

Fig. 4 Watermills of Picón y Folón, Rosal, Spain (photo: G. D. Carlos).

Fig. 5 Village in Suai, East-Timor (photo: G. D. Carlos).

Fig.6 Rural settlement's layouts, examples in Galicia (author: M. Rey)

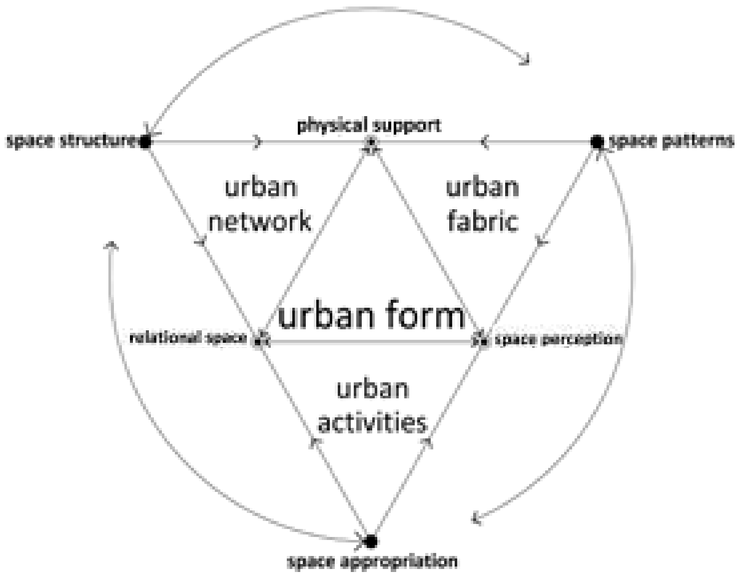
The coexistence of distinctive features is mostly based on the complementarities of qualities. Most of all reveal a dynamic relation, rather than a rigid preservation procedure. The intervention is not avoided, but its intensity appears to be measured according to an important factor: its reversibility. In all the studied examples, one strategy seems to be fundamental to develop the aforementioned relation: the outstanding geographical landform elements are always assumed. If the current conventional planning tends to contour, or even to overcome them as implementation obstacles, the vernacular ownership approach has the distinctiveness of embracing them, as essential intervention generators. Although its consequences can be transversal to a large number of the general aims, regarding all the identified scopes, their effects can be more objectively observed on the environmental scope, and in how they respond to the general need of enhancing the existing superstructure and the natural resources, thus responding to all its main principles.

The most suitable vernacular communication structures are always a result of the possible relation between the available construction technology and the relief constraints. They are usually based on a territorial matrix conformed by the main ridge and the outlines of the settlement implantation.

The formal configuration of the settlement follows this matrix as an organic structure, adopting a conceptual grid moulded to its geometric variations and forming a cadastre, also influenced by the average household type and material prosperity. This mostly adds to the economic feature, especially on how it helps reducing the im-

Fig. 7 São Miguel Island, Azores, Portugal (photo: M. Correia).

Fig. 8 Conceptual diagram of urban analysis approach (author: D. Viana).



plementation, construction and operational efforts. This is also a strong response to the contribution of the cultural landscape and its dynamics, which is the first aim of the socio-cultural sustainable scope. The productive logic and the built morphology are always related and conformed as an instrument of exploitation and preservation of the local existing resources and the natural systems that they belong to (Kennedy & Kennedy, 1999).

Morphological systems variations

The most common model variations of vernacular settlements are based on a *diffuse* or *compact* spatial organisation, and a *scattered* or *dense* building aggregation (fig. 6). Regarding its essence, vernacular interventions cannot be easily classified according to the conventional models, as they are mostly generated by spontaneous appropriation strategies that cannot be constrained in specific rational models (as opposed to a predetermined intervention process).

Within this conceptual framework, one can observe a relative tendency to adopt organic layouts, considering inside-out growth spans, focused on different intensity clusters. According to this, the resulting morphology is mostly based on the coherence of the inner relations between elements, rather than the replication of specific geometric forms, allowing a great diversity of formal combinations without compromising the unity of the settlement. This has a profound reflection on the built pattern, generating heterogeneous geometric matrixes, structured by asymmetric and dynamic axis. It also concurs to complex morphological systems of difficult interpretation, especially if one assumes a conventional Cartesian approach, mostly responsible for the incorrect conception of the absence of spatial organisation principles, within the realm of informal built aggregation systems (Ribeiro, 1993).

As any logic of land appropriation, the vernacular examples tend to demonstrate a strong relation between the topographic environments and the regularity of the applied pattern. Smoother and more constant topographies generally imply the use of more regular settlement patterns, with a higher geometric homogeneity, as opposed to rough relief appropriations. Despite this feature, orthogonal based grids are not common amongst the given examples. The great majority of examples seem to be impelled by radial expansion grids, of limited dimension, and of organic and asymmetric development, that can comprise several origin points (fig. 8). Intersection and overlapping actions between these grid components seem to be a characteristic based on the settlement's level of densification, rather than a thoughtful implementation purpose.

In general, regardless of the geometric diversity, it is common to observe in the selected case studies a strong systematisation of the plot forms and their associated built typologies. Their recognition and respectability is highly assimilated in the socio-cultural identity of the inhabitants, expressing a long-term connection of the settling process and the resources management, in which the agrarian local system plays a determinant role.

As previously mentioned, the resulting cadastre (as the property division system), its long-term maintenance (through multi-generational interventions), and their interdependence towards the built structures, can highly contribute to the landscape coherence and singularity (Ordem dos Arquitectos, 2004).

The settlements' axes of reference are generally defined by collective and shared infrastructures, consolidated by progressive adjustment operations (to control, extract and redirect), and benefit from large-scale natural elements that, in particular contexts, have a fundamental responsibility in the local subsistence. The points of inter-

Fig. 9 Sorano, Tuscany, Italy (photo: B. Aguilar).

action with these types of elements, especially when they concur with the circulation system, tend to be used as collective and shared interfaces. They are also strategically positioned within the settlements, allowing an optimisation of resources within the inhabitants' management areas (which cannot be mixed with an egalitarian distribution, as the inhabitants' privileges can be very asymmetric). This justifies mainly the dynamic expression of the settlements' axes and the possible intensity variation, within their morphology (Llano Cabado, 1996).

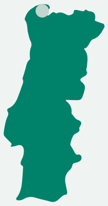
Vernacular settlements usually demonstrate a tendency towards an irregular perimeter configuration, compliant with an open and permeable built boundary. This feature appears mainly as the result of the progressive development of the settlements' implementation, reinforcing its subsequent possibilities of limit expansion, without formal ruptures. This can also contribute to a more gradual transition between the buildings and the natural surroundings. There are, of course, exceptions, which are related to particular cultural contexts that have to be positioned outside this conceptual interpretation. Religion and war conflicts are some of the examples, and seem to constitute a significant pressure in the spatial organization of settlements.

Despite the stated wide variation of settlement morphology, some specific elements seem to have a transversal influence in their configuration and consolidation. For instance, the articulation with the local water system, either in contexts of abundance or shortage, seems to constitute a fundamental formal condition to the spatial organisation of the built environment. The consequent supply and drainage networks, essential to any reliable communitarian territorial occupation, always represent a strong compromise to the morphological consolidation of the settlement. From the most concealed to the most exuberant network materialization, mainly depending on the resource manifestation and the climate characteristics, they always constitute a priority intersection division, within the building mass. Although the solutions are endless, they seem to respect very few basic principles. To assure the cyclic renovation of the resource, the implementation of the aggregation system is usually prone to adopt positions towards the main natural watercourse lines, natural or seasonal, and to avoid constituting themselves as conflicts on upstream and downstream geographical displacements.

Consequences on the lack of strategy

The most obvious counterpart of this morphological outline is mainly related to the modernisation of infrastructures, according to current standards. Most of the recent networks are based on linear underground systems, using public domain as their physical support. Frequently, the optimisation of the industrial networks, composed by massively produced and implemented elements, is not compatible with the irregularity of forms and dimensions of the settlements' cadastre (Jacobs, 2000). Influenced by the opportunity of regional reform action plans, and pressured by the licit increment of the habitants' living conditions, some settlements allow conflictive structural interventions on their original morphology. The opening of consequent straight-lined circulation axes, large scale mechanical levelling of uneven areas, or the suppression of surface water lines to allow the fixing of the mentioned infrastructures, contribute mostly to the mischaracterization of the settlement's identity and the breaking point of their sustainable balance (Hough, 1998).

This also reflects the difficult adaptation of these settlements to recent urban planning policies and regulation specifications; especially considering the required building distances, altering the fundamental relations amongst the elements. This usually results in a clear urban tissue rupture between the existent and the new intervention, transforming the traditional architectonic model and its original aggregation system.



VILLAGE OF ANTA
BEIRA ALTA, LAMEGO, PORTUGAL

authors
Henrique Rodrigues, Goreti Sousa

ENVIRONMENTAL PRINCIPLES
to respect environmental context and landscape · to benefit of natural and climatic resources · to reduce pollution and waste materials · to contribute to human health and welfare · to reduce natural hazards effects

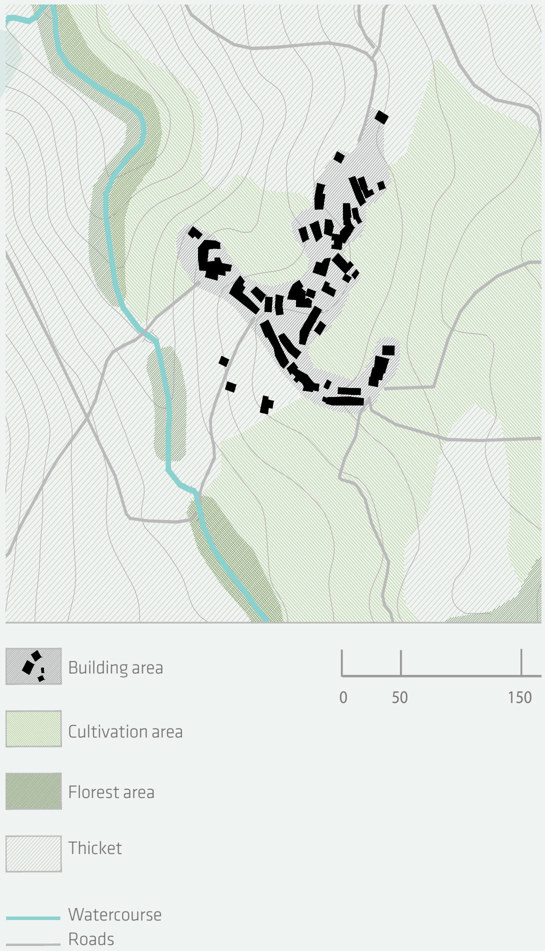
SOCIO-CULTURAL PRINCIPLES
to protect the cultural landscape · to transfer construction cultures · to enhance innovative and creative solutions · to recognise intangible values · to encourage social cohesion

SOCIO-ECONOMIC PRINCIPLES
to support autonomy · to promote local activities · to optimise construction efforts · to extend building's lifetime · to save resources

Anta is a village located in Lamego municipality, in central Portugal. The village is situated on a plateau on the northern edge of Serra de Montemuro. It occupies a territory defined by an austere climate of intensive rain and low temperatures, where snowfall is common during the winter. The soils are poor, forcing an effective and sustainable management of the scarce resources. The survival of these highland communities depends on the exploration of multiple resources, as agricultural, livestock and forestry. Thus, the morphological structure of the village, as well as its architecture have to be understood in a broader context, comprising agricultural or forage fields and vacant land used for pasture. The village displays a compact morphology, developed in the centre of its territory. The cluster spreads linearly, along the two roads crossing the mountain.

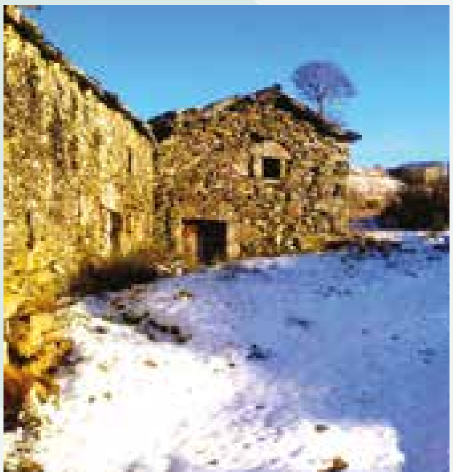
Different building typologies have been identified due to animal shelters and storage for agricultural products and instruments, which determine a ground floor or a multi-storied house. Regardless of these differences, the houses have a compacted rectangular floor plan. The functional division is vertical, with the animals sheltered on the ground floor to produce heat that improves the thermic comfort of the residential space on the upper floor. Morphologically, the reduction of openings in the walls, usually just a door and a small window, and the absence of chimneys or openings in the thatched roof are systems used to reduce the heat losses.

It is thus possible to observe how functionality, rationality and resource economy are principles observed in this settlement, in such a way, that architecture and its morphology cannot be studied separately



Anta general plan (drawing: H. Rodrigues).

General view and buildings in Antas Settlement, Lamego, Portugal (photos: H. Rodrigues).



MONTARIA

NORTHWEST IBERIA, PORTUGAL

author
Gilberto D. Carlos

ENVIRONMENTAL PRINCIPLES

■ to respect environmental context and landscape ■ to benefit of natural and climatic resources ■ to reduce pollution and waste materials ■ to contribute to human health and welfare ■ to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

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SOCIO-ECONOMIC PRINCIPLES

■ to support autonomy ■ to promote local activities ■ to optimise construction efforts ■ to extend building's lifetime ■ to save resources

Montaria is a typical mountain village of the Iberian Northwest, a small-scale settlement of scattered buildings deployed in a low/ medium altitude with high precipitation values, abundance of water streams, and a reduced temperature range. The settlement was established on a southern slope, thus taking advantage of the sun exposure, and the wind protection of the north granite cliffs. The water lines are the main structural components of the cluster development, which constitutes two complementary and interdependent systems: the circuit for the field's irrigation and the energy supply network for the local flour-mills. The settlement's implantation follows the plateau, and the main watercourse, setting a parallel-elongated configuration between the north valley and the south ridge-line. The north outline corresponds to a range of agricultural land and pastures, establishing a longitudinal limit between the granite boulders outcrops, where human intervention is minimal. The agricultural system results in two different land appropriation solutions, conformed by transversal bank-terraces and longitudinal agras (Bouhier, 1979). The first are individually and privately owned; and the second are managed in communal consortium, allowing their rotating exploitation (Ribeiro, 1999).
The case of Montaria acquires particular interest, since these two structuring systems constitute a mixed solution, based on the application of earth retaining walls, which establish subtle transitions between the artificial interventions and the natural topography. The built perimeter of these elements acquires infrastructural functions in the conformation of circulation networks, while integrating artificial water channels, and thus optimising the community building effort based on granite masonry techniques.

Building area

Cultivation area

Florest area

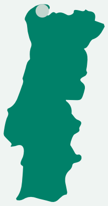
Watermills area

Watercourse

0 50 150 20

Montaria's general plan (author: F. Gomes).

Montaria Settlement (photos: G. D. Carlos).



GAVIEIRA

SERRA DA PENEDA, PORTUGAL

author
Filipa Gomes

ENVIRONMENTAL PRINCIPLES

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The *Gavieira* village is located in Serra da Peneda, North of Portugal. The Serra's settlements are conditioned by its specific elevation and drastic topography variations, determining a significant variety of micro-climates on a relative small extension. *Gavieira* has the particularity of being a seasonable occupancy settlement, integrated in a wide system of complementary clusters that were developed to support the major local subsistence activity: livestock breeding. Due to the harsh climate conditions, this activity depends on ancient transhumance practices, which allow the transfer of cattle between the upland pastures, during the late spring and summer periods, and the plateaus of the low valleys, during the cold season (Gomes, 2014).
The *Gavieira* represents the main settlement, used for the winter period (Inverneira). Located at 600m of altitude and confined by the valley slopes, *Gavieira* is complemented by the smaller clusters of S. Bento do Cando and Benzgalinhas, which are only used for the summer periods (*Brandas*). These are located at the top of the mountain (between 900 and 1000m of altitude).
The *Inverneira* is conformed by one compact and dense small cluster of buildings, set on the limit of the agrarian fields. These fields are displayed to the west, and are structured in terraces. *Inverneiras* are usually located near main water streams, and have fertile adjacent areas. The public space emerges from the articulation between the houses and the communitarian equipment, such as watermills, corn granaries and threshing floors.
The building's location is conditioned by the slope areas, which are the areas with less potential for agriculture exploitation. The dwellings adapt to the topography and use the rocky outcrops for the construction's foundations. This is a general condition, also found in the *Brandas* settlements (Gomes, 2014).

Forest area

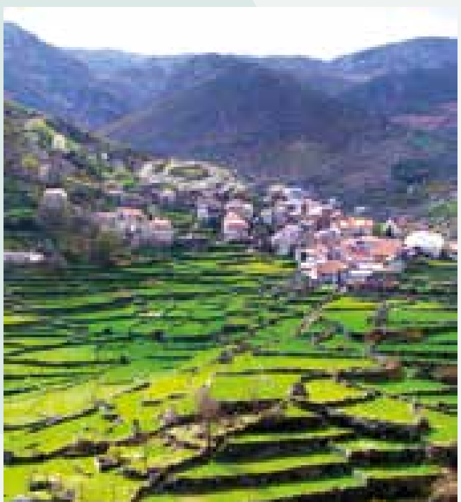
Cultivation area

Building area

Watercourse

↑ Gavieira's general plan (author: F. Gomes).

↓ Gavieira Settlement (photos: F. Gomes).



ECOLONIA

ALPHEN AAN DER RIJN, NETHERLANDS

Project Coordinator: Lucien Kroll Atelier[1]

authors
Gilberto D. Carlos, Filipa Gomes

ENVIRONMENTAL PRINCIPLES

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to support autonomy · to promote local activities · to optimise construction efforts · to extend building's lifetime · to save resources

The Ecolonia development is located in Alphen aan der Rijn, in the Netherlands and was created in 1989-993, under the coordination of the Lucien Kroll atelier. Ecolonia represents an experimental urban intervention supported by the Netherlands government, through NOVEM, the Netherlands Governmental Agency for Energy and Environment. The Agency aims to stimulate urban developers to adopt sustainable solutions. The matrix of the implemented urban fabric is structured around the integration of a rainwater retention lake, assumed as the convergent element of the circulation network. The lake is responsible for the viability of most of the plan green leisure areas, and for a 20% reduction of water consumption, a significant collective resource. The circulation network, although conformed by the application of a regular grid, presents a very asymmetrical layout, resulting from the different adjustments of the public space to the natural topography and to the different outskirts of each quarter. Like the organic logic of the vernacular cadastres, the quarters have very similar dimensions, but very distinctive geometries, It follows the intention of creating a heterogeneous morphology, based in different house types, which can vary between one and three floors, aggregated in semi-detached and terrace houses. To reinforce the fabric diversity, the design process produced nine different architectural studios, determined by a special consideration for articulating different situations, in order to assure a coherent contextualization of all the specific residential elements. The overall solution to face this articulation was based on Christopher Alexander's patterns concept. This resorted on the creation of a set of public 'components' that should work as communitarian interfaces, adapted to the landscape singularities (Ruano, 1999).

Ecolonia general plan (drawing: F. Gomes based on the original drawings by project designers)

Rainwater retention lake (photo: J.P.Moehrlein architekt).
Integration of different housing typologies (photo: Alberts & Van Huut international architects B.V.).
Building with passive design strategies (photo: P. van Gerwen architecten).

[1] *Collaborators*: Bakker Boots Van Haaren Van der Donk architectenbureau; Architectenburo J.P. Moerhlein; Architectenbureau Hopman bv; BEAR Architecten, Architectural and Renovation Consultants; Architectenbureau Alberts and Van Huut; Lindeman c.s., Architects and Engineers and Cuyk, Energy Management Consultants; Vakgroep FAGO, Faculty of Building Technology; Peter van Gerwen; Architectenbureau Archi Service.

Quarter of dyers, Fez, Morocco
(photo: L. Dipasquale).

Productive settlements

Letizia Dipasquale, Saverio Mecca, Bilge Özel
DIDA University of Florence, Florence, Italy

Human settlements grow as places of social, cultural and economic exchanges, of different relationships and interactions. There are numerous different reasons that encouraged mankind to settle and live collectively but the conventional view holds that human settlements were formed after the Neolithic revolution which introduced agriculture and made human populations denser (Bairoch 1988, pp. 3-4). Paul Bairoch, in his book Cities and Economic Development, states that agricultural activities stand out as a necessary reason for the foundation of 'true' cities. Of course there are other necessities for which settlements are formed, such as security and defence, but the majority of cases show that the main reason is related to productivity.

The general notion of production indicates a process of combining various inputs in order to obtain outputs (material or immaterial goods) for consumption. The aim of production is to create goods or services that have a certain level of value and generally contribute to the welfare of individuals (Kotler et al., 2006). In the case of vernacular settlements, production consists of the creation processes of outputs for meeting common survival needs of communities. In this context production refers mainly to the activities of basic sectors like agriculture, craftwork and energy production.

Background of 'productivity'

The history of productivity and human history appear to have a parallel development and they are both based on an evolutionary progression defined by 'punctuated equilibrium' (Bloomfield, 1993). This type of evolution is characterised by a series of steps with long periods of stability interrupted by short periods of transition. The modality of food procurement is the best indicator of the evolutionary status of productivity. While in tribal societies simple tools were used for hunting to procure food, in peasant societies man started to domesticate animals and to cultivate the land (Bloomfield, 1993). After the industrial revolution, machineries were introduced to farming activities and as a consequence, technological development reduced the need for human labour in agricultural production.

In the history of productivity, the Neolithic revolution, which is also called the 'agricultural revolution', has a crucial significance as it represents a transition of many human cultures from hunter-gathering to agriculture by leaving their nomadic lifestyle and settling to a sedentary form of life. The reflections of productive activities on the aggregation of dwelling units may be seen in Çatalhöyük, the largest and best-preserved Neolithic proto-city settlement of south Anatolia. Çatalhöyük, which had 10.000 inhabitants according to the estimations, flourished between 7500 BC and 5700 BC and was composed entirely of domestic dwellings with no obvious public buildings (Mellaart 1966, pp.15-191) (fig. 1). The settlement was situated on alluvial soil, which strengthens the thought that this choice may derive from the purpose of favouring agricultural activities. The mud-brick dwellings were built adjacent to each other in an agglutinative way (fig. 2). There were no streets or footpaths and it appears that they used the rooftops as streets instead. Each dwelling was accessed by stairs from a single opening on the ceiling. In the formation of the settlement the courtyards have an important role as

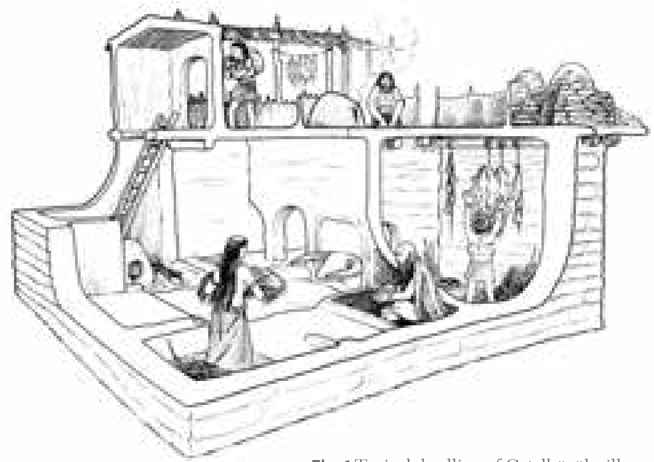
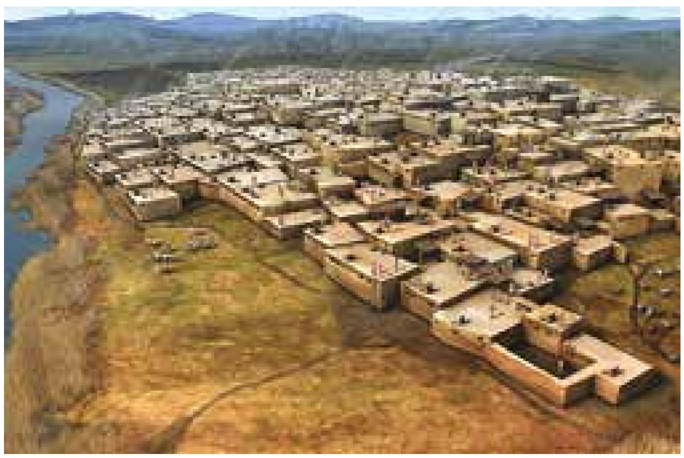


Fig. 1 Typical dwelling of Çatalhöyük village and representation of daily activities (drawing: Hodder, I. *Çatalhöyük: The Leopard's Tale*).

Fig.2 An artist's impression on the restitution of Çatalhöyük settlement (drawing: D. Lewandowski).



M. Correia, L. Dipasquale, S. Mecca (edited by), *VERSUS: Heritage for Tomorrow. Vernacular Knowledge for Sustainable Architecture*, ISBN (online) 978-88-6655-742-5, ISBN (print) 978-88-6655-741-8,

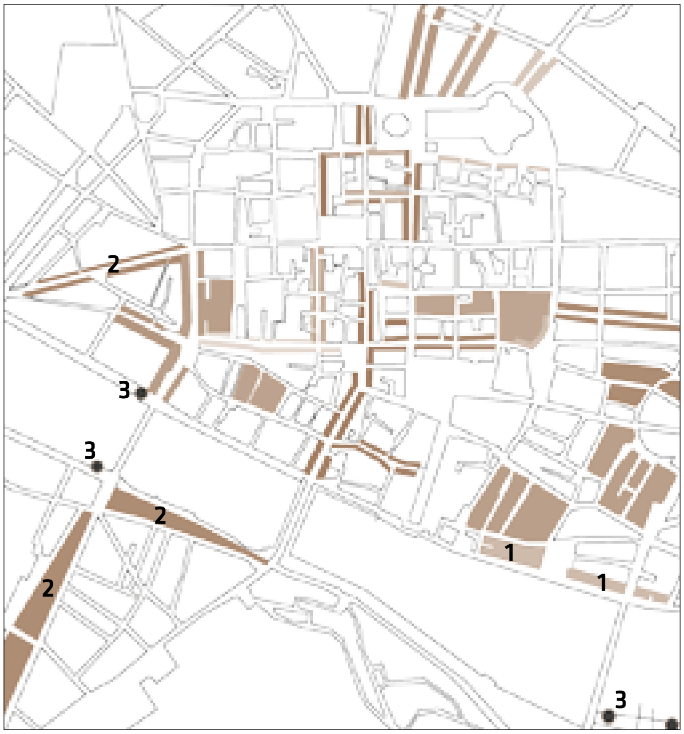


Fig. 3 Districts of various sectors in Florence from the 14th Century (redrawn by B. Özel after the original map of G. Fanelli from Firenze *Architettura e Città*, 2002).
1. Wool and leather washing 2. Wool workers 3. Water mills (*gualchiere*)

they constitute key elements in creating neighbourhoods; the houses were clustered around courtyards where stalls and other common spaces were located. These courtyards also provided natural light and ventilation to the houses. The dwelling units were consisted of two main spaces; a central room, which served for cooking and daily activities, and an ancillary room which was used for the storage of cereals and was directly accessible only from the main room (fig. 1). The findings of archaeological excavations indicate that there were no apparent social classes in the community of Çatalhöyük since the houses show nearly the same features without particular distinctive signs or symbols (Stavrianos, 1991; Gutrie, 2005). In later periods communal ovens appeared on rooftops, which indicates the presence of 'collectiveness' in the daily activities of production. Several research projects have been undertaken regarding the 'nested' configuration of the urban fabric of Çatalhöyük and they have shown that the reason for building such a compact settlement is based on the existence of strong family ties over generations and of a collective way of living. Since there are no traces of any destruction or war, it becomes apparent that defensive concerns cannot be the purpose behind the building of this 'nested' urban pattern.

In the European Middle Ages, the urban structure of human settlements is closely related to productive and economic activities. Usually a certain district or street of the city is occupied by the members of a particular production sector; in medieval cities of Europe such as Florence, special productive activities gave their names to streets. The tintori, dyers of fabric and leather, gave their name to Via de' Tintori (street of dyers) where all dyeing workshops were located. The same is true for Via delle Caldaie, or the street of 'boilers' (which is where the service of boiling water for the wool dyers took place)[1] (Fanelli 2002, pp. 123-130). This tradition of naming streets according to the activities undertaken helps us today to read the traces of productive sectors performed in particular parts of the city, and it also strengthens the collective memory and identity.

The clustering of special sectors in particular zones also brought a social segregation that typically led to the formation of 'quarters' or 'wards'. Especially in pre-industrial Arabic cities such as Aleppo and Fez, the quarters of different social and occupational groups were sealed off from each other by walls, and each walled quarter was further protected by closing the gates at night (Sjoberg 1955, pp. 438-445). In Europe, sharp social physical divisions, similar to walled quarters, have not been observed.

The medieval city's productive activities are divided into different zones; the selection of the place for a particular sector is done in order to reach local resources that can facilitate a certain production. In Florence, the sectors with an intense requirement of water access such as dyeing workshops and wool washing facilities were situated in the quarter of Santa Croce, along the banks of the Arno river (Fanelli 2002, p.130). Regarding the management of local resources, numerous water mills (gualchiere) were located in south-eastern Florence along both sides of the Arno in order to produce energy for various activities.

In the 14th Century different production sectors and services appeared in medieval communities. Only in Florence there were 21 major and minor arts, which were mainly related to the manufacturing of wool and fabric and the trading of handcrafted products[2] (fig. 3).

[1] 'Boilers' had an important role in the process of dyeing wool and cloth, for example in fixing the colours and heating the dye pools.

[2] The major arts consisted of: merchants, judges and notaries, currency exchange, wool workers, silk workers, doctors and apothecaries, furriers. Whereas the minor arts were constituted by smiths and armourers, locksmiths, shoemakers, saddlers, leather workers, second-hand dealers, blacksmiths, stone masons, lumberjacks, carpenters, bakers, butchers, wine producers, oil producers, hoteliers (Fanelli, 2002, p. 25).

Fig. 4 The common infrastructural features of vernacular productive settlements: urban pattern scheme and hierarchical street network of Medina di Tunis, Tunisia (credits: B. Özel).

Fig. 5 Aeral view comparison between the urban pattern and morphological features of the Medina of Marrakesh and its colonial city, Morocco (Map data: Google, DigitalGlobe).

In this period money exchange and notary services had a big development due to the increase in trading facilities.

Since 1700, with the advent of the industrial revolution, the role of mankind in the production process has changed; improved technology and the development of machinery for particular sectors brought 'automated production systems'. Moreover, the socio-cultural features of industrial communities required some distinctions with respect to pre-industrial ones; industrialization demands more rational, centralized and extra-community economic organization in which recruitment is based more upon 'universalism' than 'particularism' (Sjoberg 1955, pp. 438-445). Therefore, with the changing role of humans in production, the social structure of the community also changed.

The prime difference between industrial and pre-industrial production is based on the type of 'energy source'; while pre-industrial cities depended on the production of goods and services mainly through animate (human or animal) and local, natural sources, industrial cities satisfy their need of energy through inanimate and non-local, or mobile (steam power, electricity, etc.) sources (Sjoberg, 1955). Of course the changing systems of energy production brought positive effects to intensive production; thanks to inanimate energy sources that allowed production (food, goods and other services) to increase, population has risen today to seven billion people.

The growth of modern industry led to massive urbanization as cities turned into centres of industrial production. Urban areas became increasingly more attractive for people since they offered new employment opportunities that stimulated a massive migration from rural to urban areas. At the same time, rapid urbanization caused several problems in terms of environmental, social and economic vulnerabilities in the face of abrupt demographic and climatic changes (Özel et al., 2014b). Therefore the concept of 'self-sufficiency' gains more importance each day in the search for increasing urban resilience.

Features of productive vernacular settlements

Production in vernacular communities predominantly consists of agriculture and other basic sectors of craftwork that respond to the essential survival needs of the society. Agriculture is considered as the prime sector of production that procures food; it therefore constitutes the most essential survival activity in vernacular societies. The other 'basic needs oriented' sectors are mostly related to craftsmanship such as smiths, locksmiths, tanners, shoemakers and carpenters. These sectors all regard the manufacturing of raw materials such as wood, iron, and leather in order to produce goods and objects for daily use as well as furnishings and building elements. In the field of building construction there are also stone masons, carpenters and lumberjacks who are specialized in the manufacturing of raw stone and wood. These specialized crafts are usually handed down from father to son or from master to apprentice in vernacular culture.

Regarding raw materials of animal origin, butchers hold an important position; after slaughtering, they have the role of distributing skin, hair and animal fat to different sectors such as soap producers, tanners, leather workers and weavers.

These methods of production are mostly based on animated sources such as manpower and therefore; the productivity remains at basic levels. In comparison with industrial societies where the intensity of production adapts to the population, in vernacular communities it is the population that has to adapt itself to the productive capacity and not the other way around. This is due to the fact that resources and energy are limited. Vernacular societies have the awareness that the maximum adaptation to nature, through the creation of the most adequate settlement morphology and social links can

Fig. 6 Distribution of productive activities in the medina of Chefchaouen, Morocco (credits: L. Dipasquale).

help to reduce energy consumption and foster production. The main features of productive settlements are 'proximity', 'collectivity' and 'integrated production'.

Proximity (walkability) and compactness

Vernacular settlements generally have well-determined territorial limits that are often marked by walls or other physical formations. This morphological feature coincides with the requirements of self-sufficient habitats; in fact, the territorial extents of vernacular settlements are usually defined by a radius of walkable distances that contributes substantially to the reduction of transportation and infrastructure costs. Moreover, this 'human scaled' urban system favours productivity by suggesting advantages such as reduction of energy loss, optimizing energy consumptions, increasing accessibility and improving the local economy.

Collectiveness and sharing knowledge

One of the main features of vernacular communities is undoubtedly 'collective living', where entities collaborate together to deal with challenges and resolve common problems. 'Collectiveness' means 'sharing' of infrastructure, energy, knowledge, ideas and also challenges through interactions between entities.

Such interactions occur within the 'shared places' such as workshops, laboratories and factories where the collective production is carried out. In this context the concept of clustering the workshops of the same sector in a particular district favours the sharing of knowledge.

Integrated production

Vernacular settlements are like open-air factories. One of the most distinctive features of these settlements is that the production areas are not sealed off from the rest of the habitat; on the contrary, productive spaces are spread out homogeneously all over the settlements.

This spatial conformation indicates that the production is integrated to the daily activities of the society in such a way that even the houses contain productive domestic spaces.

The role of 'production' in the formation of the urban structure

The productive activities within the vernacular settlements have a relevant role in shaping the urban structure. In infrastructural terms, the first and main reflection of productivity is seen in the street network. The streets are not mere passageways for people; they also indicate the density of social interaction. Moreover, the streets constitute important transportation and connection axes but the flux density of each street is not equal. According to the typology of the activities, the street patterns are formed in a hierarchical way that bases on the density of use (fig.6). Generally the composition of street patterns consists of primary and secondary streets, which are reserved for trading and transportation issues, whereas the narrower streets or cul-de-sacs provide access to the dwellings. The distinction between the thoroughfares is quite visible within the urban infrastructure network (fig. 4).

Productive vernacular settlements are distinguished from modern cities by their urban patterns; the necessity of building for 'proximity' made them progressively obtain more compact geometries. The 'compactness' allows having a car-free settlement that forms a 'human scale city'. The difference is evident when we compare the urban patterns of productive settlements and modern cities that require more energy input for transportation and production (fig. 5).

Apart from the physical influences of production facilities on vernacular settlements, productivity also reinforces 'local identity'. The productive districts of particular sectors such as *souqs* (or *bazaars*)[3],

[3] A *souq* is an open-air marketplace or commercial quarter in Middle Eastern and North African cities. The equivalent Persian term is '*bazaar*'.

Fig. 7 Fondouk, Chefchouen, Morocco (photo: L. Lupi).

Fig. 8 A traditional house with the workshop and laboratories on the ground floor in Safranbolu, Turkye (photo: N. Peskircioglu).

bedesten[4], *caravanserai* (or *fondouk*)[5] cacharacterize the local structures, which are influenced by local cultures and climatic features (fig. 7). Each locality has different natural resources and production cultures. Even the same type of product shows diversities in different localities due to the fact that the craftsman is responsible for the whole process of production, from manufacturing to trading. Therefore the production culture appears as a determining issue in terms of the physical and socio-economic structure of vernacular settlements.

The reflection on spaces of productive activities

In vernacular communities production occurs in two main scales according to the modality in which the production is carried out. The first scale determines the 'collective production', while the second scale, which has a minor dimension, consists of 'individual production' (Özel et al., 2014a). The production system of vernacular communities is defined by a 'production chain' which is articulated in collective and individual activities. Vernacular settlements appear with various spatial arrangements in architecture and urban scale in order to meet the requirements of collective and individual production.

Spaces of collective production

Collective production comprises primarily major scale activities such as farming, grain processing, baking, manufacturing of raw materials and craftsmanship. The sectors of collective production all require 'co-working' in order to achieve an efficient management of resources, production of energy and sharing of infrastructures. As seen, these sectors demand either complex structures/systems or large amounts of energy. For this reason entities feel the necessity of working together to overcome these challenges. Public collaboration in production processes also enhances the optimization of energy consumption and the reduction of environmental pollution related to post-production. Moreover, shared facilities encourage social cohesion and create spaces for exchanging and developing new ideas. Since the Neolithic revolution, with early human settlements, shared facilities like common furnaces began to appear. This indicates that since pre-historic cultures mankind needed to collaborate and share.

[4] A *bedesten* (or *bezistan* or *bedestan*) is a covered market usually for haberdashery and craftsmanship (Jayyusi et al., 2008). The *bedesten* were built during the Ottoman Empire and their design is based on that of mosques (Norris, 1993).
[5] The *fondouk* is a large structure able to provide accommodation to travellers, traders and farmers who come to Chefchaouen to sell their agricultural products and to buy handmade goods.

Fig. 9 Communal bread oven in Chefchaouen, Morocco (photo: L. Dipasquale).
Fig. 10 Collective oven in Custonaci, Sicily, Italy (photo: Marco Cadinu).
Fig. 11 Water mills for producing renewable energy from natural sources, Verona, Italy. (photo: Casa Laboratorio Mulino Simbeni).
Fig.12 A communal fountain in Lunigiana, Italy (photo: L. Dipasquale).

Vernacular settlements are furnished with common facilities such as communal bread ovens where people bake their daily home-made bread (fig. 9-10). In traditional cultures bakeries open their ovens to the public after they have finished baking their products for commercial purposes. Sharing ovens surely avoids wasting energy and makes vernacular way of living more sustainable. The same system is seen in the use of mills. The mills are systems that produce mechanical power from natural sources, mainly from wind or water. Mills are mostly used in a collective way in grain processing to produce flour, but also as a source of energy related to lumber or textile production (fig. 11). Dairy plants are another communal production place where local people milk cattle in order to produce saleable dairy products such as butter, cheese and yogurt.

Water undoubtedly has an essential role in productivity. In vernacular settlements the access to water is obtained through the use of wells and fountains. Such shared facilities are generally situated in squares and other central public spaces to facilitate communal access, and often these facilities also become places where people meet and socialize (fig. 12).

Spaces of individual (domestic) production

In vernacular settlements dwellings constitute a significant part of the 'production chain'; they provide adequate spatial arrangement for the activities of individual production. From this point of view vernacular dwellings act like 'workshops' and they enable various domestic production facilities.

There are several spatial elements that favour productivity among which the patio or the courtyard. The courtyard has a fundamental function as it offers a semi-open introverted form (fig. 13). Its geometric features facilitate having a central spatial arrangement that provides a better organization for productive activities. As commonly seen in many traditional dwellings in the Mediterranean region, productive spaces like stalls, domestic workshops, wells, ovens and storages for products are articulated around this central space. According to the dimensional features, the patio can even include a domestic garden for cultivation of fruits and vegetables for the household's needs but most of the time the food grown is also shared with neighbours. Other indispensable spaces of the productive dwellings are storages. Vernacular dwellings are equipped with different

Fig.13 Space for individual productive activities in the courtyard of a *masseria*, Sicily, Italy (photo: L. Dipasquale).

Fig.14 Fortified granaries; Ksar Ouled Soltane in Tataouine district, Tunisia (photo: © STML).

Fig. 15 Terraces used to dry fruits and vegetables, Salina island, Sicily, Italy (photo: L. Dipasquale).

Fig. 16 A productive vernacular house with domestic laboratories in Greve in Chianti, Tuscany, Italy (photo: B. Özel).

types of storages, which serve for preserving seasonally produced food during the year; granaries, for example, constitute a fundamental part of traditional houses. In Northwest of Spain and in Northern Portugal a granary, locally known as *hórreo*, is built for each dwelling. In the Black Sea region of Turkey granaries, which are called *serender*, in some cases are not only mere grain storages but also act as domestic workshops. Granaries show different features in different regions but the common purpose is to build a raised storage building to prevent the access of rodents and protect the grain from humidity. In southern Tunisia the adobe granaries, called ksour, are built up to four stories high and are reached using narrow staircases (fig. 14). Vernacular dwellings are mostly characterized by the profession of their residents.

Spaces like the craftsman's workshop, where production and commercial activities take place, are incorporated within the house (fig. 8, 15, 16). In medieval Florence, the loggia used to be a distinctive spatial element of the dwellings since it was a specifically designed semi-open terrace where wool and cloth were extended for drying after a series of processes. Therefore the loggia often appears as an indicator of the wool and textile manufacturers' houses. Similar cases are seen also in Safranbolu where workshops are mainly situated in the ground floor of houses. These are the places where the resident family perform their professional activities such as shoemaking or other crafts.

Sustainability lessons from vernacular settlements for contemporary cities

In the context of urban design strategies and building cultures, vernacular settlements establish an adaptable responsive spatial organization for the different dimensions of production. By adequate principles of land management, cleverness in the integration to the place, smart ways of producing natural renewable energy, reduction of pollution, and consequently, reduction of transportation and management costs, vernacular communities become important cases to analyse for better understanding, as well as for recognising the value of self-sustaining principles.

Below are descriptions of the primary lessons that can provide inspiration in making our cities more 'self-sufficient'. Some lessons have already been applied in an innovative way in some contemporary cities.

Fig.17 *Hortet del forat*, urban garden in Born district, Barcelona, Spain (photo: P. Munné).

Urban farming

In productive vernacular settlements agriculture has a fundamental role in the regular food supply and in providing food security in cases of emergency and natural disasters. In terms of self-sufficiency urban farming can improve both the ecological and socio-economic well-being of contemporary cities. Farming in the city ensures availability of fresh food, reduces packaging, storage and eventual transportation needs; moreover, it creates income possibilities. It also helps to recycle urban waste-water through farming processes. Urban farming links socio-cultural values to socio-economic issues and incentives local productivity and therefore it eventually helps to develop local economies and socio-economic resilience. Transmission of local production cultures and collectiveness are the other aspects of urban farming that enhance social cohesion.

The notion of urban farming is gaining new significance in contemporary cities and metropoles; at the beginning of 19th Century the concept of peri-urban agriculture was introduced to urban life. As can be understood by its name, this type of agriculture is carried out on the urban fringe, mainly for the purpose of providing low-priced food to the increasing population of industrial cities (Özel et al., 2014b). The peri-urban agriculture has been prevalently used as a local food production strategy in Europe. Krakovo Gardens, in the city of Ljubljana, Slovenia, is one of the examples of the integration of farming activities in the city. Krakovo Gardens are constituted by an allotment system, and are situated within the urban area. These gardens are playing an important role as a source of fresh vegetables for the local people.

In the current century, the concept of urban gardens, so called orti urbani, introduces a new application method of collective farming conducted in vacant plots, verges, terraces and balconies within the urban areas. The first initiatives of this movement appeared in many cities, among others Rome[6] and Barcelona (fig. 17).

Self-manufacturing

The production process in vernacular communities is based upon a triangle of interactions that consists of three phases: 'knowledge – creativity – production'. In this cycle knowledge represents the person's background of know-how which is accumulated by the transmission of production techniques over generations. Creativity is more concerned with the personal skills necessary for re-interpreting knowledge in the creation of goods. Production involves entire processes of transformation to obtain goods by employing available resources.

The 'triangle' of interactions can be adopted and re-adapted to the technological features of today.

In recent years many experiences regarding self-manufacturing are increasingly developing in the field of product and furniture design. Self-produced design is a time-tested practice in the experimental design field; nevertheless, its meaning today has evolved toward a contemporary trend, hinging on a growing demand for quality and sustainability and becoming a key point for grasping future trends in manufacturing, distribution and consumer changes (Maffei, 2013)[7]. New generation of designers, embracing in a innovative way the 'Do It Yourself' approach, choose to directly follow the entire production chain of their products, from the concept, to their manufacturing, – mixing low-tech and high-tech ideas and production processes – selling and marketing. Self-made design paves the way for a rediscovery of craftsmanship and for the integration of creativity, production and

[6] The shared urban gardens of Rome have risen by 50% in one year, going from 100 to 150 gardens in almost every district of the city. The farming activities are carried out generally in neglected public spaces, urban parks, and abandoned plots within the urban area (www.zappataromana.net).

[7] In Italy Self made design is recognized as an increasing trend and it is supporting by annual exhibitions and competitions dedicated to self-produced and small-scale design, such as Open Design Italia in Venice, Source-Self Made Design in Florence, Operæ-Festival del design indipendente in Turin, A Designer A day in Milan, etc.

Fig.18 Fab Lab, Barcelona, Spain (photo: S. Mecca).

technology in a new manner, where designers are responsible for the entire production process, improving their competence with an entrepreneurial attitude.

At the same time new and innovative spaces for self-manufacturing are increasing. 'Fab-lab' (fabrication laboratory), which first appeared in Massachusetts[8] in 2001, can be considered as a project of re-interpretation of converting the content of information to a physical representation by taking advantages of advanced technology. 'Fab-lab' is a small-scale workshop offering digital fabrication (Menichinelli, 2011). It offers an equipped laboratory with flexible computer aided tools that cover several different length scales and various materials that enable 'mass-production' (Gershenfeld, 2005). The idea of 'fab-lab' enables individuals creating customized objects and goods by using computers and computer-controlled devices. In this way individuals can become more active and autonomous in production processes (fig. 18).

Self-building

In the field of housing building, there is a growing recognition that self-build practices can be an affordable way toward a sustainable living. In self-build practices inhabitants actively participate in the construction of their own house, adapting it to their specific requirements (fig. 19). The self-building process is often supported by professional, architects and builders, or in other cases the owners manage building sites and deal directly with planners, tradespeople and materials suppliers, as project managers. Several experiences have shown how self-building processes can reduce the cost of building, creating at the same time the competence for a self-maintenance of buildings by the community and promoting a wider environmental, economic and social awareness (Mecca et al., 2014). Self builder associations of both professional and common people have emerged in many European countries to diffuse information and knowledge, to facilitate education, and to work on the fiscal and juridical policy dimensions development, while specific building codes and regulations on self building are yet to be determined.

Fig.19 Self-building in Pontassieve, Tuscany, Italy (photo: L. Dipasquale).

[8] The programme began as a collaboration between the Grassroots Invention Group and the Center for Bits Atoms (CBA) at the Media Lab in the Massachusetts Institute of Technology with a grant from the National Science Foundation in 2001.

Knowledge sharing

In vernacular communities knowledge sharing occurs in all spaces that regard production, primarily in workshops, factories and even in homes. Obviously the contribution of the most important philosophy, that of the 'collective way of living', cannot be denied in the creation of the knowledge flow. With globalisation, the transportation of foods and goods had a rapid growth that caused numerous negative effects and increased environmental impact. When the depletion of natural resources and the negative consequences of climate change are considered, the necessity of reducing transportation becomes evident and essential. Therefore the feature of self-sufficiency that we want to attribute to our cities should take into consideration the fact that it should be the knowledge to share rather than the physical exchange of goods; in this way diffusing knowledge will allow communities to produce locally and reduce the necessity of transportation. In the contemporary context several interesting experiences of knowledge sharing on architecture are being developed. Thanks to the worldwide computer network, open source communities can share and improve information and education regarding technologies for building. For example, the Open Architecture Network launched by Architecture for Humanity, is an online, open-source community dedicated to vernacular and sustainable design, which allows open access to blueprints, replacing traditional copyright restrictions with Creative Commons licensing. Opensource Architecture is an example of a virtual platform that uses the shared spaces of the World Wide Web to enable an inclusive approach to spatial design and a collaborative use of design software applications using relational data and parametric connectivity, which can supplement and replace traditional architectural design tools (AA.VV., 2011). Following the same philosophy, Open Source Ecology (OSE) is a network of farmers, engineers, architects and patrons, whose main goal is sharing open-sourcing blueprints and information through the use of wikis and digital fabrication tools, for allowing anyone to build their own industrial machines designed to create a sustaining village with modern comforts (Jakubowski, 2001).

The same scope of sharing knowledge is pursued in a physical space – as it is in traditional workshops – by 'coworking' communities. A 'coworking' space involves a shared working environment, often an office, where a group of professional, often freelancers, can work independently, sharing at the same time a collaborative attitude, or rather contributing their own knowledge and competences, such as enjoying the synergy that happen from working with interdisciplinary teams in the same space.

Beneficial effects of self-sufficiency for contemporary cities

Embodied strategies of vernacular communities for self-sufficiency are inherently proven and reliable as they incorporate long-term experiences with the wisdom of facing vital challenges with limited resources and amenities. They are surely worth to be analysed, understood and re-adapted to the conditions of contemporary cities. Applied approaches of self-sufficiency in vernacular settlements offer beneficial effects in environmental, socio-cultural and socio-economic terms. In environmental issues, self-sufficiency promotes 'locality' in production processes, and therefore favours reducing evidences of human-initiated climate change as it depresses carbon emission caused by the transportation of goods. Local production, conceptually called 'production at km 0', accommodates the basic needs within short and comfortably walking distances. This fact increases the 'independence' of people and promotes 'car-free' cities.

Self-sufficiency also helps to prevent the negative effects of climate change in urban areas by reducing social and environmental vulnerabilities. In terms of urban resilience, self-sufficiency encourages collective production of knowledge; in this way it stimulates a more capable community, skilled in the production of its own food and other need satisfiers, even in cases of emergency and natural hazards. Beyond the beneficial effects on environmental and socio-cultural issues, self-sufficiency has positive outcomes regarding urban economies.

In this era of globalisation, where cities represent the engines of economic development of countries, a new concept is raised, called 'cultural cities' that presupposes an awareness of the value of local cultures. This concept is based mainly on marketing the cities by recognising and promoting their traditional cultural heritage (Tucker 2008). Self-sufficiency has an important role in strengthening local economies and cultural authenticity, which are distinctive and specific according to the particular local material and immaterial variables.

THE MEDINA OF MARRAKESH

MARRAKESH, MOROCCO

author
Bilge Özel

ENVIRONMENTAL PRINCIPLES

to respect environmental context and landscape · to benefit of natural and climatic resources · to reduce pollution and waste materials · to contribute to human health and welfare · to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

to protect the cultural landscape · to transfer construction cultures · to enhance innovative and creative solutions · to recognise intangible values · to encourage social cohesion

SOCIO-ECONOMIC PRINCIPLES

to support autonomy · to promote local activities · to optimise construction efforts · to extend building's lifetime · to save resources

Marrakesh is one of the largest cities of the northwestern African nation of Morocco and is the capital of the mid-southwestern economic region of Marrakesh-Tensift-El Haouz. The history of the Medina of Marrakesh, which represents the distinct, walled core of the city, dates back to the beginning of 11th Century. Trade and craftsmanship are the most relevant activities for the local economy. The major part of the production activities occur in the core of the Medina of Marrakesh which is constituted by 18 souks employing a significant percentage of the population. The souks consist of divided areas for specialized sections that deal in specific types of productive activities such as leather and fabric crafts, metal works and hand-woven works. In addition to their formal names, the souks are colloquially named after the product that they specialize in such as the fabric souk, the leather souk, the spice souk etc.

The souks of Marrakesh appear like specific parts of an open-air factory as they are composed by various types of workshops where both production and trading activities are carried on. The souks contain a wide range of items from traditional babouches1 and belts to woven baskets and ironworks. Two of the largest souks, Souk Semmarine and Souk Cherratine, sell everything related to leather-works, while Souk Sebbaghine specializes in dyeing activities characterised by the presence of giant cauldrons. Souk Haddadine, which is known as ‘corner of the smiths’, contain numerous ironwork workshops (Kerry, 2009). As seen on the layout scheme of the sectors, the souks form an ‘integrated production area’ within the Medina of Marrakesh. Today the souks still have a substantial role in producing sufficient goods to meet the needs of local people, and are furthermore an important landmark of the city.

LEATHER WORKS
- Souk of leather
- Leather merchants and manufacturers of slippers
- Manufacturers of slippers, belts and saddles
- Shoemakers
- Souk of slippers
- Souk of saddles

ORGANIC WORKS
- Woodworkers/carpenters
- Merchants of rope and twine
- Merchants and manufacturers of baskets

FABRIC WORKS
- Dyers
- Souk of fabrics
- Souk of coverlets
- Souk of wool fabrics
- Tailors
- Souk of silk fabrics

METAL WORKS
- Armourers and jewellers
- Coppersmiths
- Blacksmiths

Layout scheme of Souks of Medina of Marrakech (redrawn by B. Özel after the original scheme of A. Mandleur, Croissance et urbanisation de Marrakech, 1972).

The various souks of Medina of Marrakesh (photos: L. Dipasquale).




THE SARDINIAN COURTYARD HOUSE

SARDINIA, ITALY

author
Maddalena Achenza

ENVIRONMENTAL PRINCIPLES

to respect environmental context and landscape; to benefit of natural and climatic resources; to reduce pollution and waste materials; to contribute to human health and welfare; to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

to protect the cultural landscape; to transfer construction cultures; to enhance innovative and creative solutions; to recognise intangible values; to encourage social cohesion

SOCIO-ECONOMIC PRINCIPLES

to support autonomy; to promote local activities; to optimise construction efforts; to extend building's lifetime; to save resources

The southern Sardinian village is represented by an aggregate of many rural earthen houses always built following the courtyard typology. This is not by chance, since the house, even in an urban configuration, represents an extension of the rural life that characterizes these territories; life that through the centuries has preserved a strong agricultural vocation.
The single property is definitely separated from the road by an enclosure wall and therefore the house results strongly introverted. The house becomes in this way the retreat after a day of labour in the fields, but also represents an appendix of this labour. In fact, according to the different local living traditions the residence is located either in the front or in the rear of the courtyard. But whichever the position chosen for the house, some other constructions are always present next to it: the warehouse, to store and transform the agricultural products (especially grapes to be turned into wine, and wheat stored to dry), barns to protect the working animals (horse and donkey), a shed for protecting both the tools and the cart, and a space for the oven to bake bread.
Sometimes there is more than one courtyard. In this case one is definitely dedicated to work and is used in a more 'public' way, the second one is kept private for the use of family members only. But in both, many different activities are undertaken that are related to the local agricultural work.
The Sardinian courtyard house is therefore an exemplary system where the living function is perfectly integrated with the productive activities.

Plan and cross section scheme of the House in Qaurtu S. Elena (drawings: M. Achenza).
1.Entrance; 2.Open gallery; 3.Courtyard; 4.Annexes; 5.Warehouse 6.Kitchen.

Courtyard houses in Samassi, in Soleminis, and in Ussana, Sardinia, Italy (photos: M. Achenza).

URBAN GARDENS IN ROME

ROME, ITALY

author
Chiara Belingardi

ENVIRONMENTAL PRINCIPLES

■ to respect environmental context and landscape ■ to benefit of natural and climatic resources ■ to reduce pollution and waste materials ■ to contribute to human health and welfare ■ to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

■ to protect the cultural landscape ■ to transfer construction cultures ■ to enhance innovative and creative solutions ■ to recognise intangible values ■ to encourage social cohesion

SOCIO-ECONOMIC PRINCIPLES

■ to support autonomy ■ to promote local activities ■ to optimise construction efforts ■ to extend building's lifetime ■ to save resources

The city of Rome has a long tradition of urban gardening: it is possible to affirm that the cultivation of land inside the city never ceased since its foundation. This is testified in many historical maps, as the one drawn by Nolli in 1784, that includes not only houses, streets and churches, but also cultivated lands inside and outside the city walls. The map also shows the 'Prati del Popolo di Roma', a common in which people were allowed to graze, celebrate and to seed. Other references can be found in historical pictures of the city, especially during World War II, or in the books of Pasolini (in 'Ragazzi di vita', Riccetto stole some pumpkins in a garden near Mandrione street, not far from San Giovanni church). Subsequently urban gardens became common among retired people or immigrant workers from the south of Italy, both as income support and as a form of maintaining the tradition of working the land.

During the last years community gardens have become widespread, with some differences between this practice and that of the classical urban gardens:

1. The people involved are not only pensioners and immigrants, mostly men, but a mix of highly educated people, women, families, and young people from different origins (both Italians and foreigners);
2. Management and usage: not only single individuals lots, but shared spaces and in some cases shared lots, with a particularly high attention to ecological and educational issues;
3. Motivations: gardens are grown not only for income support, but also for sharing something with one's neighbors and to create social links.

The practice of community gardening has become quite widespread: in 2011 Zappata Romana, an association involved in community gardens, charted around 70 of these places, whereas by 2013 around 150 of these community gardens were counted by the same association. And the numbers are increasing.

↑ The map of urban gardens of the community of Zappata Romana, Roma, Italy (online on: www.zappataromana.net).

↓ Farming activities in the urban gardens; encamped urban garden; Garbatella, Rome, Italy (photos: C. Belingardi).

Zelve valley, Cappadocia, Turkey
(photo: A. De Pascale-Centro Studi Sotterranei).

Underground settlements

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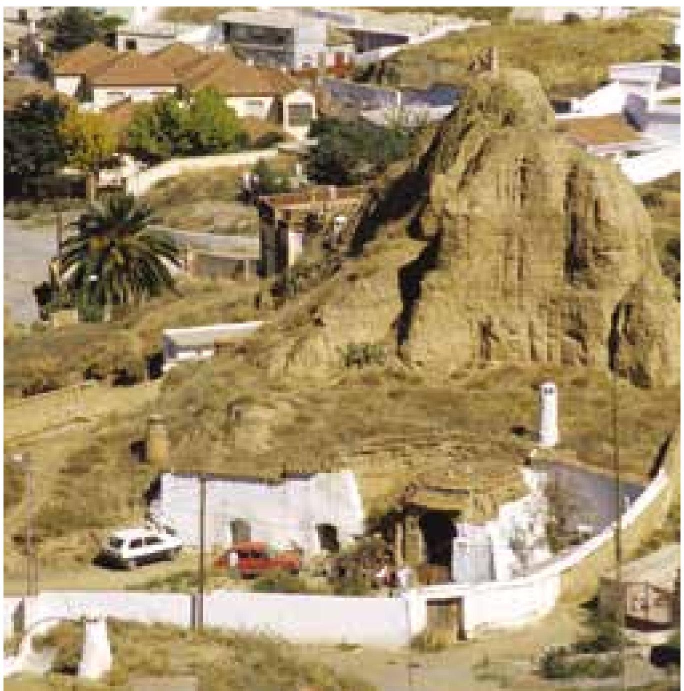
Cave dwelling architecture normally differs from other types of habitats, above all because it does not ordinarily bear any characteristic external design. On the contrary, its identity is primarily visible in its internal and 'negative' form. Underground architecture has the peculiar psychological virtue of arousing atavistic, ancestral feelings, faithfully reflecting the idea of shelter, refuge or womb.

Studies on child psychology have shown that the conception of the foetus and the new-born baby occurs topographically and, only later, this primitive form of perception is transformed by learning. Underground architecture also has a sacred, mystic halo, since it pays tribute to Mother Earth. A cave is a finished dwelling from the very beginning, complete at any point of the excavation process, even before the digging begins, since the ground holds and contains the potential space. Therefore, while digging a subterranean dwelling, the space shakes itself out of the rock in the same way as Michelangelo's statues of slaves do. Nevertheless, in this case there is no limit of growth, since it expands according to its need, becoming a totally functional dwelling (Noguera et al., 2007).

Underground architecture has a special interaction with space, the environment and constructive resources (fig. 1), as explained below. Although there are examples of subterranean architecture from every continent, this type of architecture is mainly to be found in Eurasia (Golany, 1983).

Fig. 1 Cave dwelling excavated on the slope of a promontory in Guadix, Spain (photo: F. Vegas and C. Mileto).



Subterranean architecture is not necessarily limited to domestic architecture, but also public spaces, such as rock sanctuaries, cemeteries, refectories, refuges, tunnels and burrows, or productive spaces, like farmhouses, wine-presses, cellars, stores or poultry farms. In most instances, these examples are not isolated cases, but form actual subterranean cities. Contemporary scientific interest in cave dwellings has been aroused only since the mid 1970s (Nicoletti, 1980). However, for a variety of reasons, people have lived in such structures for centuries, intuitively using great passive design concepts (Kempe, 1988). There are several basic needs that urged people to excavate spaces to live and work in, among which we can mention: protection from outside attacks because they were inaccessible, as well as easy to defend and camouflage in their natural surroundings; they were cheap and easy to build in places that fulfilled the right geological conditions; they offered bioclimatic advantages; or their capacity to be enlarged as the family augmented. The cave has been considered as a possible origin for architecture (Font, 2013a), and has been studied and mentioned through the centuries by several authors[1]. Some subterranean cities are also reserved for the dead, but at certain times in history they were used by the living who needed shelter. In this group we could include the catacombs of cities like Paris and Rome, Etruscan or Roman *columbaria* (Cristini et al., 2007), hypogean Byzantine necropoles (Montero Fenollós et al., 2008), etc. On the other hand, underground quarries scattered through the world are sometimes unintentional tests for cathedral-like spaces (AA.VV., 2002).

The underworld in the collective subconscious

The underworld has always been a fascinating theme in popular imaginary, mythology and culture. The existence of an underworld appears in the culture of Sumerians, Greeks (*Hades*), Christians (Hell), Scandinavians (*Svartálfaheimr*), Hebrews (*Sheok*), Tibetan Buddhists (*Shamballa*), etc. The caves into the underworld are also common in the culture of the Greeks and Romans (Averno), Celts (*Cruachan*), the Oceanic (*Obukula*), the Mexicans *Mictlán*, the Hopi (*Sipapu*), etc. Unlike Christianity and its literature[2], not all these cul-

[1] Among others, see Aeschylus, Posidonius, Vitruvius, Seneca, Goethe, Hirt, Hegel, etc., see Font, J. 2013a., *op.cit.*

[2] See as example: Alighieri, D. [ca. 1310] *La Divina Commedia. Inferno.* Reprint 1986 Editrice Ferraro, Napoli.

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Fig.2 Underground dwellings in Scicli, Sicily, Italy.

Fig. 3 Pantalica was born as a necropole but was used as dwellings from time to time. Sortino, Sicily, Italy (photos: L. Dipasquale).

tures identified the underworld with evil, but as an alternative habitat or even as the place their ancestors came from[3].

Nevertheless, the literature about underground architecture that interests us most is the one that points out the bioclimatic advantages it has (Font, 2013b). It is worth giving special mention to *The Societies and Governments of the Moon* by Cyrano de Bergerac, in which he describes dwellings that can rise up from the ground or sink into it depending on the sunshine and the temperature outside; *The Black Indies* by Jules Verne (Verne, 1877, p. 13), where a miner called John Ford lives contentedly in his underground dwelling; or story number 701 of *A Thousand and One Nights*, where Aladdin describes his wonderful subterranean garden.

Outstanding vernacular examples of cave-dwellings

It is not easy to make a complete survey of European cave dwellings, considering that within historical times these examples of architecture are scattered throughout the continent. In spite of this it is interesting to discover such a variety of great underground spaces, starting in the Northern countries and progressively making our way down to Mediterranean areas[4].

Rather surprisingly, many people have traditionally lived in cave dwellings in the United Kingdom. Especially outstanding examples are nowadays conserved in Scotland (Wick Bay and East Lothian) and also in England, for example, in Yorkshire (Harrogate), Derbyshire (Buxton), the East Midlands (Nottingham), Devon (Dartmoor)

[3]There is a great deal of literature dealing with the underworld, a genre that many writers have chosen. Among the most important literary works on the subject the following may be mentioned: Kircher, A., *Mundus subterraneus*, 1682; Holberg, L., *The Journey of Niels Klim to the World Underground*, 1741; Casanova, G. *Icosameron* or, *The story of Edward and Elizabeth: Who Spent Eighty-one Years in the Land of the Megamicres, Original Inhabitants of Protocosmos in the Interior of our Globe*, 1788; Seaborn, C. A., *Symzonia: A Voyage of Discovery*, 1920; Poe, E.A., *The Narrative of Arthur Gordon Pym of Nantucket*, 1838; E.A. Poe also wrote two more fantastic underground tales *MS. Found in a Bottle* (1833) and *The Unparalleled Adventure of One Hans Pfaall* (1835); Verne, J., *Voyage au centre de la Terre*, 1865; Carroll, L., *Alice's Adventures Under Ground*, 1864; Sand, G., *Laura*. A *Journey into the Crystal*, 1884; Baum, L.F., *Ozma of Oz*, 1907; Baum, L.F., *Dorothy and the Wizard in Oz*, 1908; Baum, L.F., *Tik-Tok of Oz*, 1914; Emerson, W. G, *The Smoky God. A Voyage Journey to the Inner Earth*, 1908; Burroughs, E.R., *At the Earth's Core*, 1914; Wells, H.G., *The Time Machine*, 1895; Tanner, C. R. *Tumithak of the Corridors*, 1930; O'Larkin, S., *Morgo the Mighty*, 1930; Tolkien, J.R.R., *The Hobbit*, 1936; Tolkien, J.R.R., *The Lord of the Rings*, 1955; Rampa, L., *The Third Eye*, 1956; Capon, P., *The Cave of Cornelius*, 1959; Lewis, C.S., *The Silver Chair. The Chronicles of Narnia* Vol. 4, 1953; Galouye, D.F. *Dark Universe*, 1961; Barrett, G.J., *City of the First Time*, 1975; Rucker, Rudy, *The Hollow Earth*, 1990; Cook, R., *Abduction*, 2000; Farren, M., *Underland. The Renquist Quartet* Vol. 4, 2004; Collins, S., *The Underland Chronicles*, 2003; Mc Caughrean, G., *The White Darkness*, 2005; Long, J., *The Descent*, 2001; Long, J., *Deeper*, 2008; Pynchon, T., *Against the Day*, 2006; Hodgman, J., *More Information Than You Require*, 2008; etc.

[4] AA.VV. (2010/2012). *CHRIMA project (Cultural Rupestrian Heritage in the Circum-Mediterranean Area) EU Research Project.*

Fig. 4 Sassi di Matera which means 'the stones of Matera', ancient troglodyte dwellings. Matera, Italy (photo: B. Özel).

or Cornwall (Downderry). One of the most interesting groups of rock dwellings in Britain are in Staffordshire (along the Kinver Edge), where a string of former sandstone cave units were inhabited until 1950-1970 (Baring-Gould, 2008).

France has a long-standing tradition of cave-dwelling typologies too. The major cave dwelling area is around the Loire-Loret region, where the local chalk is particularly amenable to excavation. Indre-et-Loire, Loir-et-Cher, Main-et-Loire are areas with plenty of examples of cave dwellings, from houses to farms, from cave cellars to mushroom-growing caves. Similar cave settlements can be also found along the Dordogne, Dronne, Célé and Eure rivers or the Rhône Valley and Provence. Cave dwellings built into volcanic rock were found in Haute Savoie, Auvergne and Cevennes (Kempe, 1988).

Italy possesses scattered examples of cave dwellings (Settignano, near Florence, or Lucca, Pisa or the provinces of Perugia, Verona, Ragusa, Siracusa) (fig. 2) and necropoles used as dwellings from time to time (Pantalica, Siracusa, Gravina di Puglia, etc.) (fig. 3), but probably the most outstanding example is the old city centre of Matera (fig. 4). Here a well-conserved complex of houses, locally known as *Sassi*, which are dug into the calcarenitic rock itself and originated from a prehistoric settlement, is inhabited nowadays after a period of decadence in the second half of the 19th Century (Laureano, 1993).

Spain also has interesting examples of domestic cave dwellings. Probably the most famous are in Granada, Almanzora and Guadix, in the Andalusian region (fig. 5-6). The first of these are on the slopes of Sacromonte, where dwellings and taverns are occupied above all by gypsies and their descendants. The second case, occupying approximately one square mile, stands out above all for the ventilation chimneys of the underground units, visible everywhere in the city. In spite of these well-known examples, other interesting cases can be found above all in the eastern area of the Peninsula, where geological *facies* are easily excavated surfaces. Paterna (fig. 7), Crevillente, Moncada, Bocairent (Valencian region), Alcalá del Jucar (Castilla la Mancha), Aguilar de Campos (Castilla-León) (fig. 8) are some interesting Spanish examples of domestic architecture still in use (Aranda Navarro, 2003).

There are inhabited caves in many Mediterranean islands. Well-preserved examples can be found in Malta (the northern area of the island) and Sicily (Val d'Ispica, Bronte, Maletto, and Siculiano, among the most outstanding) (Monaco, 1997). A few caves are still lived in and have been converted into tourist sites also in Minorca (the Balearic Islands), Crete or Santorini (the Cyclades). Some Atlantic islands were inhabited by subterranean dwellers too. Caves are clustered in the fertile valleys of northern Gran Canaria, in the volcanic soil of Tenerife, as well as in Madeira. Fishermen with their boats and tackle have used cave dwellings, cut directly into cliffs and rocks close to coasts or bays (Carmody, 1993). Caves have been places to live or to work in in Poland (Wilieczka salt mines), Bul-

Fig. 5 The lunar landscape of Guadix full of cave-dwellings. Guadix, Spain.
Fig. 6 Two cave dwellings at Guadix with no concession to aesthetics.
The entrances to Guadix, Spain.
Fig. 7 Flat landscape in Paterna with its numerous cave-dwellings, Valencia, Spain.
Fig. 8 Cave cellars at Navapalos used to store wine, Soria, Spain.
(photos: F. Vegas, C. Mileto)

garia, Cyprus, and in the Crimean peninsula, from Kape Kersone to the bay of Ratla, thanks to the presence of layers of limestone alternating with clay and hard shale (Kempe, 1988).

Outside Europe, there are examples of important underground cities in many parts of the world, such as Derinkuyu, Kaymakli, Mazi, and Özkonak (fig. 9) with are part of a series of as many as 27 abandoned subterranean cities in the Cappadocia region (Turkey), some of which are connected to each other by tunnels; cavemen still live in Matmata (Tunisia) (Golany, 1988) (fig. 10); the Dogon people live in ancient cave dwellings cut into the cliffs of Bandiagara (Mali); there are also numerous underground cities in China inhabited by millions of people, of which the one near Tungkwan is one of the most important; there is an underground city in Nooshabad (Iran), a country famous for its tradition of *qanats* and cooling systems; Lalibela (Ethiopia) has monolithic rock-cut churches (Rudofsky, 1973); and the Nabatean town of Petra (Jordan) also deserves special mention; etc.

The idea of protection, defence and custodianship associated to these excavated architectures has arrived to the present day with examples like the Mormons' subterranean chambers in Salt Lake City; the network of military galleries built under the city of Arras (France) during World War I; the Japanese underground passages on the island of Okinawa; the sewers used during the Warsaw Uprising; the underground military bases like the one inside Afi mountain (Verona, Italy); the bunkers that sprang up all over the world, especially during the Cold War; the tunnels excavated by the Vietnam guerrillas, etc.

Common basic types of cave dwellings

Historically, cave dwellings can be grouped according to their features in three main general types of solutions: cliff cave spaces, built into the sides of cliffs (A), pit cave dwellings, normally built on flat land with pit areas open to the sky (B), mixed dwellings, constructed either above ground or thanks to a semi-subterranean solution, using cliff and/or pit cave dwellings (C), and finally a hybrid solution is also possible, thanks to earth-covered structures (D) (fig. 11).

The first type (A) is usually constructed on the sides of slopes, natural terraces or gullies. Digging into the side of a cliff is interesting because it affords the opportunity to shape a terrace that can be used as a confined enclosure or a squared patio, thanks to the soil removed. Four to six rooms form a 'normal' articulated family space,

Fig. 9 A cave dwelling in Zelve valley, one of the last abandoned monastic valleys of Cappadocia, Turkey (photo: A. De Pascale-Centro Studi Sotterranei).

Fig. 10 A cave dwelling with its characteristic patio for an extended family. Matmata, Tunisia (photo: F. Vegas, C. Mileto).

with a kitchen, a living room, one (or more) bedrooms, a livestock pen and storage space. Normally cliff cave dwellings also have a higher average number of rooms per dwelling complex than pit cave dwellings. Frequently, depending on the topography, the typology of these caves allows them to be accessed from a higher-level terrace or they may also have an entrance to the courtyard from an alley.

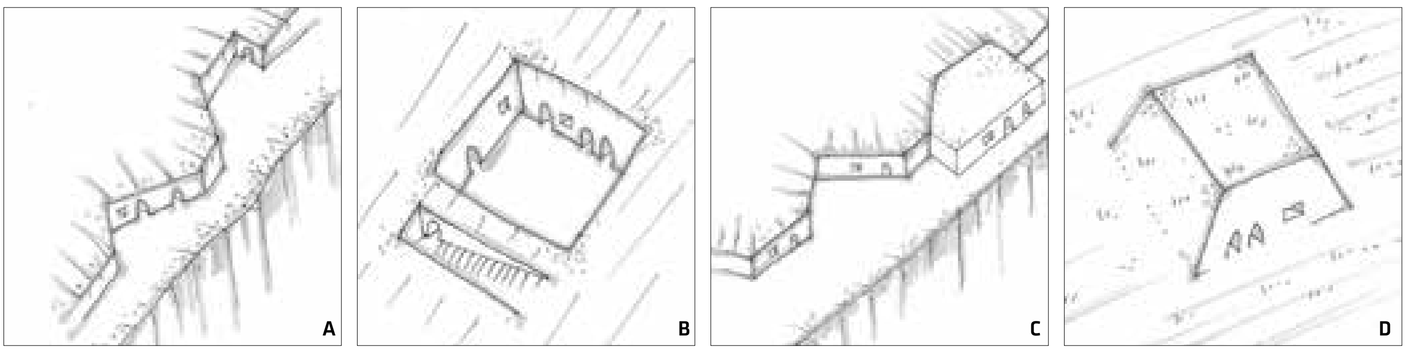
The second solution (B) principally comprises a patio (square, elliptical, trapezoidal or rectangular) which is surrounded by underground dwelling units. This type of construction is usually built on flat or slightly sloped land and the patio is normally excavated to a depth of more than 6-7 m. This courtyard typology has various rooms on each side: sleeping units are usually east – or west – oriented, living rooms are south-oriented, and storage spaces are commonly north oriented. Also there is a well or a cistern in the patio and graded entrances can lead directly to the courtyard by a stairway.

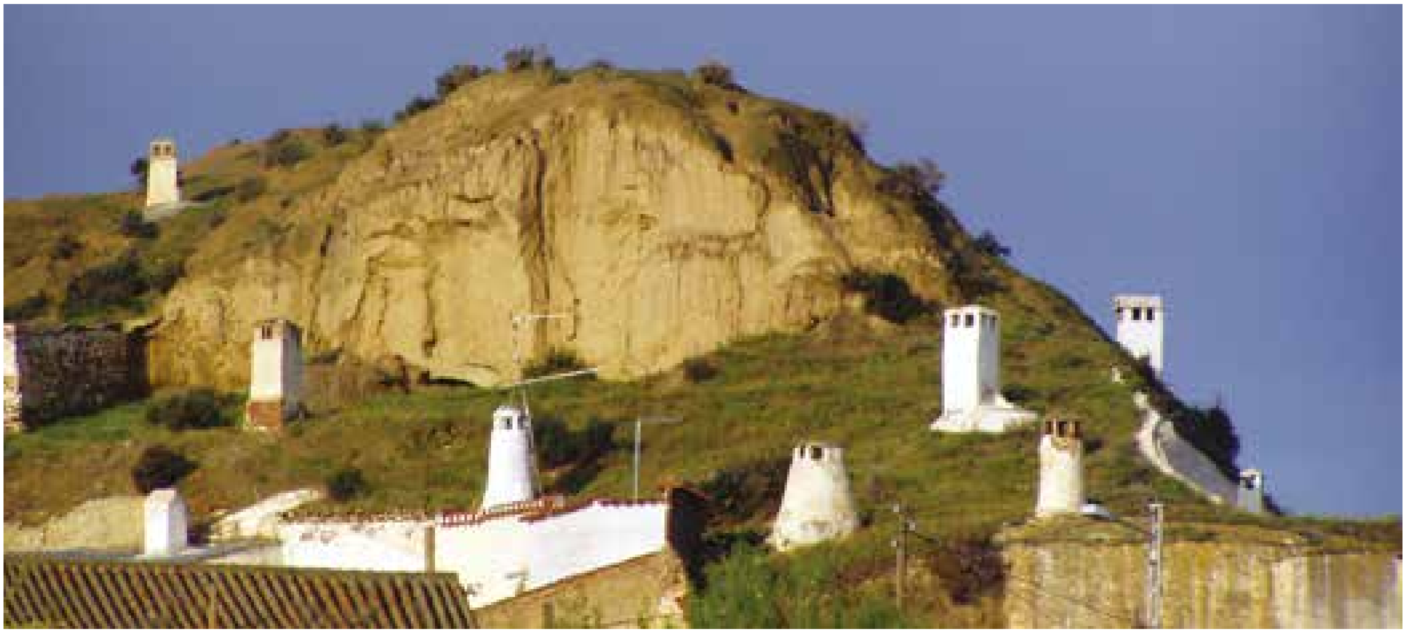
Another frequent solution is a combination of below – and above-ground space usage (C), with cliff or pit cave dwellings attached to each other. This construction may be, for example, a house close to the cliff combined with rooms excavated directly into it. The above-ground building compensates for the deficiencies of the underground space and vice versa.

The fourth possibility (D) counts on an 'excavate-and-cover-building solution'. This is a unit with an earth-covered structure, which is basically located at the grade and then earth-bermed and covered or integrated into a partially or fully excavated site.

Either one of these solutions is related to a wide variety of sub-types of constructions, that are the results of socio-economic, topographical, geomorphological, as well as climatological and cultural variations. Environmental forces, like temperature, precipitations and the composition of the soil, usually contribute to the detailed articulation of sub-types different that differ from one example to another. Traditional cave-dwelling solutions are above all related with the first options, called cliff (A) and pit (B) underground units; at the same time contemporary experimentations work more on space combinations, as explained in the two other options, known as hybrid (C) or earth-bermed (D) structures.

Fig. 11 Schemes of common basic types of cave dwellings (A, B, C, D) (drawings: V. Cristini).





Weaknesses and deficiencies of vernacular cave dwellings

There are some problems related to cave dwelling design that require special attention, such as land consumption, humidity, ventilation and waterproofing (Chiras, 2004). The first point emphasises the fact that cliff caves are normally developed according to topography but mixed structures or pit caves use up much more land, with a consequent problem of 'land consumption'. Generally the stability of a pit cave dwelling is guaranteed by a larger area than the aboveground space due to the thickness of its supporting walls. Consequently it is important to underline that a cave dwelling may sometimes consume more land than other construction typologies. Besides, there is a great paradox inherent in these private underground dwellings due to the fact that the space above them is often public. This may lead to legal, cadastral and urbanistic misjudgements that are difficult to solve (Noguera et al., 1997).

Another important disadvantage is the possible 'lack of active or passive ventilation', usually caused by the unsuitable design of chimneys, corridors, vertical shafts and constructive options for air circulation. This point is crucial also in keeping control of high levels of radon (radioactivity caused by the decomposition of uranium), a risk that is quite common in any earth-enclosed space. The control of air circulation is also important to limit dampness, condensation and moisture, especially in cave dwellings designed in areas with rainy seasons or with extreme climate during the year. In this case, a high relative humidity registered between patios, exterior terraces and rooms can be a serious problem (Golany, 1983) (fig. 12).

Frequently, important alterations to cave dwellings are also caused by water. In this case, some problems visible in traditionally cave dwellings are, for example, erosion of the soil, inadequate drainage (above all in pit-cave units), lack of waterproofing finishing solutions (like drainage trenches, pipes, sloped layers, etc.). The penetration of water will generally cause the development of cavities, cracks and rising dampness, moisture and interior condensation. All these factors have a negative effect on comfortable stable temperature and relative humidity, two characteristics associated to cave dwellings that traditionally guarantee human comfort in all seasons (Neila González, 2000).

Potentials and challenges of cave dwellings

One basic consideration is that when the units are properly designed, climatologic variations affect the soil very slowly while seasonal time-lag usually provides cool temperature below ground in summer and a warm temperature in winter. So, from a thermal point of view, soil is a great potential insulator and a great heat retainer (Stojic et al., 2009). This capacity of the subterranean habitat to adapt temperature has aroused growing interest in the study of climate control in the burrows of naked mole rats, underground wasps' nests and termite mounds (Korb et al., 1999), among others.

The energy cost of living in a well-designed cave dwelling is really low. Heat gain and loss, as well as energy consumption are minimal. Especially considering the effects of an extreme climate, it is worth to underline some interesting points. A good underground unit should have a stable diurnal temperature and a small indoor-outdoor seasonal temperature contrast. Another important aspect in terms of

Fig. 12 Chimneys emerging from the ground for proper ventilation at Guadix cave dwellings Guadix, Spain (photo: F. Vegas, C. Mileto).

cost has to do with 'construction' and 'maintenance'. Undoubtedly, blasting increases costs, and also geological and soil mapping are very expensive. On the other hand, fewer building materials are required (fewer windows, fewer external structures, etc.) as well as less external maintenance (façade painting, volumes remodelling, roof replacements) (Boyer et al., 1987).

From a *socio-economical* point of view, an interesting potential of the use of underground space is related to urban problems regarding land prices and urban soil consumption. This type of architecture could solve some of the dilemmas derived from space shortage and high demand of housing, and it could also be a paradigm for minimum impact on natural or urban environments. Underground architecture, obviously combined with other traditional design practices, can help solve some planning problems (Golany, 1992). It is difficult to point out all the options for the design of cave dwellings, above all considering the wide range of comfort and environmental variations. Nevertheless, some aspects like ratio of height to width, ceiling to surface thickness, the proportion of supporting walls, orientation, or the criteria for façades, remain almost identical factors throughout centuries and places (Golany, 1992). The first point is interesting because 'width' and 'height' in cave dwelling are normally correlated. In the event of a lack of auxiliary walls (with bricks, stones, concrete, etc.), the width of a cave unit should not normally exceed the height of the cave vault.

The second point, related to 'ceiling to surface thickness', is also interesting to analyse. A minimum amount of thickness is required between the ceiling of the cave and the surface of the ground above to avoid potential leaks caused by rain, moisture and the loads applied. Traditional architecture demonstrates that a thickness of up to 3.5 m is generally reasonable, always depending of course, on soil features (loess, limestone, sandstone and volcanic soils are usually the easiest option for cave dwellings).

On the other hand, the basic minimum requirement for 'spacing between units' depends primarily on structural reasons, in order to support the mass of earth above the cave. It is also frequent to find corridors built between adjacent units to connect them together. Traditionally the soil is not supported by auxiliary walls and normally the vault form is different from one region to another. Several vault styles can be found in different countries: flat ceilings or parabolic, pointed, elliptical, semicircular, depressed, and lancet arch vault-sections are the most common solutions (Neila González, 2000).

It is interesting to consider also that south-facing orientation has often been chosen in a wide range of cave dwelling architecture typologies; above all, because a cave space that faces north will normally have serious problems with dampness and moisture. Furthermore, south-facing orientation allows for a maximum exposure to sunlight (Boyer et al., 1987).

Finally, it is worth making a reflection about *façades*. Historically, a cave dwelling is a 'negative' construction in the sense that it is built without consuming building materials. However, the elevation of the cave requires a façade normally finished with walls (using stones, bricks, a concrete structure, etc.) and carpentry (for window and door frames). This finishing solution is quite variable. It may just be a closing wall for the cave or it may be shaped in a volume, added to the excavated unit. The elevation also provides and guarantees the penetration of sunlight into the dwelling, depending on the location of windows and *brise-soleils* (Carmody et al., 1993).

Contemporary underground architecture

The architecture of the last century has not overlooked the possibilities of underground architecture, initially due to its plastic potential and, more recently, due to its bioclimatic virtues. As underground train networks appeared and then spread through the major cities of the world, different projects and proposals arose (fig. 13-14).

Regarding plastic inspiration, special mention must be made of German expressionist architects (Solà-Morales Rubió, 1982) and, in particular of Hans Poelzig (Pehnt et al., 2007), in whose oeuvre the concept of excavated architecture was important (Bismarck Memorial, 1911; the Grosses Schauspielhaus in Berlin, 1919; the sets for the films *Der Golem* and *Lebendes Buddha*, 1920 and 1922 respectively, etc.).

Other examples which undeniably evoke excavated architectures are the spatial collages known as Merzbau (1923-1936) that Kurz Schwitters made in his home in Hannover (Germany), the project for the End less House (1924-1959) by Friedrick Kiesler, and the structures built by André Bloc in Meudon (France) Another example would be the project that Le Corbusier designed but never actually built for Sainte Baume (1948), an underground basilica that was to run through the mountain illuminated by natural light through many oculi with three

Fig. 13 Cave dwelling dug out of lava stone. Lanzarote, Spain (photo: F. Vegas, C. Mileto).

Fig. 14 Stairway in a semiburied cave dwelling dug out of lava stone. Lanzarote, Spain (photo: F. Vegas, C. Mileto).

large spaces of different height and crossed views. A similar example is the frustrated project of the sculptor Eduardo Chillida to carve out the interior of the sacred Mount Tindaya on the island of Fuerteventura in the Canaries (1985-1994). Another interesting modern subterranean project that never materialised is the Silkeborg Museum in Denmark (1963), by Jörn Utzon, intended to house the works of the artists of the CoBrA movement, with shapes inspired by the surrealist nature of this style of painting. A more recent impressive underground project was designed for a museum in Mönchsberg, Austria (1989), by Hans Hollein, but it never saw the light, although some of the ideas were used for the Vulcania Museum (1997) in the Auvergne region (France) by the same architect. Another fascinating project that never materialised was the theatre in the rock at Oya in Japan (1996), designed by Tadao Ando, which took advantage of the suggestive underground spaces in the quarry of volcanic tuff. No great projects for underground structures have been created in recent times, but contemporary design does take into account its plastic features, like the continuity of the sinuous surfaces of Frank Gehry's Guggenheim Museum in Bilbao, Alejandro Zaera Polo's topological spaces in Yokohama Maritime Terminal or the cave-like interiors often used by Steven Holl, among other examples.

Regarding the category of underground architecture that has focused the most on its capacity for integration and its bioclimatic virtues, it is worth mentioning the Temppeliaukio Church cut into the rock in Helsinki (1969) by the Suomalainen brothers; the UNESCO headquarters in Paris, conceived as a village of cave-dwellers cut into the loess (Rudofsky, 1977); the underground house that the architect Fernando Higueras designed for himself in Madrid in 1977, for which he coined the ironic term *hellscraper*; the Phillip Island House in Melbourne, Australia (1983) by Denton Corker Marshall; the fifty or so cave-dwellings near Zurich designed by the Swiss architect Peter Vetsch between the late seventies and the present; Villa Vals in Switzerland (fig. 15) (2010) by SeARCH and Christian Müller Architects (Broome, 2010), integrated into the slope and thus forming part of the landscape; the cottages at Fallingwater (2010) by Patkau Architects, on the land close to Frank Lloyd Wright's famous house; the project for the Subterranean Museum of Self-Archaeology (2011), by Jon Martin, which took advantage of the web of abandoned railway tunnels under Antwerp-Centraal railway station; the Crafts Centre and Ecomuseum at the Pan del Valle del Zalabí in Granada (2012), by Eduardo Canals; the project for the Hotel Klimahouse by Matteo Thun (2010) and the underground school (2013) constructed by Cleaa Architetti, both located in Bolzano (Italy); etc.

Following the tradition of several cities in the world that overlap an overground urbanism on top of an underground urbanism, for different reasons, such as burials (the catacombs of Paris, Rome, etc.); levelling (Edinburgh); wine cellars (La Guardia, Requena, Villacañas, Sant Cugat Sesgarrigues, etc. in Spain) or strictly for separating the

Fig. 15 Villa Vals in Switzerland designed by SeARCH and Christian Müller Architects in 2010, Vals, Switzerland (photo: SeARCH Architects).

traffic (the Pioneer Square District in Seattle), in the last fifty years there have been several projects that propose the creation of underground cities for reasons of both space and climatology.

Utopian projects have been drawn up for subterranean cities, like the upside-down buildings in the design for Leicester Square (1990) in London by Zaha Hadid, with skyscrapers cutting the earth and waterfalls running along inverted ravines that would act as a refrigeration system; or Sietch Nevada (2009), by Matsys Designs, a city buried in the desert directly inspired by Frank Herbert's novel *Dune* (1965). But underground cities are not necessarily strangely-shaped figments of the imagination.

Large subterranean areas can be found in contemporary metropoles, not only related to transport, like underground trains or tunnels, but also to galleries and shopping malls, leisure spaces, etc. It is a fairly common phenomenon, especially in cities with very extreme climates. These underground complexes began to appear in the 1960s and have kept increasing since. This is the case, for example, of the underground shopping centre in Westmont Square (1967), with tunnels connecting it with other parts of the city of Quebec, which was designed by Mies van der Rohe. Other cities like Toronto, Helsinki and Phoenix have myriad interconnected subterranean complexes. The most outstanding example is Montreal, with a present subterranean city of 12 million square metres, the equivalent of the walled city of medieval Barcelona.

The future

The negative historical consideration regarding underground dwellings is progressively being changed through a new approach gradually introduced by high-quality contemporary architecture, far from the stereotype of unhealthy and claustrophobic spaces. Undoubtedly, since the last part of 20th Century, newly emerging movements and trends have appeared. A new perspective regarding residential underground space (above all in developed countries) is now a tangible reality, far from stigmas based on the idea that a cave dwelling is a paradigm of troglodytes and poor living conditions. Human physiological comfort, diurnally and seasonally, is principally regulated by temperature, relative humidity, intensity of evaporation and the stability of all these factors. This combination of aspects may be totally guaranteed by a properly designed project of underground architecture. Besides, some contemporary examples have demonstrated that it is possible to introduce light, or contact between indoor and outdoor areas in cave dwelling design, just as in aboveground architecture.

Acknowledgements: *We wish to thank Juana Font for pointing to the underground literature that praises the bioclimatic virtues of habitat, as well as the information from the webpage http://en.wikipedia.org/wiki/Subterranean_fiction, which we have partially used. We would also like to thank Prof. Vicente Blanca for the examples he suggested.*

THE *SASSI* OF MATERA

MATERA, ITALY

author
Ippolita Mecca

ENVIRONMENTAL PRINCIPLES

to respect environmental context and landscape · to benefit of natural and climatic resources · to reduce pollution and waste materials · to contribute to human health and welfare · to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

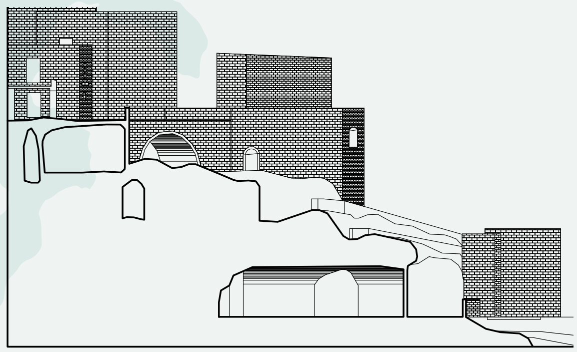
to protect the cultural landscape · to transfer construction cultures · to enhance innovative and creative solutions · to recognise intangible values · to encourage social cohesion

SOCIO-ECONOMIC PRINCIPLES

to support autonomy · to promote local activities · to optimise construction efforts · to extend building's lifetime · to save resources

The area around Matera has always had a tormented morphology full of valleys, ravines and terraces, as well as natural rock formations which has given rise to the fortified town of *Civitas*, above, and to i Sassi along the deep valleys bellow. As an urban settlement, the *Sassi* are unique in the world, and their form is directly related to the calcarenitic rock, locally known as *tufo*, which constitutes the basic element of construction. The calcarenite stone, which provides excavation precision and stability, has made it possible to add new caves to the existing ones using parts of the formal structures of built architecture, and to shape into the rocky habitat the necessary housing facilities, roads, architectural schemes and decorations of their urban systems.

The shape of the oldest house is a cave in the tufo with a closing wall formed by the blocks from the excavation. The caves that open onto terraces are flanked, branch-out and then sink into the ground obliquely to allow sunlight to penetrate all the way to the end and to facilitate natural ventilation. Many houses overlook a shared courtyard called *Vicinato*. With demographic growth more houses have been excavated and constructed, and the roofs of some houses have often become roads for the houses above. This urban settlement is an exceptional example of the accurate use of natural resources: water, land, and energy. Whereas today in modern buildings everything is provided by energy-intensive technological systems, in the Sassi these needs were secured through the 'natural' performance of buildings that were able to provide protection from both cold and heat, collect rainwater, use solar energy, block winds in winter and divert them in summer. The *Sassi* of Matera were inscribed on the UNESCO 'World Heritage List' in 1993.



Plan of cave dwellings of Sassi di Matera; cave dwellings cross section (Author: I. Mecca).

Underground dwellings of *Sasso Cavioso*; dwellings with cavern foundations of Sassi; detail of an underground dwelling, Matera, Italy (photos: B. Özel).

UNDERGROUND CITY OF DERINKUYU

CAPPADOCIA, TURKEY

author
Bilge Özel

ENVIRONMENTAL PRINCIPLES

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SOCIO-CULTURAL PRINCIPLES

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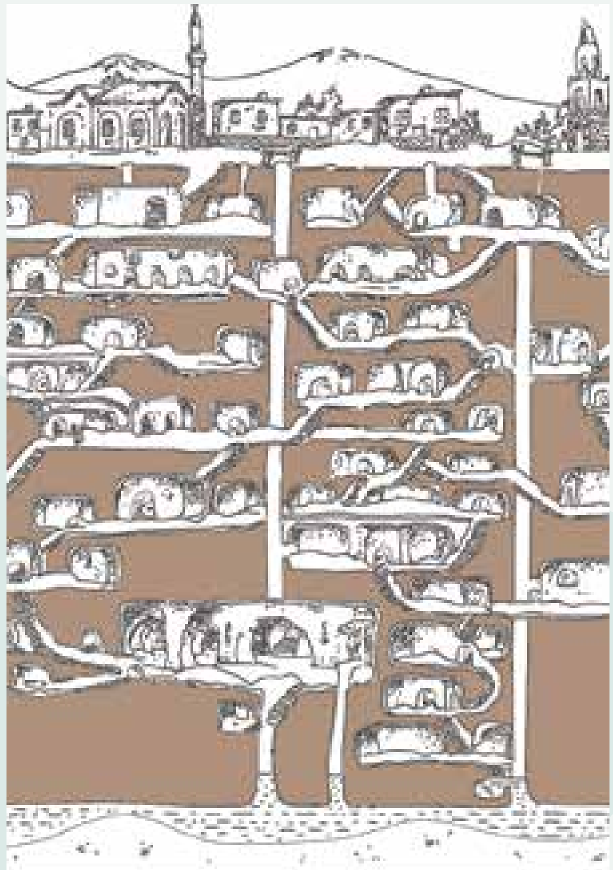
SOCIO-ECONOMIC PRINCIPLES

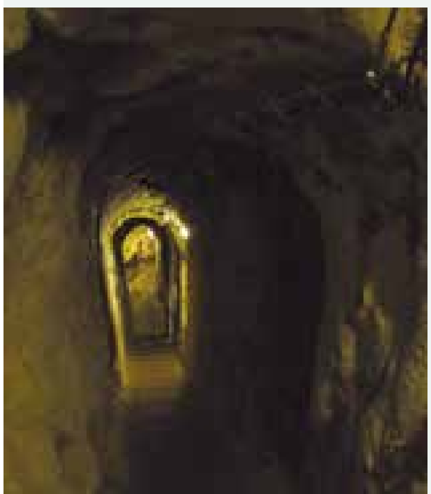
■ to support autonomy ■ to promote local activities ■ to optimise construction efforts ■ to extend building's lifetime ■ to save resources

Derinkuyu underground city is one of the numerous large underground cities of Cappadocia in the province of Nevşehir, Turkey. Extending to a depth of approximately 85 m and with 8 floors, it had a capacity of accommodating almost 20.000 people together with their livestock and various storages. According to some sources its foundation dates back to the Proto-Hittite era, and later in the Byzantine period it was enlarged and reached 4, 5 km2 of total area. Derinkuyu underground city sheltered the first believers of Christianity and provided a safe place for people who wanted to spread their religion. The underground city was used between the 6th and 7th Centuries as a refuge against Arab invasions. The complex has a total of 8 levels and each level can be closed off separately thanks to the stone doors that can be shut down with millstones in case of a raid. All rooms of the underground city are connected by narrow corridors and staircases. According to the levels the spaces are articulated in the following way;the first level consists of stables, a winery, missionary schools and a baptistery; the second level includes kitchens, food storages and related units; the third level is constituted by a tunnel that connects the upper levels to the lower levels; the fourth level contains living rooms, bedrooms and food stores; the fifth and sixth levels act like distribution spaces with different ventilation tunnels which are also used as connecting corridors; the seventh level is the most spacious space which includes a church and a burial chamber together with a great central meeting room. In the lowest level there is a water channel.
The appropriate interior conditions are ensured by 52 water wells which also act like air shafts to provide natural ventilation through the underground complex. The presence of storerooms and direct water access make long stays possible.



Connecting corridors; Living rooms and bedrooms; Winery.
(photos: A. De Pascale-Centro Studi Sotterranei)

Partial section scheme of Derinkuyu underground city (based on the scheme of Ömer Demir from his book *La Cappadocia. Culla della Storia*).



TROGLODYTE HOUSING AT MONTSOREAU

PAYS DE LA LOIRE, FRANCE

authors
Nuria Sánchez, Enrique Sevillano

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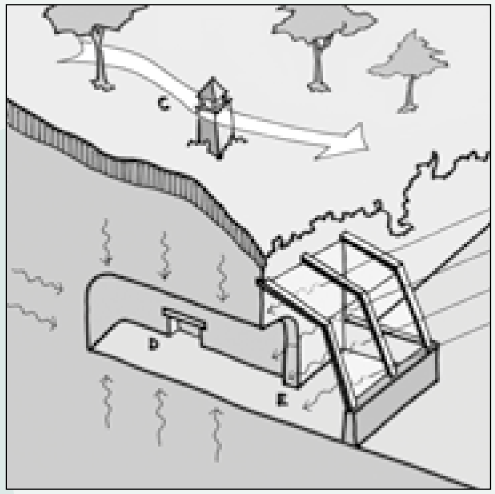
SOCIO-ECONOMIC PRINCIPLES

to support autonomy · to promote local activities · to optimise construction efforts · to extend building's lifetime · to save resources

The village of Montsoreau is inserted in one of the regions of France where troglodyte habitats are more numerous, populated and dynamic. Its habitats are dug on the north side of the hill, some metres over the Loire River. The principal asset of rocks is their thermal inertia, therefore excavated habitats have a great capacity of accumulating heat and slowly replacing it. They keep an almost constant temperature through all seasons, and a small difference between morning and night. The variations in their capacity of absorption, depends on water content, colour, specific heat, and vegetation covering. Some meters away from the façade, the dug interior space has an average temperature of around 17°C. In addition, the layer of soil and vegetation on top of the cave has a high insulating capacity. So there is no need of air conditioning in summertime, and a restricted need of heating in winter.

Troglodyte habitats usually have a chimney. It is used either to provide supplementary heat, to cook, or even to bake bread. Its conducts also help evacuating the excess humidity, which is the most important issue to deal with.

Nowadays, troglodytes habitats are often renovated with higher comfort standards. They integrate new systems like floor heating or others. Nevertheless, any gas heating system is very discouraged because it risks a lack of evacuation. The addition of an exterior greenhouse is recommended because it helps lowering the disparity between the inside and outside temperatures, and the resulting humidity condensation.



A Thermal insulation from soil layer
B Thermal inertia from rock
C Ventilation through chimney
D Extra heat supply from chimney
E Greenhouse: extra thermal supply

External view of the troglodyte housing (photo: N. Sánchez).
Internal view of the troglodyte house (photo: E.Camarasaltas).
External view of the troglodyte housing (photo: N. Sánchez).

Axonometric section of the troglodyte housing (Nuria Sánchez).

UNDERGROUND HOUSE-STUDIO

MADRID, SPAIN.

Architect: Fernando Higueras

authors
Fernando Vegas, Camilla Mileto

ENVIRONMENTAL PRINCIPLES

to respect environmental context and landscape · to benefit of natural and climatic resources · to reduce pollution and waste materials · to contribute to human health and welfare · to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

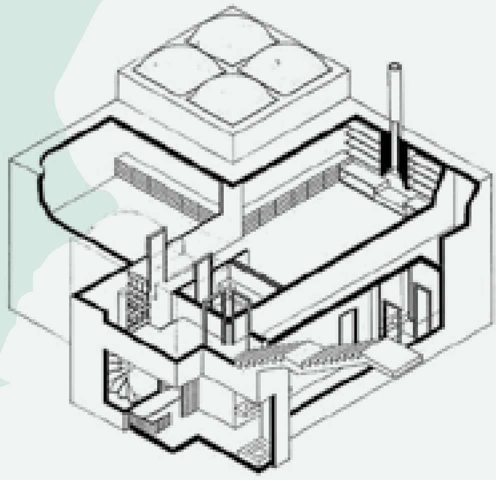
to protect the cultural landscape · to transfer construction cultures · to enhance innovative and creative solutions · to recognise intangible values · to encourage social cohesion

SOCIO-ECONOMIC PRINCIPLES

to support autonomy · to promote local activities · to optimise construction efforts · to extend building's lifetime · to save resources

Fernando Higueras (1930-2008), a great architect who refused to conform to fashion, designed this underground space in the garden of his family home. This underground dwelling is made up of an 8 m high single space with four concrete walls lit by four large double skylights above the large courtyard, as well as a smaller one above the staircase landing. The fact that the house-studio is underground, as well as the fact that it has two metres of earth on the roof, make the indoor temperature practically constant, between 20° and 25°C, with an approximate energy saving of 65% compared with a standard above-ground home. It was turned into a combined home and studio in the latter period of the architect's life and is currently the seat of the Fundación Fernando Higueras. For Higueras, the only defect this house had, was that he was so comfortable working in it that he barely went outside.

The author called it his first *hellscraper*, in contrast with *skyscrapers*, an idea he later revisited in a project proposal for the reconstruction of Ground Zero in New York (2002). There he designed two transparent twin towers as symbols of the missing buildings with all the necessary underground office space below a crater-shaped sloping garden. According to Fernando Higueras, these underground buildings could grow and be expanded downwards with enormous creative and spatial potential, also making use of the ground's thermal inertia to guarantee a more pleasant climate.



→ Cross section and axonometry of the underground studio of F. Higueras.

↓ Interior views of the underground studio of F. Higueras.
(M. Lasalle - Courtesy Fundación F. Higueras).

Pattern and materials of the town's pavements create quality in urban public places. Erice, Sicily, Italy. (Photo: M. Cadinu).

Collective and shared spaces

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Collective and shared spaces in vernacular settlements have extensive variations in use and morphology through Europe. Despite the influence of the Greco-Roman urban concepts and references in the European territory, vernacular collective spaces can constitute a distinct approach, as the spaces are not formal instruments of administrative and institutional representation. Therefore, this kind of spaces should not be confused with the western classical notion of public space, as they do not rely exclusively on the authority privilege over the private land use (Coelho, 2007).

The majority of the vernacular examples are the result of pragmatic strategies to facilitate the use and management of the settlement's main infrastructures. Specifically, they constitute interfaces between the settlement's inhabitants and the previous infrastructure network, adapted to the private ownership of the local system. The lack of resources and the scale of the settlement are proportioned with the involved collective effort in the embodiment of these elements, a fundamental premise in the attribution of the right of use amongst the community. This can result from the participation of single families, neighbours, or all the settlement inhabitants; but most of them allow the designation of specific property. These circumstances tend to evolve in complexity over generations, as the multiplication of the inherit-right can easily compromise the compatibility towards the settlement's communal interest.

This is generally intended to provide physical conditions for the development of the main local activities of subsistence. The more interesting cases can assume the role of instruments of mediation between the common available resources (natural and artificial) and the individual production, establishing in each settlement, the basic parameters for social cohesion and communal tolerance (Mandal, 1979).

The most common examples of collective and shared spaces are elements of interaction with the water supply networks, storage facilities, livestock shelters and the processing of agricultural production of raw supplies. There are also examples of storage areas for large-scale objects and equipment. All the mentioned cases establish a fundamental connection to the settlement's circulation network, adjusting operability to the specific conditions of community mobility and transportation. This relation can be so significant that some of these places can constitute vital complementary spaces for the population main itineraries and activities circuits. This can be easily understood in the examples of strategic shelters that allow the crossing of harsh mountainous routes; the location of water wheels and waterholes in hot and dry areas; or the floating platforms and wharfs destined to support villages near lakes, rivers or riversides (fig. 1-5). These collective and shared spaces tend to be characterized, according to the evolution of the community subsistence, considering the upgrade of the collection capacity or the production increase. Consequently, they can also assume a more profound anthropological meaning, up to the point of creating social and specific religious rituals in the enclosures. Most of these spaces were progressively adapted to be articulated with modern religious ceremonies – as pilgrimage, burial ceremonies, patron saints homage and festivals – but it is not uncommon to find previous connection references to ancient Animistic traditions. Therefore, the origin of the sacralisation of the vernacular collective spaces is generally associated with the acknowledgement of natural deities – usually reflected in

Fig. 1 Washhouse, Antigua Guatemala (photo: G. D. Carlos).

M. Correia, L. Dipasquale, S. Mecca (edited by), *VERSUS: Heritage for Tomorrow. Vernacular Knowledge for Sustainable Architecture*, ISBN (online) 978-88-6655-742-5, ISBN (print) 978-88-6655-741-8, CC BY-SA 4.0, 2014 Firenze University Press

Fig. 2 Collective granaries in Dogon country, Mali (photo: M. Correia).
Fig. 3 Collective piers and platforms, Ganvie, Benin (photo: T. Joffroy).

climatic element actions – and the inhabitant's prosperity. In this socio-cultural aspect, there is a considerable parallel in the interpretation of the vernacular collective domain and the classical public concept (fig. 6-8).

Another significant aspect is the exceptional jurisdictive framework between the private and public domains, regarding vernacular examples. Generally, the vernacular spaces are a consequence of the endeavour of a private dynamic that requires additional conditions for its sustenance and development. This factor is an incentive to the hybridization of the property domain (Torricelli, 2009).

The spaces and the elements are often shared. The common infrastructure can overlap the private land-right. In several regions, the application of a rotation for use rights is common. This has a direct influence on the preference for collective and cooperative actions regarding management and maintenance. This can be a requisite to overcome the uneven relation between the inhabitant's needs and the available resources. This feature also reflects a more sensible scale of intervention, where the oversizing errors and the function conflicts are less common (Chisholm, 1973).

The urban public spaces constitute central symbolical references in the community. Through time, they progressively acquire a collective sense of recognition by the community. When the urban public space has no reason to exist, it becomes an obsolete element, and it is easily abandoned. Sometimes, the cadastral surroundings have the organic capacity to absorb it, eventually closing gaps in the territory layout. A process that is practically impossible in the actual contemporary public domain framework. This can justify the higher percentage of abandon of the collective urban public spaces in the vernacular heritage (Carmona et al., 2007).

In the collective and shared spaces, the appropriation processes have a higher level of impact in the formalisation of elements and components. Collective demographics and economical variations have a profound and sudden appearance in the formal evolution. Usually, to face this vulnerable condition they resort to all kind of adaptable mechanisms that can be adjusted. This is another opposition to the classical public space, which is more rigid in definition and configuration. In the vernacular environment, most of the collective and shared spaces and equipment have a flexible configuration. In some cases, they even adopt a modular structure that admits extension or fragmentation operations, without compromising the function and relations with the surrounding built environment. Therefore, one may infer that their physical and conceptual limits are more informal, and less dominant in the geometric composition of the settlement's layout (Pozo, 1979).

The spatial building processes in actual collective spaces are very similar to the ones implemented in the vernacular infrastructures, as they mostly rely on the mobilisation of a specific group inside the community. Once again, the articulation condition should be noted,

Fig. 4 Collective village hut, East Timor (photo: G. D. Carlos).

Fig. 5 Pasture shelter, Soajo, Portugal (photo: M. Correia).

as a great number of these items work as true infrastructural interfaces. When the benefit is too discrepant, even if they present similar functions and configuration, the domain is usually transferred from public to private. This characteristic tends to increase the sense of justice between the different community sectors, and to reinforce social cohesion.

The matrix grammar of the gathered and transitional elements, assumed as social mediators, coexists with collaborative logic conformation with spatial transformation and spatial appropriation processes, inter-related with diversity and flexibility. This perspective implies the notion that the inhabitants 'invent' their own common spaces, often deprived of the rules that compose the consolidated and referenced public spaces (Bauman, 2000).

The population reorganises, assigns hierarchy, and manages the collective elements after construction. This generates the system's multiplicity, responsible for the constant renewal of use. It also enhances the constant and varied upgrade of these elements' structure, reflecting the plurality of the inhabitant's living, production and consumption. Conformation provides accumulation of dysfunctions and juxtapositions, expressing the overlapping of the different ap-

Fig. 6: Channels drains (*regaderas*) along the streets in Candelario, Spain (photo: M. Cadinu).

Fig. 7 Belfry's bell Tower in Măldăreşti, Romania (photo: M. Correia).

Fig. 8: Holly images and Pilgrimage itineraries: street shrines, Melgaço, Portugal (photo: G. D. Carlos).

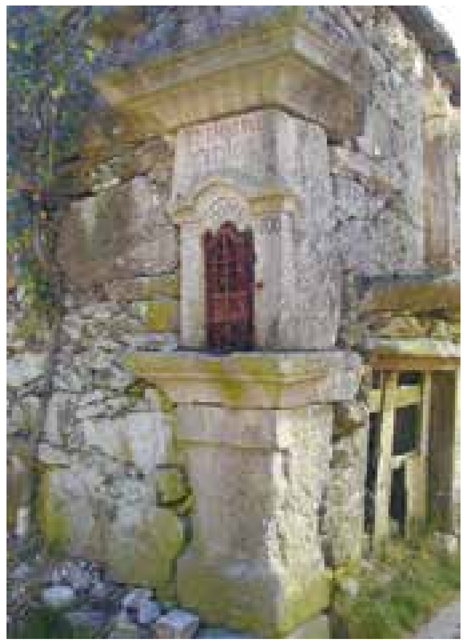


Fig. 9 Spontaneous appropriation of outdoor spaces. Integration of recreational elements, Yazd, Iran (photo: M. Correia).

Fig. 10 Arcades along the middle age streets, as a place for meeting and selling. Astudillo, Spain. (photo: M. Cadinu).

propriation forms and contributing to the involvement of the different fabrics, organisations and patterns. The recognition of this type of spatial configuration, which adopts temporary and volatile uses regarding collective living dynamics, assumes the importance of daily-life procedures of socio-physic assemblage and spatial acculturation. This enables them to be more adapted to accommodate inclusive and mutual actions amongst the community.

In short, when studying vernacular landscapes, it is possible to perceive another dimension implicit in the collective spaces, where very informal processes of humanisation continuously occur. The relevance assumed by specific elements, such as a fountain or a spring, a channel or a drainage trench, a container wall or an embankment, expresses with a surprising vigour the multiplicity of dynamics that can occupy this category of spaces. When served with efficient communication networks, these simple elements can easily evolve into true economic and cultural references. Many of the commercial areas of vernacular settlements present this sort of genesis (Beatly, 2000).

The formal configuration was the progressive result of the user's pressure and the neighbour's privacy needs, using everyday life appropriation as a design reference, through the addition of open areas support. Most of these specific elements, especially because of their scale, can seem insignificant at a first glance. However, they usually entail an evocative history and context, contributing to the individual and collective memory, and acquiring a predominant role in the expression of the collective spaces. Usually, depending on private action, they resort to adjacent structures, also of private domain. This feature implies that, formally, these elements cannot assume a central position in the configuration of the open space. Therefore, it isless visually predominant when compared with the classical examples of geometric orientation. This also concurs to the hybrid condition acquired by some of these collective spaces. Being attached to private elements, their limits and transitions are more ambiguous and vague, relying on a higher use of tolerance amongst all those intervenient. As most of the spaces and equipment evolve according to the logic of appropriation, the definition of the domains confinement is very reasonable, as it implies a permanent process of renewal through communal negotiation, where the borders of each domain can change without creating significant conflicts. Therefore, the consequent individual monitoring of the spaces, made by each

Fig. 11 Transition collective spaces. Common covered path between houses, Monção, Portugal (photo: G. D. Carlos).

Fig. 12 Circulation galleries in the Old Ksar of Beni-Abbes, Algeria (photo: G. D. Carlos).

user and neighbour, reinforces the mentioned communal process of maintenance and upgrade (Provoost, 2010).

One fine example of this private-communal tight relation is the location of devotion figures within private elements. Usually, these devotion figures are positioned at the entrance of the property (over the fence, wall, the main gate or integrating the building *façade*), but always oriented to the public domain. This kind of tribute, of individual initiative, plays an important role in the collective memory, as many times, over time, it can become a reference in terms of the contiguous space organisation. It may influence the placement of other figures, and create a street unit component, in such a way that it may alter nearby routes of inhabitants and visitors. It can also stimulate the complementary nature of the context, adding architectural components (stairs, niches, pergolas, balconies, arcades, and porches); furniture; new materials or even to re-configure the geometry of the surrounding open space, offering better conditions to the community to contemplate the symbol. This evolutionary process is proportional to the acquired importance attributed to the original figure and the cultural dynamics it has meanwhile created (Romero, 2007).

The contexts of human congregation require a constant renovation of processes in order to frame the communal intervention. This results from a new conceptual tendency of what may be called chameleonic genesis, which integrates and mixes urban processes of top-down and bottom-up approaches into spatial devices with intricate cultural components. In this perspective, the study of vernacular communal structures can be of great value to the contemporary urban planning. As stated by Sennet "we concentrate too much on visual legibility, and so on making legible landscapes through framing street corridors, or making public spaces without unsightly obstructions. The planner should counter the logic, by looking in another way. What need to be put on display are scenes of social mixture, in all their messiness and vitality" (2011, p. 45).

Weaknesses and lacks in the vernacular strategy

Possibly, the most significant constriction of collective and shared vernacular spaces is the difficult articulation with the use of mechanised systems. The circulation network required for the vehicles, either for agriculture or for transportation, cannot be easily adapted to the vernacular element's configuration, as the scale and material

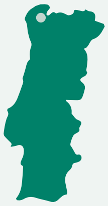
Fig. 13 Public square in Madrid (photo: L. Dipasquale).

Fig. 14 Street in Villanova, Cagliari (photo: S. Ferrando).

resistance may not be compatible. Although the characteristic flexibility of the configuration might be able to permit some compromises, in many cases the dimension, the location site or the original construction system cannot accommodate the required changes without a full loss of character. From all the punctual interferences caused by the modernisation of the circulation network, the adaptation of these collective spaces to automobile traffic and the inclusion of parking areas, are by far the most problematic and are also the most exhaustively studied. Car parking and the demand of car access to private plots, where the habitation unit is situated, represent one of the greatest difficulties for the vernacular built structure.

Neither the dimension nor configuration of the vernacular spaces seems suitable for the actual available technology. Usually, this particular fact determines the acceptance of a different reality that cannot be easily integrated. The territory appropriations are approached as an asymmetric and unbalanced system that cannot always compromise with the modern human structure and system. For the new urban analytic tendencies, this is a comprehensive and a bearable spatial condition. For most of the inhabitants from vernacular settlements, this fact is not so easily accepted, as this interpretation determines their abdication of a certain actual living condition. Usually, these have strong social and economic implications, as they feel it has a competitive condition reduction, that strongly reflects on the land value, the infrastructure connection, the building degradation and, ultimately, on the inhabitant's migration and the abandonment of settlements. In this particularly case, a close urban parallel may be drawn with the constriction observed in many medieval quarters of consolidated cities, or to the traditional pattern of Islamic cities, where recent necessary interventions have raised the same recurrent issues (Lofland, 1998).

The collective and shared spaces of vernacular propensity are indeed practical elements of the settlement fabric. The most important objective is to advance the main productive activities and to improve the conditions of communal interaction, but the design scale reference is always individual. Even if some cases can have a higher capacity for collective use or accommodation (fig. 13).



GRANARIES AND THRESHING-FLOORS

SOAJO AND LINDOSO, MINHO REGION, PORTUGAL

authors
Filipa Gomes, Sandra Rocha, Mariana Correia

ENVIRONMENTAL PRINCIPLES

to respect environmental context and landscape; to benefit of natural and climatic resources; to reduce pollution and waste materials; to contribute to human health and welfare; to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

to protect the cultural landscape; to transfer construction cultures; to enhance innovative and creative solutions; to recognise intangible values; to encourage social cohesion

SOCIO-ECONOMIC PRINCIPLES

to support autonomy; to promote local activities; to optimise construction efforts; to extend building's lifetime; to save resources

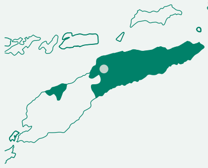
Soajo is located in the Municipality of Arcos de Valdevez and Lindoso in the Municipality of Ponte da Barca, villages situated in the Alto Minho region, in the North of Portugal. The economic subsistence and social structures of both villages are supported by agrarian and livestock activities. For centuries, the subsistence of these communities was possible thanks to the development of community structures located in collective spaces.

Vernacular architecture in Soajo and in Lindoso is internationally known, due to the unique characteristics of the granary structures (*espigueiros*) and the communitarian threshing-floors (*eiras*). The main function of the granary is to dry agricultural products, especially maize. These granaries are located in communitarian spaces, which are exposed to wind in order to facilitate the drying of the maize. Morphologically, the granaries have a rectangular shape and a high standing volume. Usually, granaries stand on pillars, which raise them from the ground, to protect the maize from rodents. Some granaries present ornamental elements, most often associated with beliefs and customs of the community, such as the cross to bless and to protect the crops. Near the granaries are the threshing-floors, in a flatter area, paved by a rocky support. All the local population, in a rotating system, can use the collective threshing floors.

This communitarian equipment is directly linked to agricultural activities, such as maize husking, as well as the development of cultural and social activities, like festivities related with marriage ceremonies, and festivals associated with crops. At the end of August and beginning of September, in the Minho region, the celebration of the corn takes place in each small village in a common and collective space. The population gathers together to thresh the corn collectively, and to find the red corn among the crops.

↑ Granaries in Soajo, Minho region, Portugal (photos: M. Correia).

↓ Granaries and threshing-floor in Lindoso (photos: M. Correia).



LORO-BÁ

BOBONARO REGION, EAST TIMOR

authors
Gilberto D. Carlos, Sandra Rocha

ENVIRONMENTAL PRINCIPLES

to respect environmental context and landscape ■ to benefit of natural and climatic resources ■ to reduce pollution and waste materials ■ to contribute to human health and welfare ■ to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

to protect the cultural landscape ■ to transfer construction cultures ■ to enhance innovative and creative solutions ■ to recognise intangible values ■ to encourage social cohesion

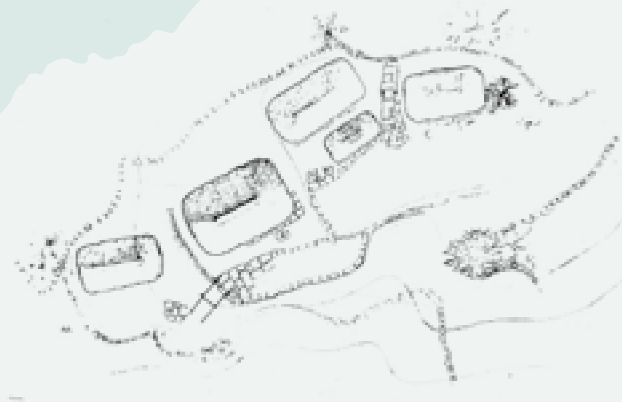
SOCIO-ECONOMIC PRINCIPLES

to support autonomy ■ to promote local activities ■ to optimise construction efforts ■ to extend building's lifetime ■ to save resources

The selected case study refers to a representative example from East Timor, in the island of Timor, which is located between the Indonesian Archipelago and the North of Australia. In accordance with its geographical location, its construction culture corresponds to the Papuan and Austronesian architectonic languages, and thus is based on the same formal archetypes and technical features (Chen et al. 2014). This particular case is part of a small settlement in Loro-Bá, in the Bobonaro region. The most important activities in the area were related to coffee production, developed in artificial land banks and terraces, which significantly influenced the consolidation of the landscape. The Bobonaro region is located in the westernmost region of the country, bordering the Indonesian part of the island, and it is characterised as a mountainous area.

Usually, the settlement presents a disperse organisation, admitting in some specific areas a dense aggregation of houses (Cinatti et al. 1987). The settlement has long paths for pedestrian circulation, surrounding the clusters of houses, which have the particularity of converging into an open-air space that works as the settlement's social centre. This collective area is physically dominated by an extremely important symbolic element, the sacred tree. It is under this tree that some of the main religious and cultural events of the community take place (Cinatti et al., 1987).

Although the built limits of these shared spaces are not clearly defined, the demarcation of each cluster of houses by surrounding dry masonry stonewalls expresses their divergence of domain and use typology. This results in the configuration of a dominant, but rather flexible collective element for the community, which can accommodate distinctive types of use, from celebrations to trade activities, with no noteworthy functional conflicts. The collective space is able not only to serve the inhabitant's needs, but also to receive external groups into the settlement.



Drawings of a house cluster in Loro-Bá.
(Credits: Leopoldo de Almeida, Historic Archive of IPAD)

Collective domain and house cluster in the Bobonaro's region.
(photos: G. D. Carlos)

MAGOANINE

MAPUTO, MOZAMBIQUE

authors
David Viana, Sandra Rocha

ENVIRONMENTAL PRINCIPLES

to respect environmental context and landscape · to benefit of natural and climatic resources · to reduce pollution and waste materials · to contribute to human health and welfare · to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

to protect the cultural landscape · to transfer construction cultures · to enhance innovative and creative solutions · to recognise intangible values · to encourage social cohesion

SOCIO-ECONOMIC PRINCIPLES

to support autonomy · to promote local activities · to optimise construction efforts · to extend building's lifetime · to save resources

Magoanine is part of the Municipal District of KaMabukuana (DM5) in Maputo, Mozambique. The development of this peri-urban area has been due to the need for resettlement of the population affected by the 2000 flood. It is characterised by the socio-economic precariousness of its residents. Several NGOs sought to contribute to the urban quality of the citizens relocated in that part of the city by developing local support programmes, intervening and implementing infrastructures, and providing urban facilities and services.

One of these NGOs was the Mozambique Association for Urban Development (AMDU). Maria dos Anjos Rosário (former President of AMDU) guided the strategy for Magoanine, which focused on the notion that the dynamics should involve the active participation of the population. This would deepen collaborative logistics and participatory processes that would support a liable and responsible community structure and the maintenance of cohesive and engaging practices. It was set out to create collective spaces, to bind the produced flows and to create interdependencies. Shared central areas were established, which contemplated the location of fountains; as well assmall premises like a kindergarten and the headquarters of the organisation of inhabitants, who take care of and run communal life issues. These areas, among different types of uses and ways of appropriation (e.g. used by a group of young dancers that rehearsed and performed there) were meeting places for people. The collective space also included arboreal elements that created shadows and marked sites.

The concern of AMDU was to provide the physical housing for Magoanine; but it was also understood that satisfying the need for dwelling was not enough, that the interaction between city dwellers should also be enhanced, as well as the access to work, so that people could get income from their occupations. Local production was promoted (food products, domestic furniture and textile manufacturing, and housing self-construction). This enabled residents to benefit from consumer goods from their own neighbourhood, traded in collective and shared spaces.

Kindergarten facilities.

Solar Cooking Project with people living in Magoanine.
Local young dancers performing.
Water supply device.
(photos: D. Viana)

Marshall landscape at Sallertaine, France (photo: N. Sanchez).

Landscape, water and resources management

Hubert Guillaud
CRAterre-ENSAG, Grenoble, France

"The territory we have gradually emancipated ourselves from because of technical development is seen and used as a mere technical support for economic activities and functions, of which the location is determined by a rationale that is increasingly disconnected from place and that does not take account of its characteristics, whether related to the environment, culture or to identity [...]. We can now locate any activity anywhere, at our discretion. Originally, this emancipation encouraged the mobilisation and valorisation of considerable human and environmental resources. On the long term however, it has generated dependency and fragility". **Alberto Magnaghi (2003, pp. 14-15)**

Rebuilding a territorial logic through improved resource management

As pointed out by Magnaghi, we are ignoring and destroying the reproductive capacity of the environment. The territorial scale of his 'local project' considers vernacular heritage not as an object or artefact but in terms of space. We are thus invited to consider other dimensions such as site, landscape, and other ways of living and designing our environment. This logic and 'true construction' of space that has generated human activity creates representations and uses that designate a variety of elements which structure this same space. These elements can be related to history, architecture, and landscape. They are part of a collective heritage, of a common good. This 'territorialized' heritage becomes an issue, a resource, as well as a new economic context that contributes to local and regional development through various means of recognising its value. This is particularly true for vernacular heritage, as a territorial resource that can be only managed in relation with the cultural landscape. Therein lies a large part of the imaging process sought by territories through the use of vernacular buildings and the development of economic, social and cultural activities that are related to it.

Vernacular housing material: earth, stone, wood and straw

In this text related to the management of resources and vernacular built heritage, it appears reasonable to talk about 'matter' as natural, accessible and renewable resources for housing. Moreover, we cannot solely take account of 'natural' resources, since 'cultural' resources can also be recognized as part of this relationship with vernacular housing. Here, we refer to building cultures, knowledge and know-how that have been developed in the field of the vernacular art of building. We also refer to the existing stock of vernacular housing, whether abandoned and unusable, and increasingly inclined to turn into ruins. It is a resource for areas wishing to maintaining agricultural activities that may be declining, or allowing not so affluent families to buy a home in areas where the cost of land and of construction is unaffordable[1]. Everywhere on the planet, man has built housing by transforming the materials he had access to, either around or under him. Vernacular housing, in various parts of the world, directly informs the diversity of environments and the builder's capacity to adapt to local constraints, in particular those imposed by the type of soil. One could only build with what was available around the building site. The soil provided earth at the bottom of the wall, and branches from the nearby forests to build in wattle and daub or in cob, for moulding unbaked bricks of building in rammed earth.

The local geology offered various types of building stone quality. They were collected when fields were ploughed, and were usually produced by exposing large rocks first to fire then to water in order to split them. These stones were also found in quarries that had been

[1] In France, non-governmental organisations such as *Terres de liens* are at the heart of these issues.

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Fig. 1 Dry stone walls and terraced landscaping; Hyblean hills, Sicily, Italy (photo: L. Dipasquale).

Fig. 2 Terrace cultivation; Nonza, Corsica, France (photo: N. Sánchez).

Fig. 3 Dry stone walls, nord Isère, France (photo: S. Moriset).

Fig. 4 Water channels in Coulon, Poitou-Charentes, France (photo: E. Sevilllano).

Fig. 5 Saltworksin Trapani, Sicily, Italy (photo: S. Onnis).

Fig. 6 Water is structuring the urban landscape at l'Isle-sur-Sorgue, Vaucluse, France (photo: N. Sánchez).

operated for centuries. Similarly, the forest provided spruce, pine, poplar, oak, and chestnut trees that were originally used by stacking logs, and later on by developing the art of carpentry as illustrated by the heritage of timber frame housing. Straw from cereal crops, reeds and other types of grass found in ponds provided the material used for thatched roofs. All these natural local materials, whether earth, stone, wood or straw, were not only used for the construction of housing – though many European regions are strongly influenced by the dominant characters of the local materials – but also for developing a better landscape management. They have contributed to the design of their cultural identity as may be seen in Mediterranean Europe (Provence in France, Sicily or Abruzzo in Italy, or the foothills of the Pyrenees in northern Spain) by the wonderful terrace cultivation systems (fig. 1, 2) built using the beautiful dry stone bonding system, or by enclosure walls that define fields and trails, as well as the status of property (fig. 3). Local stone slabs were also used for channelling water and paving streets, not only in rural territories but also in old cities.

Water: a vital resource and an essential element of new territorial projects

Water has always penetrated inhabited space. It may well be the element which governs our environment. Water falls from the sky through rain or comes from snow melt. It runs down mountains and hills, generates streams and rivers that flow towards seas and oceans. It percolates from the surface, and is found underground in water tables. But there is a water shortage in areas where the climate is hot, dry and arid. The Mediterranean area shows that the issue of water has been important throughout the history of this region. This is illustrated by the ingenious solutions that allowed water to be taken from one place to another through aqueducts, irriga-

Fig. 7 Management of local natural resources; producing energy with wind power. Louresse. Pays de la Loire, France (photo: E. Sevillano).

Fig. 8 Energy management: a windmill in the island of Faial, Azores, Portugal (photo: M. Correia).

tion canals, wells, or *foggaras* in North African countries, as well as *norias* and *shadoofs* that were commonly found in older times (fig. 4, 5, 6). Water, as a vital and sacred element which is mentioned in ancient texts, has become an economic and political issue, but also a true territorial project [2]: It is a main matter of concern for the 21st Century in the face of a water shortage threat and given the fact that the world population will reach 9 billion inhabitants by 2050. Political issues related to water are increasingly visible, with the building of large dams such as the one erected on Yangzi Jiang in China or with water being shared by several countries when they are crossed by one river such as Turkey, Syria and Iraq, in the case of the Euphrates river, with the Tabsa dam in Syria, which created the al-Assad lake, or with the huge south-east Anatolia[3] project in Turkey, aiming at irrigating 1, 7 million hectares of land through twenty-two dams erected along the Tigris and Euphrates rivers. These projects deny the principles of equity and solidarity with regards to water, and cause political conflicts between nations. As Philippe Dugot (2001, pp. 183) has pointed out "whatever the attempt at solving the water problem (…) the quest for a solution can only stem from a truly genuine desire to conduct negotiations driven by a true search for a viable and equitable solution for all. One should not hesitate to repeat the obvious over and over again: the solution to this problem also involves a rationale based on the catchment area".

A better management of soil and water resources means that the question of governance needs to be addressed, by mobilising all stakeholders in the area: regional and local decision-makers, water utility companies, non-governmental organisations involved in protecting the environment, as well as the civil society. The aim is to protect zones for the abstraction of drinking water from sources of pollutions, better contain rainwater, reduce soil sealing (roads and other asphalted tracks) generated by the edge city right into rural areas, retain water in the ground, build more water retention reservoirs, minimise the waste of water by fitting houses with water-saving devices [4].

As pointed out by the Italian architect and urban designer Paola Viganò[5], the new ecological rationality means that "water designs the city and the territory"[6]. This water irrigates, it needs to be drained. It is consumed, it structures the landscape (streams, canals, ponds, lakes). It is truly the agent of a project because it is also "an element of sociability, as a meeting place and a place of transit"(ibid). Paola Viganò refers to the works of John Dryzeck [7] and reminds us that designing a territorial project based on water is very complex, because we need to think on the long term, that we need to be 'very close to the site' (micro-topography), 'take time into account' (projects should be dynamic rather than static), 'design solutions for problems that are beyond our control and imagine alternative futures'. This also requires courage.

[2] Reference to a conference 'L'eau: un projet de territoire' organised on November 29th 2013 in Lyon (see bibliography).
[3] Or GAP, from the Turkish: *Güneydoğu Anadolu Projesi.*

[4] Faucet aerators, low flow shower-heads, double-flush toilets, 'A' label household appliances, rainwater harvesting for gardening, anti-bacterial and anti-viral treatment of water etc.
[5] *Grand Prix d'Urbanisme* in 2013.
[6] Ibid, conference "L'eau: un projet de territoire".
[7] John S. Dryzeck is professor of social and political theory at the Australian National University, Canberra.

Fig.9 Artificial water channels at Le Clos Des Fées, Conteville, Upper-Normandy, France, signed by CoBe Architecte (photo: L. Boegly).

Fig.10 Tached visitor centre by architects Wingårdhs sits beside the shallow waters of Sweden's Lake Tåkern (photo: T.R. Söderström).

Towards a new sustainable equilibrium

The management of soil resources is also related to the better management of energy used for housing and more generally for human settlements. A wider use of solar and wind power (fig. 7, 8) and a return to hydro-electric power in mountainous areas[8] are, of course, wise choices. But greater attention should be paid to respecting natural and cultural landscapes: in some countries, photovoltaic fields and wind farms have an impact on the environment and contribute to generating new types of visual pollution. Such issues cannot simply be guided by profit or market interests. Other social, cultural and aesthetic parameters should be taken into account in order to define a fair equilibrium, an inevitable compromise between political, economic, environmental and social interests. Innovative solutions must be designed for resistance (natural risks, and the deviance of dominating interests) and resilience of soils, ecosystems and even 'beyond human action' (ibid.) (fig. 9).

Rebuild a peaceful and reconciled relation with our territory

Building materials were therefore *picked* before techniques and tools evolved, allowing to move to more rational forms of operating, then to small-scale pre-industrial processing as reflected by the production of clay materials such as tiles and bricks. The modern industry, operating in the field of materials and construction, has progressively denatured the relationship between man as a builder and the material as the product of territories. It imposed other types of material and other operating modes which only consider resources as building material and which are high energy consumers – and in particular high fossil energy consumers. Given the current context and the housing shortage, one cannot imagine coming back to a type of housing production that would rely on 'picking' materials around a building site. However, it is possible to rebuild a peaceful and reconciled relation with our territory, to attempt overcoming the rupture between nature and culture which has been established with modernity, turning man into an operator rather than into a wise user of his environment. To attempt at making the best possible use of the resources at hand, whilst ascribing the proper value to them regarding their capacity to generate creative and innovative forms of architecture. Architectures that would contribute to restoring virtuous life cycles based on soils and raw resources (earth, stone, wood, plants) transformed into building materials which would generate jobs at the local scale, then into buildings and human settlements, thus recognising the value of the diversity of resources, cultures and the identitiy of territories – as far as possible using materials that are easy to recycle. Some may say this is utopia. But a new generation of designers is currently reconnecting with the intelligence of the vernacular. The manifesto presenting the work of the Amàco project's (atelier matières à construire) young team states "All over the planet, men and women are building with the material they have under their feet. Vernacular architecture reflects this intelligence. Today, talented architects such as Wang Shu,

[8] As was the case in the Alpine regions with what the French referred to as *houille blanche* (hydro power), connected to the paper industry amongst others.

Rick Joy or the Wingårdhs [9] (fig. 10) practice are reconnecting with an essential characteristic of this tradition: integration with the landscape. The architect must once again learn to build with what is under his feet and with what is within his reach. He must once again learn to transform materials from sites into quality architecture" (AA.VV., 2013, p. 48).

Current situation and perspectives

We have entered the time and space of a new paradigm: the limitation of our planet's resources which we have used and have greatly benefited from. Today however, we need to manage them more carefully. We should protect biodiversity and particularly soils, water and air, which are vital resources. French economist Gilles Rotillon (2005, p. 4) reminds us of the weight of 'natural resources' in the modern political economy that should be considered either in terms of environmental degradation caused by man, or of the effects of the limitations of natural resources on economic growth. He reminds us of the traditional distinction made – in economic terms – between 'supply resources', referred to as finite resources, and 'renewable resources'. Finite resources include oil, coal, gas and other minerals, whereas renewable resources are considered as 'living resources', and include fauna, flora, water, solar energy, wind power, and geothermal energy. These need to be allowed to renew themselves at their own pace, and in relation with the integrity of biodiversity, of the vitality of ecosystems (flora), of species (fauna) or of climatic variations (water, sun, wind). But according to Rotillon, no resources can truly be referred to as 'natural'. He suggests we should talk about resources that are renewable and those that are not. Stock valuation is therefore still a question in the light of the potential of use and economic profitability that has guided man to this day in his behaviour, in a mechanistic use of resources to meet his needs. This behaviour follows the rule defined by Harold's Hotelling (1931), and related to the scarcity rent of a finite resource.

This rent increases with scarcity and the resource should be preserved as much as possible since the rent will be null when the demand also is because the resource is no longer available or has become too expensive. Based on these considerations, we are at the heart of the economic dimension of resources, in other words of its market value. Others have also drawn a distinction between resources that are 'replaceable' and those which are 'irreplaceable', the latter being similar to the notion of 'vital resource'. Freshwater, drinking water and air are examples of such resources. However, many authors agree on the fact that 'ecological services' are still poorly valued. Exploitation, cost, rent, service – all these words are specifically related to the modern Western market economy which only value resources in terms of the capital and work invested to exploit them. As if these resources were inexhaustible. We are thus in the process of destroying another capital, another common good that belongs to our planet and to all the people who live on it: the 'natural capital'. This way of seeing things seems very different from the relationship between the ancestors and the resources of the places they lived in, as demonstrated by vernacular architecture. Without wanting to idealise this relationship, one could say it was based on respect and gratitude, recognizing the fact that the environment provided food, drink, materials for building and heating, and beautiful landscapes to contemplate. This relationship was also based on common sense, on caution and precaution in order to allow resources to renew themselves and last. In a first instance, man was dependant of his environment. Then, as pointed out by Magnaghi, the evolution of technical capacities lead to a Promethean emancipation that contributed to the rarefaction of resources due to frantic exploitation. Freedoms therefore lead to a new type of fragility, of renewed dependency when considering the stock of resources which may be insufficient given demographic growth and ecological footprint. It is now time to manage resources in a reasonable and sustainable manner, to return to caution, precaution and containment.

[9] Architectural practice based in Sweden. One of its recent projects, the Lake Tåkern visitor centre was built using regional traditional thatch construction techniques.

WATER MANAGEMENT IN L'ISLE-SUR-LA-SORGUE

PROVENCE-ALPES-CÔTES D'AZUR, FRANCE

authors
Nuria Sánchez, Enrique Sevillano

ENVIRONMENTAL PRINCIPLES

■ to respect environmental context and landscape ■ to benefit of natural and climatic resources ■ to reduce pollution and waste materials ■ to contribute to human health and welfare ■ to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

■ to protect the cultural landscape ■ to transfer construction cultures ■ to enhance innovative and creative solutions ■ to recognise intangible values ■ to encourage social cohesion

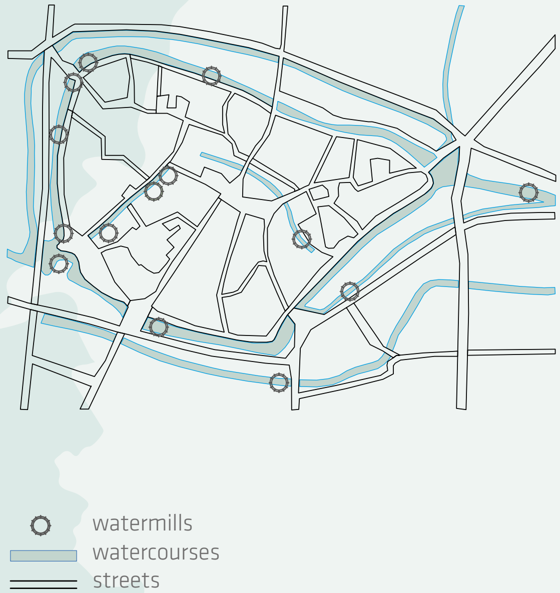
SOCIO-ECONOMIC PRINCIPLES

■ to support autonomy ■ to promote local activities ■ to optimise construction efforts ■ to extend building's lifetime ■ to save resources

L'Isle-sur-la-Sorgue is a small town historically related to the Sorgue river, its main natural richness. This town has been famous since the 1960's as being one of the main antiquary centres in Europe.

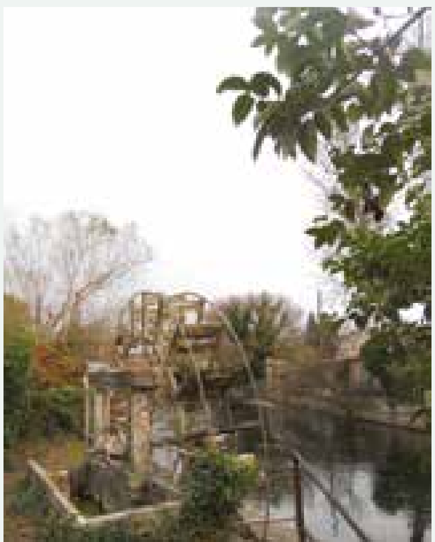
Water has always been at the core of this town, thanks to the river and its channels. As early as the 12th Century, the river, together with the ramparts, was used to defend the town. Most people were devoted to traditional fishing up to the 18th Century, when local industries started to be developed thanks to the installation of up to 62 water wheels. These water wheels generated a local, renewable and non polluting energy that served to produce a great variety of goods. There were oil and flour mills, silk mills, paper industries, tanneries, sawmills, gypsum mills, wool carding, tissue paper fabrication, etc. Nowadays there is still a local industry perpetuating the tradition of wool processing. Today 14 water wheels remain throughout the town, representing more a touristic attraction than an energy source. They testify to the intense economic activity related to the Sorgue river.

Generations of local people have taken care of these watercourses since they made their living from them. The abundance of water and the quality of the soil help to produce rich fruit and vegetable crops. Biodiversity is encouraged by the respect of the river and fishing continues to be practiced and has also evolved into fish farms. These watercourses also create a peaceful ambiance for neighbours and foreigners alike, and encourage open-air activities and social-cohesion.



Detail of a watermill (photo: N. Sánchez).
General view of a watermill (photo: E. Sevillano).
A pedestrian bridge (photo: S. Moriset).

Map of L'Isle-sur-la-Sorgue and localisation of the watermills.



THE WATER MINE SYSTEMS OF RIUDOMS

TARRAGONA, CATALONIA, SPAIN

author
Silvia Marchegiani

ENVIRONMENTAL PRINCIPLES

to respect environmental context and landscape · to benefit of natural and climatic resources · to reduce pollution and waste materials · to contribute to human health and welfare · to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

to protect the cultural landscape · to transfer construction cultures · to enhance innovative and creative solutions · to recognise intangible values · to encourage social cohesion

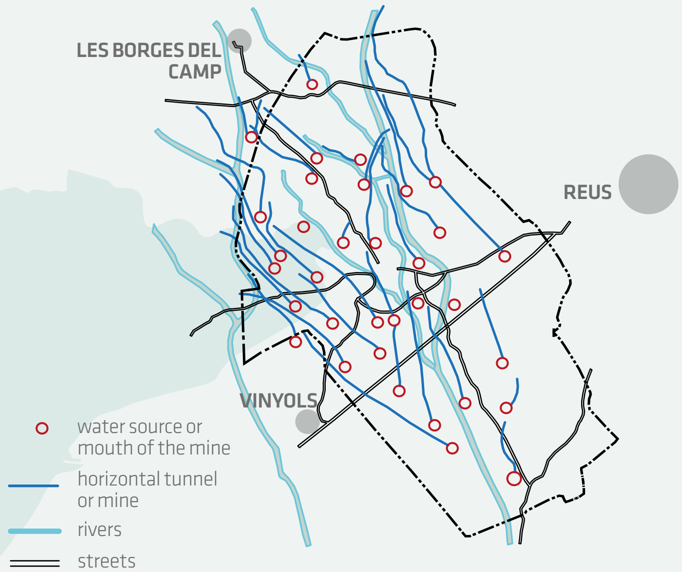
SOCIO-ECONOMIC PRINCIPLES

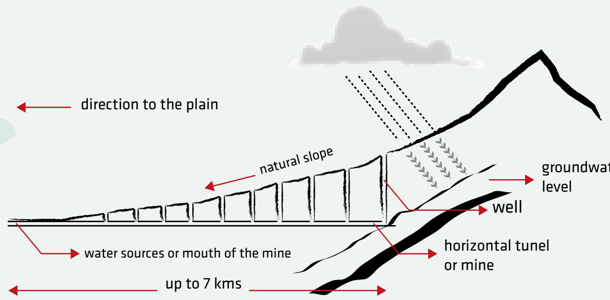
to support autonomy · to promote local activities · to optimise construction efforts · to extend building's lifetime · to save resources

The agricultural landscape of Riudoms, with an area of 32 km^2 of gently sloping land and Mediterranean climate in the province of Tarragona, Catalonia (ES), is formed around a system of water mines.

This traditional form of water channeling characterized early industrial society: water management regulated the social structure and the relationship with the land in a sustainable way. Heir to an ancient and widespread tradition throughout the Mediterranean, the mine system is not only a technical resource: its use and maintenance involves a complex network of associations that involves the community it serves, and is linked to the technical elements related to the farming system and the landscape matrix. The model of water mines recalls the system of water channeling of the oasis. It consists of a net of underground artificial tunnels designed to transport to the surface the water from the uppermost part of the water table without reducing its level. After reaching the mouth of the mine, the water is distributed through a surface pipeline system to pools where it is stored and from where the irrigation canals of the fields leave. The farmers are organized into irrigation communities in order to collaborate in the construction and maintenance of water mines. Each community has a statute and legal representatives, and every year each community establishes the necessary interventions on the mines, as well as irrigation schedules for the distribution of water among the various agricultural properties, using a system that closes off the water distribution of the surface channels.

Today many of these mines are in service, but this does not mean that there are people looking after them. The future of the water mine system and its management has to go through a necessary process of awareness, not only among its users but also among the public in general, in order to recognize its value as an appropriate system for the exploitation of water resources and as a part of the cultural and historical heritage.





Map of Riudoms and the water mines. Scheme of the water mine's system.

Water sources or mouth of the mine; general view of the water canals; particular of water sources or mouth of the mine in Riudoms.
(photo: S. Marchegiani)

NANSEN PARK

OSLO, NORWAY.

Architects: Atelier Dreiseitl

author
Bilge Özel

ENVIRONMENTAL PRINCIPLES

- to respect environmental context and landscape
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- to reduce pollution and waste materials
- to contribute to human health and welfare
- to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

- to protect the cultural landscape
- to transfer construction cultures
- to enhance innovative and creative solutions
- to recognise intangible values
- to encourage social cohesion

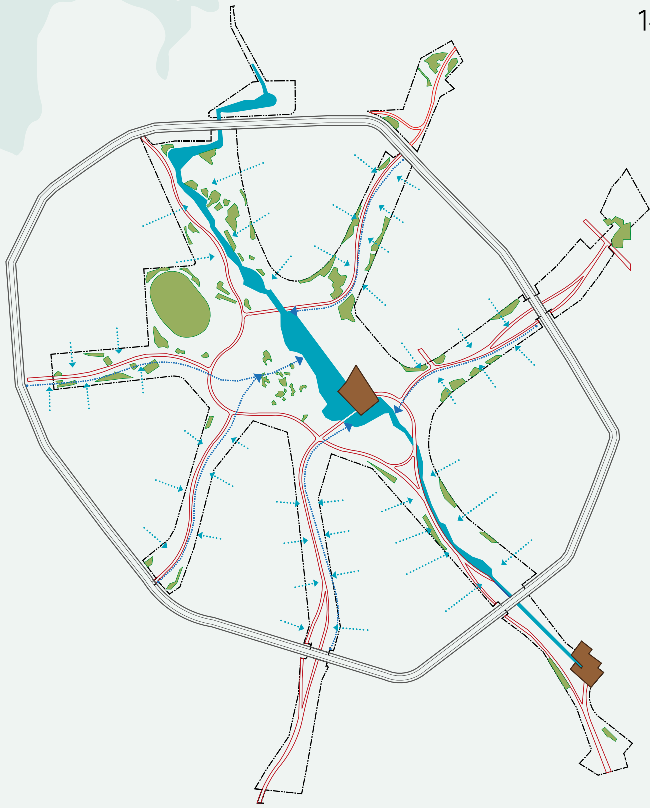
SOCIO-ECONOMIC PRINCIPLES

- to support autonomy
- to promote local activities
- to optimise construction efforts
- to extend building's lifetime
- to save resources

The central Nansen Park, covering an area of approximately 200.000 square meters is situated on a peninsula surrounded by the sea and Oslo's hilly landscape. This great park was designed by Atelier Dreiseitl to give a new strong identity to the Fornebu district by creating a new attractive gathering place for its inhabitants. The park was opened in September 2008 on the liberated area of former Fornebu airport after its closure in 1998. The liberation of the area enabled one of the city's largest natural park projects along with a redevelopment of this district. A new community has been created through a new master plan, which offers a series of dwellings, services and infrastructures with an ample unifying recreation area in the centre.

The project has been developed in a radial form. Seven arms that cross in the core of Nansen Park constitute the mobility network of the area. The width of these radial arms varies from 30 to 100 metres and they reach out in all directions. The control tower and main building of the former Fornebu airport still exist and they constitute the 'entry point' of the park. Starting from this point (northern extreme side of the area), a watercourse runs down on the north-south direction through the park and collects the surface water of the surrounding dwelling areas. The canals are set up in order to take the excessive water down to the central lake where it gets purified by biological sand filters to be used in daily activities.

The landscape architects, Atelier Dreiseitl, have developed the Nansen Park project within the frame of a strong ecological sensibility and attempted to introduce the element of water not only as a part of a playground or recreational area but also as an element of ecological infrastructure in order to improve the management of storm water and the water quality.



Scheme of the masterplan of Nansen Park, Oslo (redrawn by B. Özel based on the original master plan designed by ©Atelier Dreiseitl).

View of pedestrian pathways; view from wetlands; view from central lake (photo: ©Atelier Dreiseitl).

Architectural strategies and solutions

Courtyard dwelling in Chefchaouen, Morocco (photo: L. Lupi).

Courtyard houses

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Adelina Picone DIARC University of Naples Federico II, Naples, Italy

"The patio is neither outside nor inside: it is within an enveloping and protective mass, but out of the dark and narrow spaces of massive architecture; in other words the patio represents the aspirations of the house to open up while attempting nonetheless to limit and circumscribe the opening". **G. Alexandroff (*Architecture et Climats*, 1982)**

Since the early civilizations the courtyard house has been the most prevalent architectural typology in the Mediterranean and Middle East regions, all characterized by temperate and hot-dry climates. Also known as *patio* houses, the spatial organization of these dwellings is defined by a central open-air space on which the living rooms depend and receive light and air. The inner courtyard, the main architectural element, functions as a distribution element: the courtyard is the core of the house and therefore of daily activities, protecting the family's intimacy.

Courtyards have been used in several dwelling types according to each climatic region and to the local culture it belongs; the architecture of the courtyard house varies depending upon geography, religion, or ethnic culture, economic conditions, extension and morphological structure of the site and the regularity of the urban system. Its widespread acceptance is due to its resiliency, its capacity of response to various environmental, social and cultural requirements.

The elements of the courtyard spatial system are: spaces linking the house with the road (space filter), spaces used for domestic activities and family meetings (patio and terraces), pathways (porticoes and galleries), spaces for residence and facilities (rooms, kitchens, storerooms). All these elements are arranged around the central courtyard, and correspond to an ordered sequence determined by the use of space and the need for confidentiality: the number of these parts can vary, but the relationship between the parts remains constant (fig. 1).

Two distinct types of courtyard house can be identified (Moretti, 2005):

- the first type is characterized by a base width lower than its height; it can be covered in part or totally open. This type can be observed in the urban areas of the hottest regions, from North Africa and the Middle East to the South of Spain.
- the second one stems from the primordial form of the enclosure, which is the generating element of the Islamic city. The height of the building is lower than the sides of the base; it is more exposed to solar radiation compared to the first one. This kind of open courtyard is diffused in northern regions, both in urban and rural contexts.

Both types, having openings facing the courtyard, can be built built wall-to-wall with the adjacent buildings, to form a compact urban fabric, reducing solar radiation and the thermal loss through surfaces.

A common typology in the Mediterranean basin

Origins of the courtyard

The typological configuration of the house with one or more courtyards, has been, since antiquity, one of the common features of the housing cultures in the Mediterranean1[1].

The early form of the patio is underground. Among many cases in the world, the Berber settlements situated in the clayey plains of Matmata (southern Tunisia) represent a stunning example of underground courtyard, developed to respond to the need of protection from the harsh climate, as well as of defence against enemy attacks. The courtyards of Matmata dwellings (*houche*) are dug vertically into the ground, to a depth of about 10m. Around the hub of the court, many tunnels branch off subterraneously, to be used as domestic spaces.

[1] Roberto Pane, regarding the Mediterranean courtyard traces the following path: "in a disposition of the house collected around an open space, closed toward the external landscape, the survival of an very ancient tradition is easily recognizable, the same tradition which can be identified in the houses of Herculaneum and Pompeii, and many centuries before, beginning with the Mycenaean age, in all the Mediterranean countries". In addition L. Cosenza: "together with the domus and the villa a vernacular residential typology took place, which over time became typical of all the Mediterranean Basin, of the houses located along the northern coast of Africa, of the Iberian and Italian peninsulas, and of Transalpine Gaul. These type of houses slowly evolved toward Romanesque forms, coming back to classical configurations and then to neoclassical and popular forms; it was a unique typology which could be found in all the houses along the Mediterranean coast, unique in the basic form of the courtyard, various in the different local differences regarding the spatial elements, the internal distribution and connections".

M. Correia, L. Dipasquale, S. Mecca (edited by), *VERSUS: Heritage for Tomorrow. Vernacular Knowledge for Sustainable Architecture*, ISBN (online) 978-88-6655-742-5, ISBN (print) 978-88-6655-741-8,

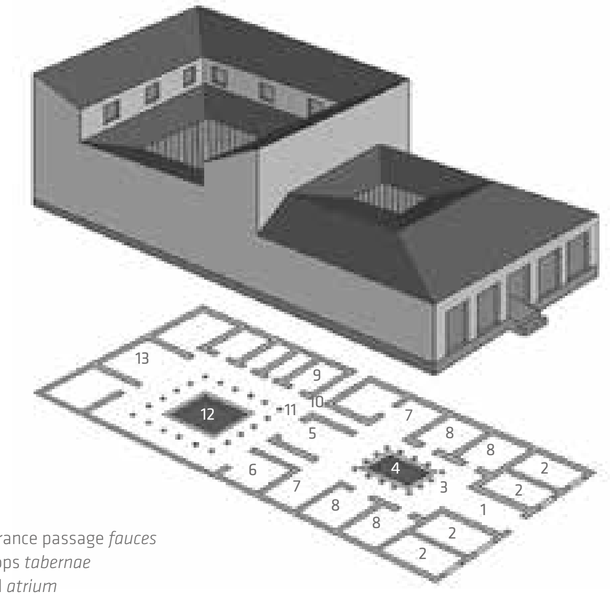


Fig. 1 Distribution of spaces in a typical Roman Domus (drawing: S. Gioitta).

1. Entrance passage *fauces*
2. Shops *tabernae*
3. Hall *atrium*
4. Rainwater basin *impluvium*
5. Passage room *tablinum*
6. Dining room *triclinium*
7. Side room *alae*
8. Bedroom *cubiculum*
9. Kitchen
10. Servants' entrance *Posticum*
11. Peristyle *Peristylium*
12. Basin *Piscina*
13. *Exedra*

The first civilized cultures, which developed around the Aegean in the past millennia, chose the courtyard house and the compact block as main building types: the great palaces of Knossos, Phaistos and Tiryns (2000, 1500 and 1200 BC), all had the court as key feature.

The courtyard in the Roman Domus

The Roman Domus – as we know from the houses of Pompeii and Herculaneum – has been the reference model both for the western and eastern house. In the *domus* the housing functions are regulated by two open spaces, where both the public life of the house (*atrium*) and the private life (*peristilio*) take place. The planimetric configuration is linked to the central axis, where open and covered spaces come in succession, each of them with a proper proportion in the planimetric and section measures. The *atrium* (courtyard) represents the central place which connects all the spaces, following definite hierarchies (fig. 1).

Le Corbusier, during his journey in Italy, drew some sketches of the house called "house of the silver wedding anniversary", figuring out it's main characteristic: the *atrium's* perspective view, a frontal view where the measures of the doors present in the atrium are compared, and a planimetrical drawing where the form of the atrium void are measured and described. "Open sky, immense chamber, colossal height of a cathedral full of shadows, and, in the background, the garden's splendour, [...] the variation in size of the doors plays an enormous role, some are very large and others very small".

Therefore the *atrium* represents at the same time the public life centre, a place fit to receive guests; the volumetric centre, due to the highness of the surrounding spaces; the distribution centre, since it is possible to reach all the other spaces of the house from the *atrium*; the climatic regulator, due to its capacity of reducing temperatures and allowing a natural cooling effect through difference of pressure and evaporation, thanks to the water in the *impluvium*.

Islamic courtyard house

In the Islamic area the courtyard house is the most common typology (fig. 2). The urban pattern is the result of the dense groupings of patio houses. They are built wall-to-wall to adjacent buildings, eliminating the wasted spaces in between as well as external heat gain or loss, and preserving family privacy (fig. 3).

> "The Arab wants to secure his house against the desert on the outside, opening parts of the inside of the house to the sky, such as courtyards which give relief to the inner rooms. The courtyard space gives the inhabitants a sense of ease and calm, and the feeling that they have their own piece of sky to use and to protect them [...] To an Arab this courtyard is more than an architectural el-

Fig. 2 Plans and section of a typical islamic courtyard house in Chefchaouen, Morocco (drawings: L. Dipasquale)

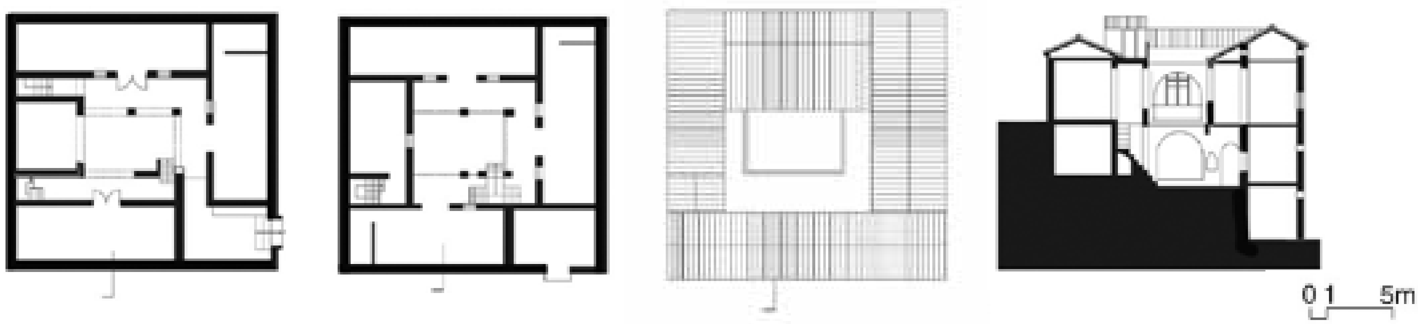


Fig. 3 Scale model of the dense urban fabric of Ghardaia, Algeria.
Fig. 4 Courtyard of a house in Valle del Draa, Morocco.
Fig.5 Courtyard in Kairouan, Tunisia.
Fig. 6 Courtyard in Chefchaouen, Morocco.
(photos: L. Dipasquale)

ement, because in his subconscious it is a global symbol springing from his innermost emotions. Its four corners carry the sky which covers the courtyard" (Fathy, 1967, p. 58).

The courtyard, called *wast ed dar*[2] in Arabic –that is 'core of the house'– serves as a common circulation space and neutral meeting ground. Being closed to the outside, it bears an introverted character, representative of the Muslim family life; in the Islamic culture, private courtyards often provide the only outdoor space for women to relax unobserved. The patio is often surrounded by the *riwaq*, an arcade that acquires the additional function of acting as a transitional space between private rooms and the open air (fig. 4-6).

Rooms are provided with simple furnishings that allow multiple usage and adaptability to several family activities; working tasks, eating, sleeping or receiving guests. During warm nights, instead, open dwelling areas become adapted as places to sleep in a cool atmosphere, particularly, thatched roofed terraces.

Multifunctional spaces of the patio house embed the nomadic nature of the desert inhabitants as these seek for the most adequate living spaces according to seasonal variations of the weather (either cooler or warmer) throughout the year.

Islamic inheritance system has also greatly influenced housing development. According to tradition, in fact, real property shall be divided proportionately between relatives, taking into account the degree of kinship, gender and the number of those that inherit. The patio house can be adapted to the needs for expansion and fragmentation, both horizontally and vertically in order to accommodate the heirs of the family.

In some of Hassan Fathy's essays, the relation between the *domus*' internal spaces and those of the Arabic traditional house is outlined. For example the palatial house in Cairo (fig. 7), where, in a similar way, two courtyards are located in succession, the first courtyard is sunny and the second one is shady thanks to the green presence of trees and plants. The two courtyards are linked by the *taktabush*, the equivalent of the *tablino* in the *domus*, both with climatic functions, due to the Venturi effect which is able to trigger an air flow, thus allowing a pleasant stay inside these spaces during the hot days.

[2] *Wast ed dar* in Morocco, *West el Dar* in Algeria, in other Arabic countries the courtyard has different names: *Ard el Diar*, *Hoch*, *Fanaa*, etc. (Abdulac, 2012).

Fig.7 Section of a courtyard house in Cairo, Egypt (drawing: A. Picone).

Fig.8 Riad in a courtyard house in Fez, Morocco (photo: G. Suzor).

Nevertheless a difference has to be underlined in order to clarify how the typological variations are connected with the cultural and religious needs in the different local contexts: while the *domus*' planimetrical layout is based on the axis, an order element for the design, the Islamic house's entrance deviates from the axis, by using the *magaz*, a vestibule, a space devoted to go through, even in the etymological sense (the Arabic etymology of the term *magaz* indicates the transition role between past and present), the function of which is to safeguard the house's introversion and the family's privacy, adding even more complexity in forms and volumetric configurations.

The Islamic courtyard house with an interior garden – called *ryad* – is a privileged space set in more affluent homes (fig. 8). In the Koran the garden is repeatedly used as the symbol for Paradise, with shade and water being the ideal elements (Brookes, 1987). Water is the most important element of the *riad*: it can be brought by means of underground tunnels or clay pipes, to be stored in tanks or cisterns, then distributed to the flowerbeds, plants and trees through channels, avoiding the loss of precious water through direct uncontrolled distribution. Fountains and flat tanks constitute other fundamental elements of the *riad*, representing in themselves symbols of beauty and contemplation.

The amount and type of trees in the *riad* depends both on the richness and the size of the house. The most common species are orange and lemon trees, sometimes pomegranate, jasmine and bougainvillea. The set of all the elements of the *riad*, such as vegetation and water, generate a microclimate, capable of mitigating the temperatures of the external space and influencing the rest of the house.

The Islamic courtyard house was replicated in slightly varied forms in Spain and in many Mediterranean countries, before travelling to Latin America, beginning in the colonial age, where it took on new shapes and decorative details, under the influences of the local cultures. By far, the European country with the richest courtyard history is Spain. In Andalusia courtyard-inspired architecture reached amazing forms and a big diffusion (fig. 9-10).

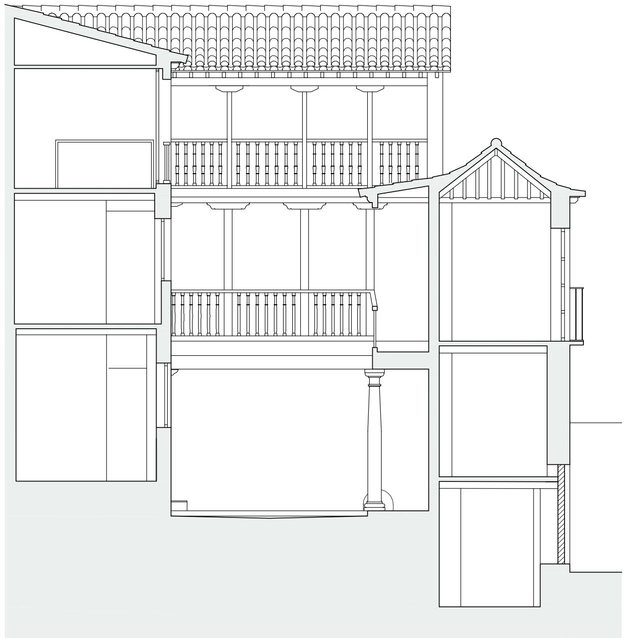
The main variants of courtyard house in the Mediterranean Region

The capability to assume variations in design without losing its preeminent characteristics, testifies to the versatility of the typology, a versatility which allows it to remain valid in contemporary architecture, with different interpretations and adaptations, even in high density housing settlements.

A significant variation is represented by the house with terrace, which is, as A. Maiuri well clarifies, the typology born when the courtyard house meets the panorama and the form of the landscape (Maiuri, 2000). In the islands of Ischia and Procida, for instance, the courtyard remains mainly in the rural areas, or in urban areas when internal to the primordial core of the settlement, where it is generally shared by the houses built around it, as in the case of the *casali*, which has various articulations of forms and often big dimensions.

Fig. 9-10 Section and view of a *casa morisca* (Moorish house) in the Albaicín of Granada, Spain (credits: J. M. López Osorio).

Fig. 11 Courtyard urban block in Ragusa, Italy (photo: L. Dipasquale).



The transition from the courtyard house to the courtyard urban block (fig.12) constituted by detached houses conformed to the terraced landscape, open toward the panorama, has been characteristic both in the islands, and in the coastal regions of Southern Italy, due to its adaptability to the rural needs of families employed in agricultural and handicraft work.

Even the elementary forms of the cities in Puglia are based on the multifamily courtyard, particularly in the Salento region, where it has defined a proper urban tissue made of multifamily courtyards.

The urban design of Salentine cities, in fact, seems to be formed by the aggregation of successive multifamily courtyards, and is characterized by the modality of the typology in the disposition around the courtyards (Defilippis, 2012).

This is not the case of the eastern house where, principally for the adhesion of the typology to climatic needs, the house preserves the courtyard, and some time redoubles it, exactly like the *domus*.

The difference between the urban house and the house of the oasis or the rural house in the extra-urban regions is significant. In Egypt, for instance, the oasis settlements are characterized by the strict compactness of the buildings, a sort of unique building, in order to take maximal advantage of thermal inertia and the climatic potentiality of the urban form. Inside the urban tissue the courtyards constitute unique spaces, both open and uncovered, since the narrow and winding streets are often covered by buildings.

According to its urban developing pattern, villages grow organically by agglutination, adding one unit after another, in a way similar to the growth of beehive structures.

In the Nubian region of upper Egypt, the answer to the desert climate is the single courtyard, not the settlement. The Nubian house has a courtyard defined by a walled fence. Inside are disposed all the rooms of the house, including the spaces used for agricultural work, covered by a Nubian vault, which is a parabolic vault made of adobe without wooden ribs.

The same model of courtyard house that includes farming working places – although with architectural morphology and materials linked with the place – can be found in Italy in southern Sardinia, in the Po valley, and in the farms of Apulia and Sicily. In Greece, up to very recently, this typology is predominant in the islands, as well as in coastal areas and in many city suburbs.

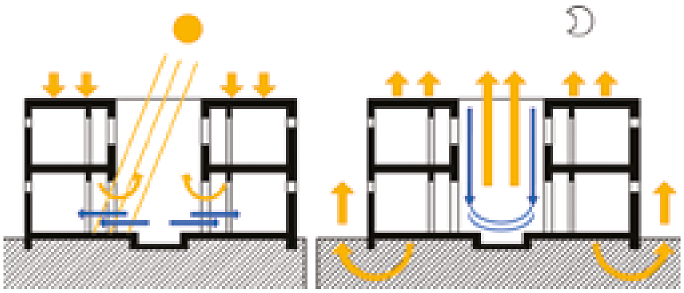


Fig. 12 Bioclimatic behaviour of a courtyard house in the Mediterranean region (drawing: B. Özel).

Fig. 13 Shading system in a courtyard house in Draa valley, Morocco (photo: L. Dipasquale).

Fig. 14 A typical floral *patio* in Cordoba, Spain (credits: Jardín Botánico de Cordoba).

Lessons of sustainability and resilience from courtyard houses

Building the house around an open and uncovered space, capturing a private piece of sky inside the architecture of the house, patio, courtyard or terrace, is one of the common characteristics, a common denominator, of housing in the Mediterranean. The re-proposal in contemporary architecture of this typology is a way of taking a cultural stand, to be in continuity with the traditional knowledge that constitutes the only true link with the environmental conditions. This is one of the possible ways for settling in the Mediterranean context without re-using stylistic features, while offering climatic answers useful for the different climates present in the Mediterranean: suitable both for temperate and hot-arid climates.

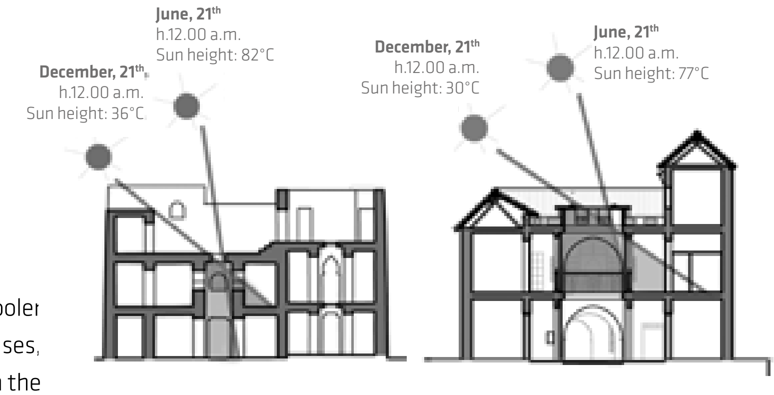
Environmental sustainability: the courtyard house as a passive energy cooling system

Courtyard houses prevail in hot climates as open central courts that act as cooling resources during hot seasons. Its morphology ensures the natural ventilation of living spaces thanks to the air convention property, which is based on a simple principle: warm air is less dense than cool air and therefore will rise; when connected with other openings in the house such as a door or window, cooler air replaces hot air, generating a continuous air current.

The thermal inertia of the walls keeps interiors cool. Sunrays do not penetrate the courtyard until noontime when the sun reaches the zenith. During late afternoon they start to release the stored heat. In the evening, the air of the patio which has been heated directly by the sun and indirectly from the walls, rises up while nocturnal cool air gradually replaces it. The chimney effect in this phase accelerates, pulling the indoor air upwards, expelling it and allowing cool air to penetrate the patio to cool down the surrounding rooms (fig. 12).

The presence of places with different temperatures causes beneficial air movement due to the fact that the heated air in the sunny areas, which is less dense, creates a vacuum that draws cooler air into the dark zones. Lodges and galleries provide valuable shade during the day, while the terraces are inhabited in the evening, when the temperature drops below that of the inside (fig 13).

During the day inhabitants use different parts of the patio according to the movement of the shade.



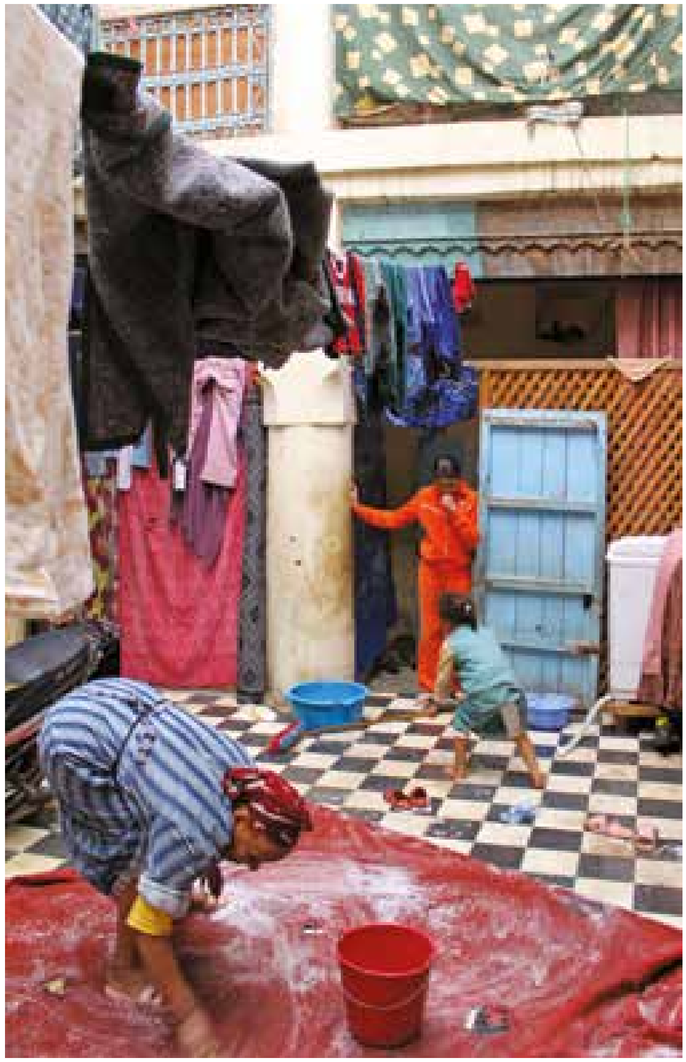


Fig. 15 The influence of the courtyard dimension on the incident solar radiation. On the left: a courtyard house in Draa Valley (dry hot climate): on the right: a courtyard house in Chefchaouen (Mediterranean climate) (drawings: L. Dipasquale).

Fig. 16 Multi-functionality in a traditional courtyard house in Marrakech Morocco (photo: L. Dipasquale).

Internal nomadism – or moving inside the house in search of cooler places – can also be seasonal. In several Tunisian traditional houses, for example, the spaces inhabited during summer are located on the ground floor, and the winter rooms are upstairs, with a lower floor height, in order to limit heat loss. The palace of Bulla Regia even has underground rooms used in the hot season, while the apartments used during the cold season are located in the upper floor, in order to enjoy the warm winter sun (Moretti et al., 2005).

Vernacular examples show us how it is possible to increase the climatic efficiency of the courtyard, using systems and devices like: screens, brise-soleils, shelters, pergolas (fig. 13). The combination of courtyard modules therefore allows minimal sections for the roads. In sub-Saharan regions streets are often covered by the buildings themselves, which create permanent shade and shelter.

Trees and plants also play an important role in helping to induce airflow and provide shade on hotter days in courtyards, and water can help cool the air through evaporation and can have a calming effect on the space (fig. 14).

Socio-cultural sustainability:
a resilient space for meeting and sharing

The patio is traditionally the space for sharing, socialization and household labour (fig. 16). It is the meeting place for the various members of the family throughout the day and during the most important religious festivities or family events. It is also the place for the reception of guests, allowing men and women to carry out their activities independently.

The structure of the courtyard house, based on the continuous spatial relationship between the inside and the outside, articulated with intermediate spaces of transition such as loggias and galleries, has as its natural consequence the generation of domestic spaces with environmental characteristics and scopes that are extremely different. The presence of open external spaces complies with functional needs, making the house flexible, transformable, and possibly expandable, according to the needs of its inhabitants.

In the traditional courtyard house more families (often linked by kinship) share the same central space. Sharing is pleasant when characterized by virtuous behaviour of mutual aid and exchange, while it is harmful in case of intolerance between members of different families. It is frequently seen in the Islamic house how the central space of the patio has been gradually split or delimited through temporary or permanent barriers to obtain more family privacy.

The characteristics of multi-functionality and flexibility make this space resilient and capable to adapt while undergoing climatic as well social changes.

Fig. 17
Energy retrofitting of *Casas las fuentes*, Toledo, Spain (credits: Pich-Aguilera architects).

Socio-economic sustainability: reducing loss of energy and generating spaces for self-sufficient activities

A dwelling courtyard outlay leads to more efficient housing design lowering the cost of cooling since it is energy saving. It is highly recommended that this efficient system be enriched with other passive energy features such as choosing rather small and few windows, high ceilings, and environmentally friendly materials such as earthen technologies in places with earthen building tradition.

The patio house can therefore be seen as a typological model suitable for new urban areas, as it allows high-density housing, and the achieving of all the benefits of the compact city model. Moreover the merging of built parcels allows a decrease in the surface area required for circulation, since the roads – not having the task of providing light and air to the rooms that overlook them – may have a reduced section.

The patio makes it possible to merge and connect the rooms of the house not only horizontally, but also vertically, eliminating hallways and internal pathways. The vertical growth of the house involves the use of less land and therefore implies a saving of public land; moreover it allows a further compaction of the spaces, protecting them from sun radiation, while at the same time promoting a better climate functionality of the court, favouring the chimney effect. Courtyard houses can be put together in contiguity, the volumes of different properties can be wedges and the perimetral walls can be shared between bordered buildings, so that the thermal energy loss by external surfaces is reduced.

An interior private space outdoors finally encourages autonomy and self-sufficiency by the possibility of integration of production areas such as self-cultivation gardens, domestic livestock, and spaces for for any type of manual activities that need open space.

Courtyard house as a model for future resilient housing

In recent years, critical reflection on sustainable models for contemporary living has led us to believe that the typological choices for the intensive development of the city (row houses, skyscrapers, etc.), up to now were not entirely suited to meet the needs of users, and do not justify construction costs and times (Chiana, 1979). Meanwhile extensive settlements (isolated single-family houses with or without gardens) involve large costs of services and infrastructure and a considerable waste of territory.

Looking at the experience of vernacular living, we believe that the courtyard house has the intrinsic characteristic of better suiting than other types the environmental and socio-economic needs of the inhabitants, even in very different environmental and cultural contexts.

To live in Mediterranean today a great degree of versatility is required, to embrace the changing needs typical of our age, and the courtyard constitutes a good answer. The presence of opened ex-

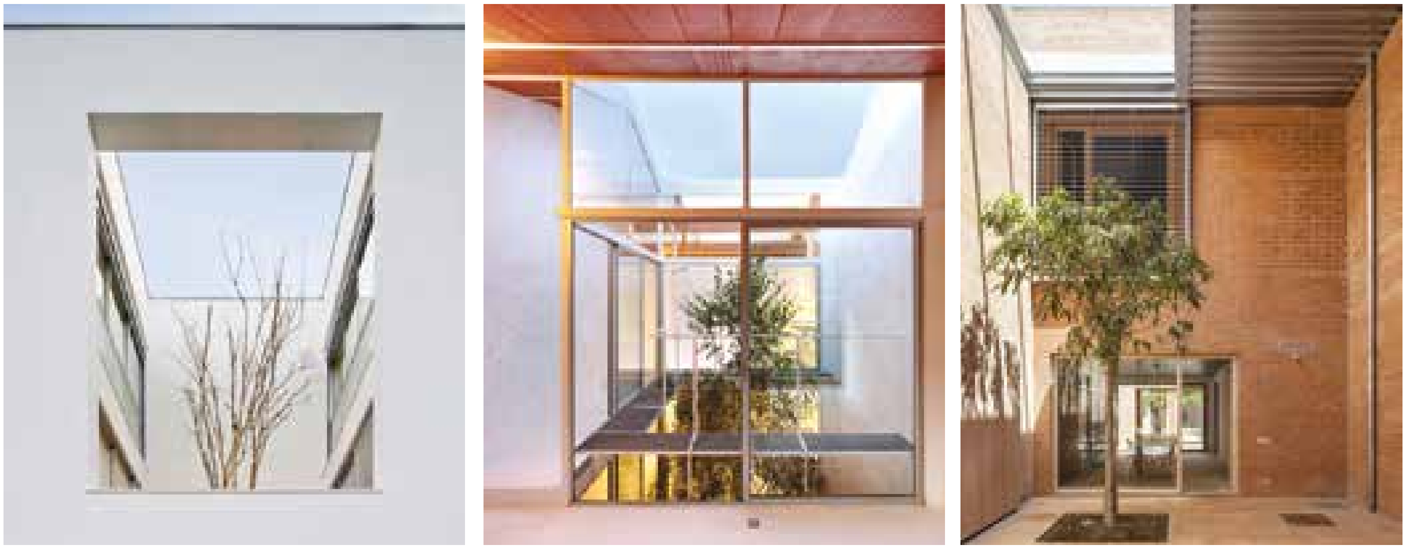


Fig. 18-20 Contemporary courtyard houses. From left to right: *House of patios*, AR Arquitetos, Sao Paulo, Brasil (credits: L. Finotti); *Casa Luz*, Arquitectura-G, Cilleros, Extremadura, Spain (credits: J. Hevia); *House 1014*, H Arquitectes, Granollers, Spain (credits: A. Goula).

ternal spaces complies with the functional needs, making the house transformable, and possibly expandable.

This typology responds to the growing need for indoor/outdoor transitional living activities as well since it can constitute an open or semi open space where the family can extend its daily life activities. The patio house makes the contact with nature possible, with an intimate open space for the exclusive use of residents, and at the same time the creation of compact settlements with higher density and lower development costs.

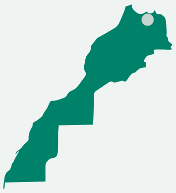
Today, the layout of courtyard houses can be an appropriate typology for the growing experiences of cohousing, providing the court as a space for encouraging a collaborative lifestyle through common activities and sharing of goods and facilities[3]. Social contacts can be related to sharing common equipment such as laundries, common tools for domestic work, or even spaces for gaming and entertainment. From an environmental point of view, starting from the traditional typological characteristics it is possible to undertake actions toward technological innovation and energy efficiency, in order to adequate the courtyard house to contemporary housing needs. The coherent usage of renewable energies, for a zero emissions house's architecture, will represent the main focus for housing research, according with the typo-morphological characters of the courtyard house in the Mediterranean environment. In the USA retractable screen systems and evolving heating techniques, which help in making courtyards a seasonal space, have already been tested [4].

It is of great interest to refer, in conclusion, to some experimentation proposing the courtyard house once again as a matrix for the tissue in the contemporary city. These examples are able to clarify the possibilities of these typologies, even in high density areas, where the formal configuration of the urban characteristics needs the inclusion or integration of private spaces.

It is useful to mention the experiments of modern architects in this direction, for example Mies Van Der Rohe's three-courtyard house, the Tuscolano neighborhood designed by A. Libera, and also in Italy the works of Pagano, Diotallevi and Marescotti. In more recent examples architects are re-proposing the mono-familiar courtyard house referring explicitly to the compact blocks of the Greek and Roman ancient cities, that become the declared reference for the Koolhaas project in the Kashi District in Fukuoka, a block composed of 24 mono-familiar courtyard houses. Significant, in the same direction, the project of MVRDV in *Patio Island*, described with more detail in the following case study sheet.

[3] Cohousing is a form of housing co-operative where private homes contain the basic features of conventional dwelling, but residents also have access to extensive common facilities designed to supplement private living areas. Collaborative lifestyles offering inter-dependence, support networks, sociability and security, addressing several contemporary issues of the contemporary cities, such as environmental degradation, social isolation and affordability (ScottHanson et al., 2005).

[4] "The screens, which start around $1, 500, can roll vertically or horizontally, allowing a homeowner to leave several sets of doors open without letting bugs in. Custom wood/gas combination fire pits or fireplaces, which cost several thousand dollars, can provide warmth or just a decorative touch. And in colder climates, heated pavement can make a walk from the house to a hot tub more comfortable". Abkowitz, A. 2013, 'Full Enclosure'



HISPANO-ISLAMIC COURTYARD HOUSE

CHEFCHAOUEN, MOROCCO

author
Letizia Dipasquale

ENVIRONMENTAL PRINCIPLES

to respect environmental context and landscape · to benefit of natural and climatic resources · to reduce pollution and waste materials · to ensure human indoor comfort · to mitigate the effects of natural hazards

SOCIO-CULTURAL PRINCIPLES

to protect the cultural landscape · to transfer construction cultures · to enhance innovative and creative solutions · to recognise intangible values · to encourage social cohesion

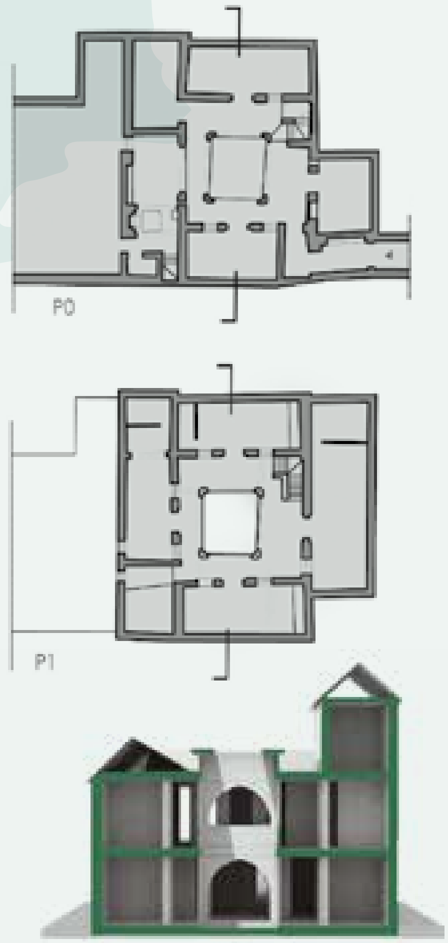
SOCIO-ECONOMIC PRINCIPLES

to support autonomy · to promote local activities · to optimise construction efforts · to extend building's lifetime · to save resources

Chefchaouen was founded by Andalusian Arabs in the 15th Century in the north of Morocco. The city stretches close to the source of River *Ras el Maâ*, protected by the Rif mountain ridge. Facing the Mediterranean, the climate is temperate, ranging around 32°C during summer, to 5-3°C in winter. The whitewashed *medina* of Chefchaouen reflects a unique building culture, influenced by Islamic, Spanish-Andalusian and Berber cultures.

The key element of the spatial organization of the *medina* is the *dar*, the courtyard house, where one or more families live. The houses are are built one next to the other, almost like beehive cells. The windows face the inner courtyard, while openings to the outside are scarce, small and often protected with lattice works that allow seeing without being seen. The main access of the *dar* faces an enclosed alley (*derb*), gathering several houses whose inhabitants constitute a small community. The entrance to the house is protected by an L shape atrium, which prevents direct view towards the courtyard.

The main features of the house of Chefchaouen are the large courtyards and the sloping roofs, stemming from Andalusian architecture, which respond to the need of an efficient outflow for rain and snow. Solved in three levels, each room (*ghorfa*) can hosts a family of 4 to 7 people. Rooms are simple volumes of 2.30 to 2.50 m in width and 5 to 8 m in length. Placed on four sides of the room, low sofas are used as beds during the night. The attic (*berchla*), reached by the terrace, is used for drying fruits or vegetables. Guests are received at a ground floor room (*quobb*). A considerable part of domestic life takes place at the *maqaad*, an open room in the courtyard. The courtyard is the part of the house receiving the most consideration: the welfare of the inhabitants is marked by the decoration of the arches, the richness of tile works on the walls, the paintings on the wooden ceilings, such as the presence of wells, fountains or gardens.



Plans and assonometric section of a courtyard house in Chechaouen (drawings: L. Dipasquale, B. Ozel).

Inner views of courtyard houses in Chefchaouen (photos: L. Dipasquale, V. Volpi).

CASALI, COURTYARD URBAN BLOCKS

PROCIDA ISLAND, ITALY

author
Adelina Picone

ENVIRONMENTAL PRINCIPLES

■ to respect environmental context and landscape ■ to benefit of natural and climatic resources ■ to reduce pollution and waste materials ■ to ensure human indoor comfort ■ to mitigate the effects of natural hazards

SOCIO-CULTURAL PRINCIPLES

■ to protect the cultural landscape ■ to transfer construction cultures ■ to enhance innovative and creative solutions ■ to recognise intangible values ■ to encourage social cohesion

SOCIO-ECONOMIC PRINCIPLES

■ to support autonomy ■ to promote local activities ■ to optimise construction efforts ■ to extend building's lifetime ■ to save resources

Casali are a traditional architectural typology located in Procida island. The dwellings are organized in many residential units, built up on various levels and grouped together around a courtyard. The set of buildings constitute great urban blocks where the courtyard is the space devoted to relationships and to the family's public life. The houses facing the sea side are often oriented toward the panorama, with the courtyard transformed into a terrace, or panoramic loggia.

Casali are born as an urban block following a unitary project, not as the result of a stratification process occurred over time.

Among the Casali of the Island it is worth mentioning *Casale Vascello*, located on the Terra Murata citadel, one of the original nucleus of Procida's urban history, settled with a defensive aim, where houses have been fortified in order to defend the inhabitants from the Arabic raids. Casale Vascello is a wide courtyard urban block, where three-floor row houses, surrounding a rectangular courtyard, manage to configure a sort of microcosmos, closed toward the external urban tissue and very compact both from the point of view of form and from the typology. The entrance and stairs of each house are located in the courtyard, characterized by volumes and building modalities, features and materials based on a buttress arch and cloister-vaults. (G. Cosenza, 1993). Another atypical aspect that is remarkable in this casale is represented by the high density obtained through the house's height, which makes it an interesting example to study for projects focused on new residential strategies in the field of the contemporary Mediterranean house.

➔ Plan of the courtyard block (credits: Cosenza et al., 2007).

↓ Views of the residential units grouped aound the courtyard (photos: A.Picone).

STOPPLAERE HOUSE

VALLEY OF THE KINGS, LUXOR, EGYPT

Architect: Hassan Fathy, 1950

author
Adelina Picone

ENVIRONMENTAL PRINCIPLES

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SOCIO-CULTURAL PRINCIPLES

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SOCIO-ECONOMIC PRINCIPLES

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In the Fifties, in the Valley of the Kings, an English excavation campaigns was guided by Dr. Stopplaere, who was the enlightened client of the house on the top of the hill, designed by Hassan Fathy. The sand, the material of the ground, becomes the material for building the house, where walls, vaults and domes were made with earth bricks dried at the sun, obtained with a mixture of mud and straw plastered by water and protected by a coat of mud mortar. An architecture completely within tradition. Fathy's idea was an architecture, which, on that hill of the Valley of the Kings, was able to represent the manifesto of the modern form in total continuity with tradition. From the distributive point of view the house is based around four courtyards, to which are linked a group of rooms, nearly forming small apartments.

These rooms are the archaeologist bedroom, the services area – kitchen and warehouses -, to which two bedrooms for guests are linked, the *qa'a* with a wide living room, and a hall with the warehouse for the findings. The house is divided into four parts. Each of them has the dome-courtyard element, composition and invariant unit, which defines it from the outside.

The devices adopted for the natural ventilation are focused on the functioning of the internal courtyard. In each room there is at least one wall facing north-west which guarantees freshness, as well as wide external walls in order to increase thermal inertia.

➔ Planimetric view, plan and section of the house (drawings: A. Picone).

↓ External view of the courtyards (photos: A. Picone).

PATIO ISLAND

YPENBURG, DELFT, THE NETHERLANDS

Architect: MVRDV

author
Adelina Picone

ENVIRONMENTAL PRINCIPLES

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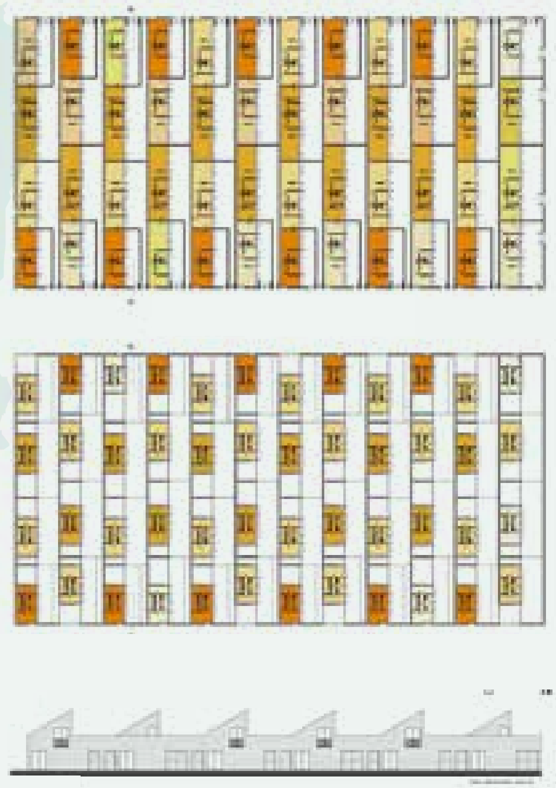
The 1994 Ypenburg Masterplan, an expansion area for approximately 11.000 houses on the site of a former military airfield, was commissioned by the Ypenburg Joint Venture. The plan has two components: on the one hand a framework of public spaces and routes, and on the other fields, which in the course of time have been developed by a selection of designers and developers into residential and business areas. Patio Island, as it has been defined by the architects due to its introvert character, is one of the residential blocks of the Masterplan.

Forty-four houses are arranged in a block of four rows also surrounded by a ring road. A continuous perimeter surrounds Patio Island and provides a clear boundary between public and private spaces. Within this wall there are four rows of black-slate houses that are connected to the outside by narrow corridors, each with its own entrance from the outside. These doors are camouflaged against the perimeter wall. About 0.5 m thick, the doors look like they belong to a bunker and not a suburban home. But once you're inside, the house performs a complete 360° turn from closed to open and introverted to extroverted. It's as if the architects split the house in two where the pitched roofline reaches its highest point, glazing the cut entirely and transforming half of the house into an outdoor patio. There is yet another terrace on the second floor from where there is a view out over Patio Island, all rooftops oriented to the southwest. The cut, the *patio*, the perimeter wall and the orientation all mean that the house is both sunny all day long and that all its domestic activities are exposed to the exterior patio.



➔ Planimetric view, plan and weste facade of the complex (drawings: MVRDV).

➔ View of the courtyards (photos: MVRDV).

Rural House in Coruche, Portugal
(photo: G. D. Carlos)

Compact houses

Gilberto D. Carlos, Mariana Correia, Filipa Gomes, Sandra Rocha
CI-ESG, Escola Superior Gallaecia, Vila Nova de Cerveira, Portugal

The fundamental attribute of the compact house is the concept of adopting a homogeneous space unit, under a common roofing element (Portela, 1984). Its spatial properties, which complement its material features and functional displays, are especially focused on generating and retaining, as much as possible, the heat on the interior of its compartments, thus enhancing the role of the heat radiation elements.

The monolithic shape of a compact house building usually presents an opaque envelope and an expressive rooftop. This is generally considered as an external response to the direct aggressions of the climate, in places where the force of the dominant winds and the intensity of the precipitation are clearly main concerns (fig. 1).

In terms of spatial organisation, the kitchen represents the key element, around which the rest of the house is developed. The fireplace, vital for the low temperatures of winter, assumes a central importance in all domestic activities. Its configuration and location is planned in such a way as to allow heat to spread to the most used divisions. The location of the fireplace in the spatial organisation of the house assumes a great symbolism for the community (Flores, 1973) (fig. 2).

As a spatial and functional component, the kitchen is clearly the opposite of the patio. The fireplace area of the compact vernacular house is the most active area of the building, where most of the household's inner time is spent. Considering the stated reasons, it is no surprise that it becomes the most suitable place for the family's collective and social activities. Although its geometrical configuration can present some distinctive tendencies, from a nuclear circle or square form, to a narrow extended shape, the regularity of the vernacular compact house's plans and façades seems to constitute a common feature, with a very elementary volumetric composition. The interior organisation is usually a direct consequence of the gradual fragmentation of a unique space, through the display of vertical light walls according to the evolution of the household's necessities, where inner circulation or distribution spaces are not considered (Bonet, 2007).

The overall size of the houses, within all the justified exceptions, converges to the idea of space compression, optimising the area and the height of every inner division, in order to reduce heat losses and its mandatory energy compensation. The few window open-

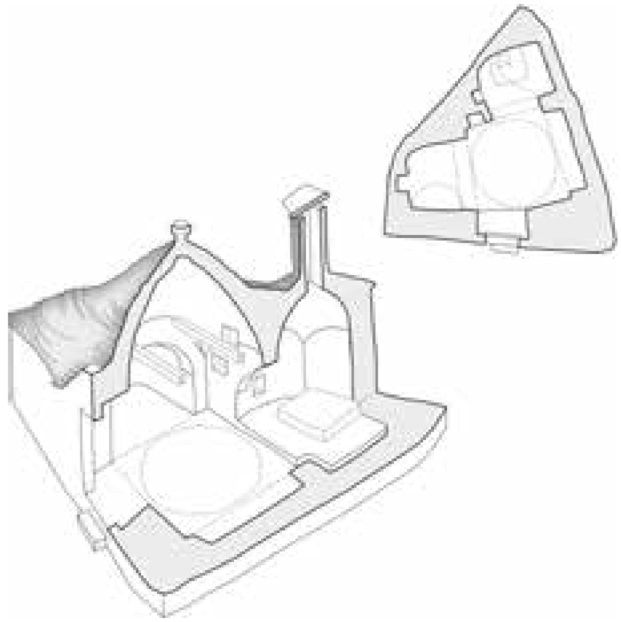
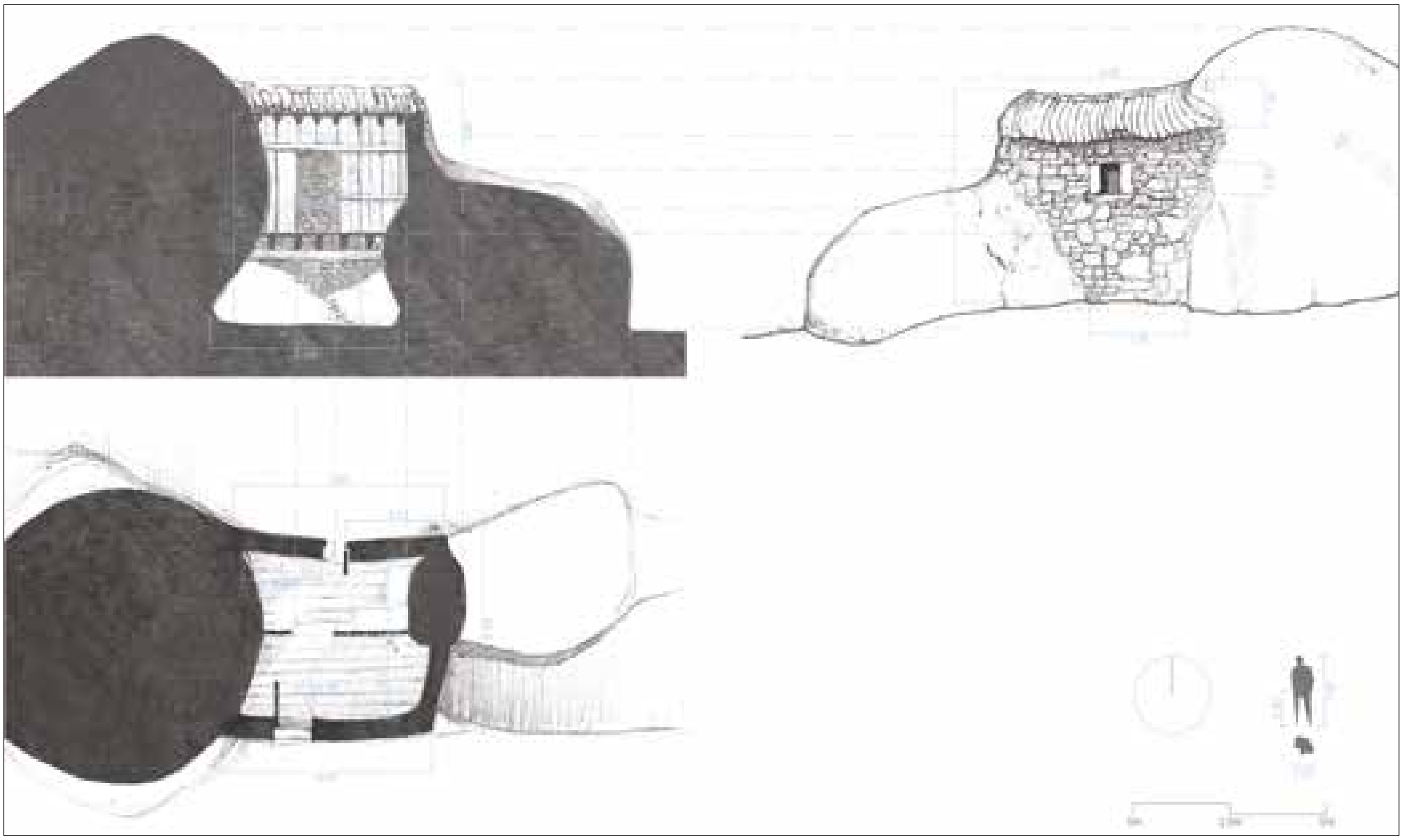


Fig. 1 Spatial configuration and organisation of spaces in a trullo, Apulia, Italy (drawing: L. Dipasquale).

Fig. 2 Apulian Trulli, fireplace, Apulia, Italy (photo: B. Özel).



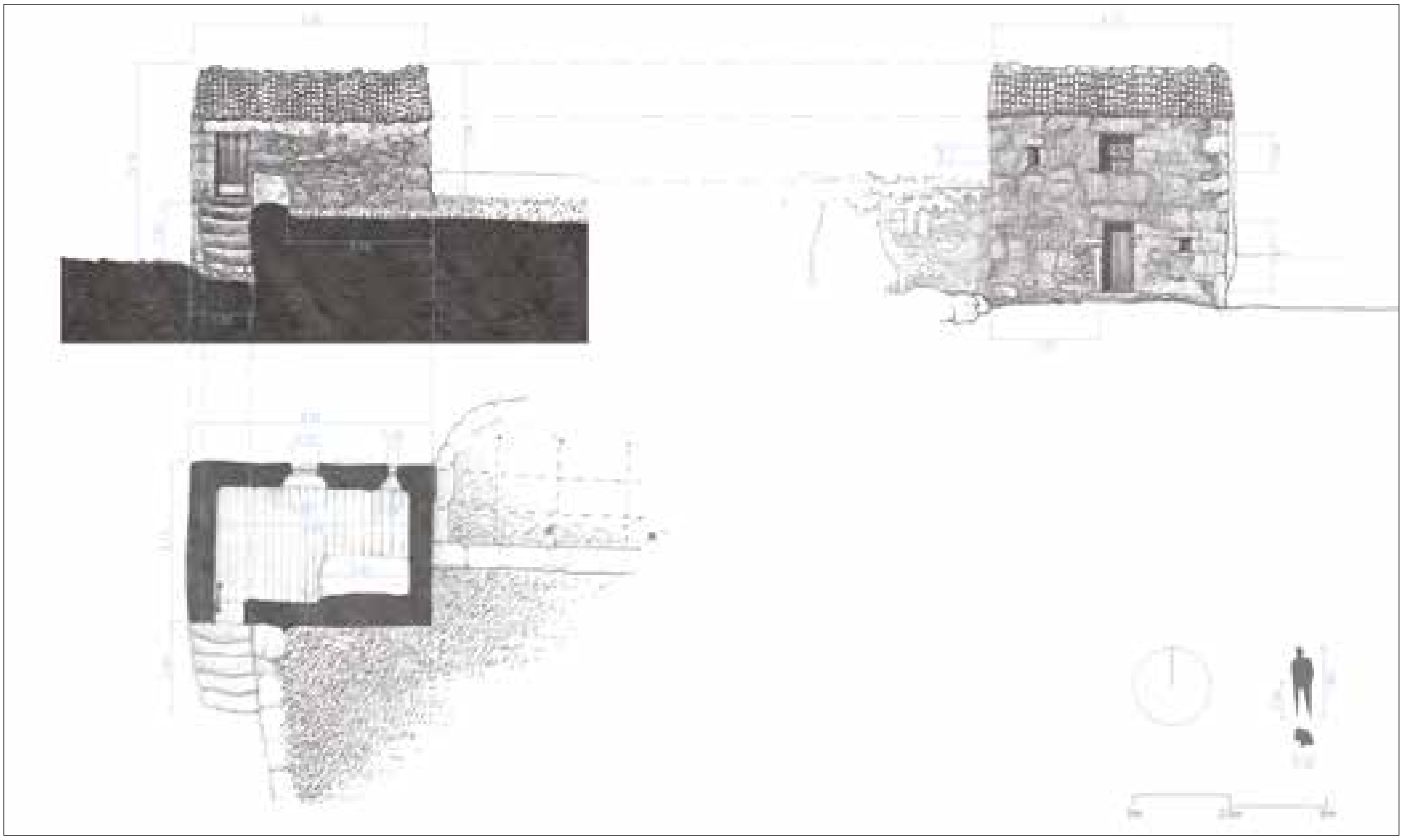


Fig. 3-4 Drawings of a dwelling unit, Paredes de Coura, Portugal (author: G. D. Carlos).

ings on the façades are usually present only on those with direct sun exposure. These are intended to minimise thermal exchanges with the outside environment, and to avoid airflows that could compromise the inside temperature balance (fig. 3).

In many cases, the building envelope's permeability is sufficient to allow the minimal air quality and to avoid water condensation, especially in more humid contexts. In some particular climates, where the season's differences are significantly marked, the most permeable façades can be articulated with buffer elements that can mediate the relation with the exterior, by taking advantage of ventilation drafts in the summer without compromising the thermal insulation of the building during winter. As it may be inferred, the thermal insulation performance of the building envelope plays a determinant role on the general strategy of the compact house.

The compact house is usually associated with a high thermal inertia perimeter wall. The implemented construction systems are commonly based on the aggregation of large dimension elements, producing thick section walls that can also assume the main structural efforts of the building, depending, of course, on the structural performance of the materials used. This feature concurs also with the constraining effect on the number and dimension of the external openings, and has direct implications on the optimisation of the interior areas and their span's covering solutions (Brunskill, 2000) (fig. 4).

The compact house can also fulfil the strategy of reducing the need of land for construction. This is especially important when the fertile soil is scarce and/or is very valuable. These are two circumstances that are usually common on contexts of rough topography or high population density (fig. 5). Therefore, it is very common to observe the predominance of this architectural solution mostly in mountainous regions or in places of intricate cadastral systems, where smallholdings are the most common land property type. In some particular cases of sensible natural environments, especially in extreme conditions like rugged hills, marshlands or dense forest areas, the compact house can be a valid solution for minimising the construction footprint, or even the landscape impact, which is a more subjective concept.

Contrary to other house typologies, and despite the stated diversity of form, the compact house, when pressured to expand, seems to demonstrate a preference for vertical expansion, rather than adopting horizontal extension systems.

Fig. 5 House in Castro Laboreiro, Portugal (photo: G. D. Carlos)

This solution allows the maintenance of the same external perimeter, and the multiplication of inner space, under the same roofing structure. It also avoids the appropriation of more surrounding land and prevents increasing the elements of confrontation with the natural elements.Taking this into consideration, it is also acceptable to relate the compact house to a solution for contexts of scarce building resources or, due to any particular reason or circumstance, to contexts where the local building culture cannot develop an elemental level of technological expertise. In some cases the compact house can be a simple strategy to reduce the dependence on the amount of building material, workmanship, or to attain the constraints of the construction process complexity (Dias et al., 1969).

In socio-cultural terms, the compact house may represent an element integrated in communities with a tendency for outside gathering activities, where social rituals imply the use of specific collective equipments or shared open-air spaces.

The domestic space can also be interpreted as a secondary living scenario, a secondary element in contexts where the main subsistence activities can take place mostly in the exterior, therefore reducing the household's need for private space to a more basic level. Another important quality is the possibility to agglomerate, under the same volume, supplementary elements like porches, balconies, verandas and galleries that have a multifunctional role in

Fig. 6 House in Serra d'Arga, Portugal (photo: G. D. Carlos).
Fig. 7 Buildings in San Salvatore di Sinis, Sardinia, Italy (photo: L. Dipasquale).

the support of productive activities, without creating conflicts with domestic activities. As a matter of fact, they can even ease the relation between the inner spaces, without harming the envelope's thermal performance, and fulfilling most of the circulation needs of the house (fig. 6).

As transitional elements, porches, balconies, verandas and galleries can play an important social part in the life of the community, since they act as filters for the household's privacy. Most of the rural collective rituals, both pagan and religious, have become very connected to these spatial elements. Communities tend to value the symbolic development of these elements, and enhancing their exceptional function, in opposition to the sober and plain appearance of the building's envelope (Oliveira and Galhano, 1998) (fig. 7).

In short, it could be stated that in the compact house the archetype is mostly related to the opacity of the building's envelope, its material roughness, as well as to the large expression of the massive roofing system, a characteristic element of cold and high precipitation areas. It should also be stated that, in more temperate contexts, some elements or parts of the building envelope could admit a different external relation. For instance, this is the case of the south façade permeability. However, these are usually isolated situations, in the overall design strategy (fig. 8).

Variations of the compact houses

Often, the vernacular compact house is not only used as a family shelter, but also includes other purposes related to the main subsistence activities. The building unit can accommodate spaces for fishing crafts, agricultural support or cattle breeding. Generally, the different functions are allocated on distinct and segregated areas that mostly correspond to different floors, as the vertical development is the preferable solution for the compact house. The interconnection between floors usually depends on the eventual conflict between the established purposes. Nevertheless, in the most elementary cases, these functions have a tendency to coexist without drastic separations.

In most cases the ground floor accommodates agricultural and livestock activities, depending on the house's geographical features. Sometimes, it can even combine these two needs. The wine cellar is also a solution that takes advantage of the thermal and light

conditions of buildings that are partially buried. This is frequent in regions of Roman legacy, where wine was introduced as an important element of the local diet. It happens mainly in areas of transition between Mediterranean and Atlantic climates, where the cultivation of grapes is still compatible with the precipitation levels.
The cowshed is also a common solution, which allows the sheltering of animals in small and low height spaces, in a direct and autonomous relation with the exterior. In general, the cowshed has small openings for ventilation purposes (Correia, 2006) (Llano, 1996). Although simple, the heat radiation provided by the animals could also be considered as a supplementary heating strategy (Correia, 2006). In the most cold and basic contexts, the separation between this function and the spaces reserved for human shelter can be very tenuous.
In coastal communities, namely in waterfronts, the lower level can be used for small fishing vessels and the storage of tools. The spaces are arranged to deal with humid and salty environments, facing high erosion conditions, and enhancing major and regular maintenance procedures. Sometimes, on more extreme circumstances, this level can be prepared to face the increment of the water level, allowing the building to be sporadically flooded (Flores, 1973).
In all the mentioned cases, the upper floor is elevated from the soil humidity. It is more permeable to sun exposure, and has better visual control over the surroundings. It is also usually reserved for human activities, and the kitchen, living room and bedrooms, are its main compartments. Only during the twentieth century, were sanitarian installations incorporated into the domestic programme. In small dwellings, the first integration consisted in the construction of an isolated and autonomous small structure to serve this purpose. In more complex dwellings, sanitarian installations were incorporated into the first floor of the house. When used, the waste would fall directly into the barn shed and would be mixed with a straw bed covering the floor ground (Correia, 2006).
The kitchen, and more precisely the fireplace, has to be compatible with the inflammable elements of the construction systems. Therefore, the chimney and the surrounding ceiling usually present a significant height variation over the rest of the compartments (fig. 10). It is very common to expose the roof structure beams to the smoke, as it serves also as a protection from xylophagous in-

Fig. 8 House in Suai, East-Timor (photo: G. D. Carlos).

sects (Brunskill, 2000). Moreover, the pavement presents a special concern, taking into account that most of the first floors are based on horizontal wood structure solutions. The area affected by the heat is usually built with stone slabs, supported by thick structural walls (Correia, 2006), or incorporating massive natural rocks that already existed on the site. Understandably, the fire area dominates the composition of the plan. It is articulated with the entrance and enables social appropriation. Moreover, most of the traditional furniture elements are incorporated into it, consigning it as the main living space.
Other important supplementary elements are the buffer spaces. Galleries, verandas and porches can play a minor, thought interesting role in the heating management strategies. The main objective is to take advantage of solar gains, especially in the coldest seasons, whenever the available sun exposure is sufficient to compensate the effort of their construction. But, perhaps, the best application of buffer spaces is where they can act as passive reversible elements, both for heating and cooling purposes, particular in places of more temperate climate, with well marked seasons. They can con-

Fig. 9 Aggregation of compact units, Coruche, Portugal (photo: G. D. Carlos).

stitute precious mechanisms to ensure the hermetic condition of the building envelope, while providing enough ventilation to replace the indoor oxygen level and to balance the relative air humidity. The mentioned hermetic condition highly depends on the appliance of high thermal inertia walls that have the ability to obstruct the heat flow, thus allowing an appropriate temperature inside buildings during the summer. Most of the examples are composed by construction systems that depend on the aggregation of heavy monolithic elements such as hard stone masonry or timber log walls. In the first case, mortar can be used to aggregate the elements, especially when lime is an available resource. But most important is the use of plasters to assure the infill of every joint and gap of the external walls. Earth plasters are also a frequent alternative, especially when lime is scarce, but, due to the high erosion circumstances typical of the compact house, an intense maintenance activity is usually necessary.

Where local stone is not a structural reliable material, there are also examples of compact houses made of half-timber construction systems, using stone, earth or baked bricks, as infill techniques. Following the wall's thermal principles, also the roof constitutes an important element to assure insulation. The most efficient solutions are provided by thatched roofing systems. However, the high need for community engagement and regular maintenance required to its production, associated with the disappearance of the expertise to do it, has originated a broad substitution of thatched roofs by tilled covering solutions. Although their thermal performance cannot be comparable, they have the advantage of providing a better waterproofing capacity to the building. This should also be a factor to consider, as a valid complement to the compact house.

The importance of insulation and ventilation in the compact houses

The main vulnerability of the compact house strategy lies probably in the fact that it depends on the existence of a strong source of heat radiation. Traditionally, this element was supported by wood

Fig. 10 Stone compact houses in Matera, Italy (photo: B. Özel).

combustion, assisted, when possible, by passive solar gain mechanisms, integrated mainly on the south façades. The significant disappearance of small forests, which used to be part of rural environments, and the exponential increase of living condition demands are leading to a high energetic dependence that still has not found a suitable alternative.

Another disadvantage is the level of inner air saturation, usually aggravated by the low permeability of the building envelope. It is very difficult to balance an efficient building insulation with an accurate ventilation system. The success of this equilibrium highly depends on the permanent capacity of the inhabitants to work to improve its performances. Operable mechanisms and maintenance activities are indispensable to accomplish these features, yet it is of the utmost importance to always adopt a preventive attitude towards building management.

The dissemination of the interior heat through the dwelling's unit determined a very fragile separation system amongst compartments. These circumstances cause a tenuous distinction between collective and more intimate spaces, with reduced levels of privacy. The same reason determines the suppression of exclusive circulation and distribution in the inner areas. The compartments are usually directly linked to each other, which is also a reason for increased conflicts regarding comfort and privacy amongst the household in daily life, a factor that is difficult to imagine considering the current living standards.

Another significant constraint is the technological difficulty to create systematic openings in thick and heavy construction systems. Usually interpreted as a technical and structural extra and as a thermal rupture point, the façade openings of compact houses are often scarce and small, resulting in very dark domestic atmospheres with a weak use of available daylight.

PALLOZAS

LUGO, GALICIA, SPAIN

author
Filipa Gomes, Gilberto D. Carlos, Ana Lima

ENVIRONMENTAL PRINCIPLES

to respect environmental context and landscape ■ to benefit of natural and climatic resources ■ to reduce pollution and waste materials ■ to contribute to human health and welfare ■ to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

to protect the cultural landscape ■ to transfer construction cultures ■ to enhance innovative and creative solutions ■ to recognise intangible values ■ to encourage social cohesion

SOCIO-ECONOMIC PRINCIPLES

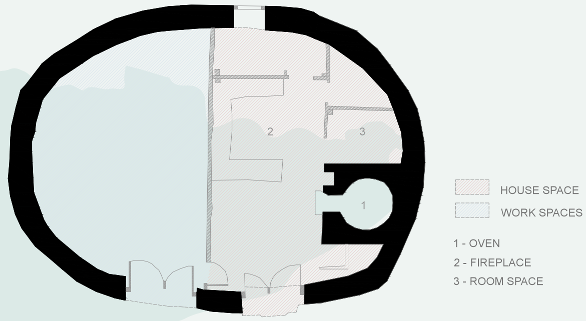
to support autonomy ■ to promote local activities ■ to optimise construction efforts ■ to extend building's lifetime ■ to save resources

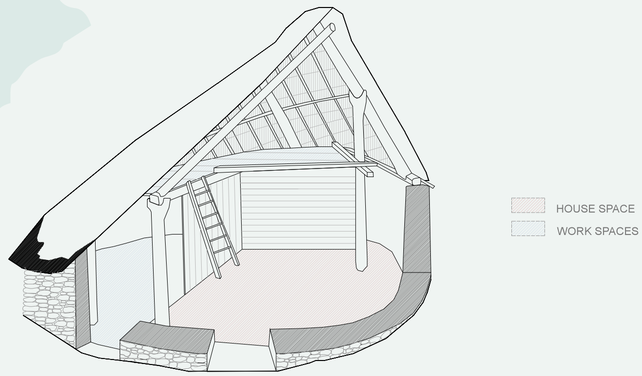
The *palloza* is a characteristic typology of the Northern Spanish mountains. The selected building is located in the village of Pedrafita do Cebreiro, in the Courel Sierra.

The *palloza* is a construction usually placed in the middle of the mountain slope without a precise sun orientation. The plan has an elliptic geometry; the perimeter walls are built with stone masonry (granite and/or schist), on which lays a large conic thatched roof (Llano, 1998).

This habitation is characterised by combining, in the same spatial unit, the functions of domestic shelter and workspace. The unit has a double height ceiling, adding the height of the perimeter walls to that of the inner void of the roof. It works as the main container of one or several smaller inner volumes, usually built in wood, resulting from placing a transversal structure, which creates partitions that have lower ceilings, and thus providing the top surface for the storage of provisions (Caamaño, 1999).

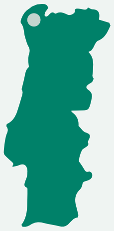
The family space corresponds to the undivided area, where the fireplace is located, using the whole interior height. The built-in compartments contain the stables/warehouse, using the natural ground slope for the water drainage. The building has only two openings, one for humans and one for cattle. Sometimes, small windows may be integrated for ventilation purposes, to avoid significant energy losses.





➜ General drawings (author: F. Gomes based on the original drawings by Llano, 1996).

↓ Exterior view of a *palloza* (photo: A. Lima).



COMPACT HOUSES IN GAVIEIRA

ARCOS DE VALDEVEZ, PORTUGAL

author
Filipa Gomes

ENVIRONMENTAL PRINCIPLES

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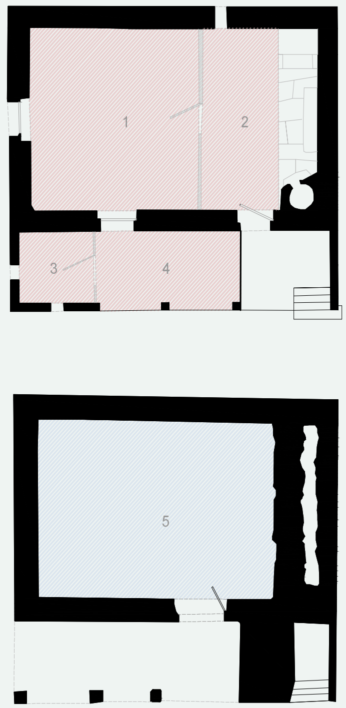
to support autonomy · to promote local activities · to optimise construction efforts · to extend building's lifetime · to save resources

The case study is situated in the village of Gavieira, in Serra da Peneda, municipality of Arcos de Valdevez, Portugal. The compact house in Peneda is intended as a refuge, but it also comprises several other purposes, such as storage for agricultural products, and livestock shelter. Housing becomes crucial on agro-pastoral production, being an integrated economic and social unit. The materials used are the ones existing in the area, in this particular case granite and wood. Granite was used for the elevation of the walls, formed of blocks slightly levelled, disposed without any plaster. Wherever possible, the housing leans on any existing outcrop, and thus saves the need for a wall. Close to the ground lay the larger blocks and above them medium or small size blocks were used. The floor was made of wooden planks, mostly oak. The same elements were used for doors, wooden shutters and the roof structure, which was subsequently covered with a thin layer of heather, due to its resistance and durability. However, in some cases, brush is also used, even if it is less durable. The materials used in the construction of the house helped to protect the inside from climatic conditions. During the summer the thatch helped keeping the interior cool. In the winter, the low height of the houses, combined with the successive layers of vegetable matter used in the roof, favoured the retention of heat from the fireplace, along with the heat produced by the presence of the animals stabled downstairs, inside the house. Thus, the structure of the house shows a perfect compliance with the environment and the needs of this particular socio-economic organisation (Gomes, 2014).



FIRST FLOOR

HOUSE SPACE

1 - LIVING ROOM
2 - KITCHEN AND FIRE PLACE
3 - ROOM SPACE
3 - BALCONY

GROUND FLOOR

WORK SPACES

5 - STORAGE AND LIVESTOCK SHELTER

Exterior view of compact buildings in Gaveira (photo: F. Gomes).

General drawings (author: F. Gomes).

CASA DA OLIVEIRA

COUREL, GALICIA, SPAIN.

Architect: Carlos Quintáns Eiras

author
Filipa Gomes, Ana Lima

ENVIRONMENTAL PRINCIPLES

to respect environmental context and landscape; to benefit of natural and climatic resources; to reduce pollution and waste materials; to contribute to human health and welfare; to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

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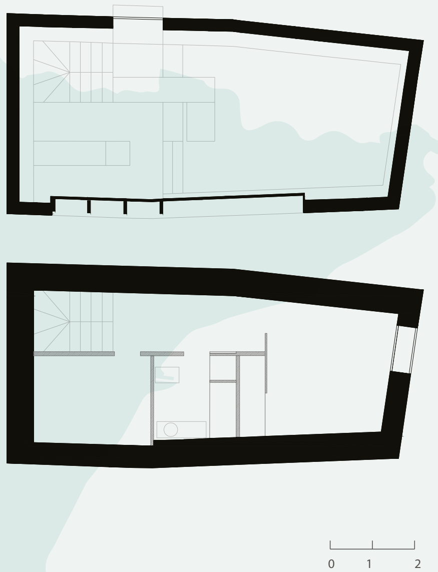
SOCIO-ECONOMIC PRINCIPLES

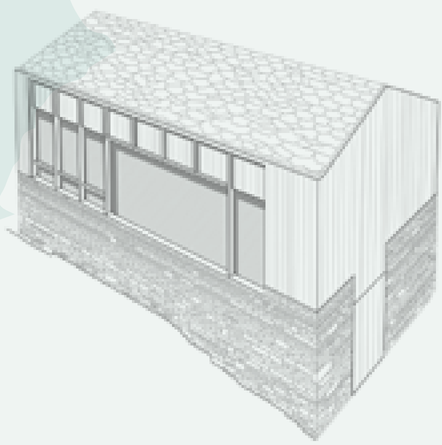
to support autonomy; to promote local activities; to optimise construction efforts; to extend building's lifetime; to save resources

Casa da Oliveira is a dwelling designed by the Architect Carlos Quintáns Eiras, located in the Mountain of Courel, located in Galicia, Spain. The design arises as a rehabilitation of an existing barn, which has been turned into a house dwelling.

The implementation of the building is made strategically relying on the implementation of the structure of the barn. Concerning the construction process, the building has been rebuilt based on the construction techniques and principles implicit in the vernacular buildings already existing in the area. As for the orientation, the new project draws on the techniques applied in the construction of the barn, respecting not only its solar orientation, but its exposure to the winds as well, in order to obtain a better environmental performance of the building.

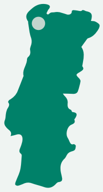
The new building is therefore based on the principles of the compact house, characterised by its small size and taking full advantage of each space: the first floor is composed of a common area (living room/kitchen), and the ground floor is intended for a private space (rooms). Parallel to what occurs in the vernacular compact house, this project is also designed to assemble small spaces, essential for its habitability. The construction process is based on the use of a timber structure on stone masonry. The exterior is characterised by the presence of an imposing roofing system, but also by the use of materials from the old building.





General drawings (drawings: G. D. Carlos based on the original of Carlos Quintáns Eiras).

Exterior views (photo: A. Lima).



GRANARY-HOUSE

GUIMARÃES, PORTUGAL

Architects: José Gigante, Vítor Silva

author
Filipa Gomes

ENVIRONMENTAL PRINCIPLES

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SOCIO-CULTURAL PRINCIPLES

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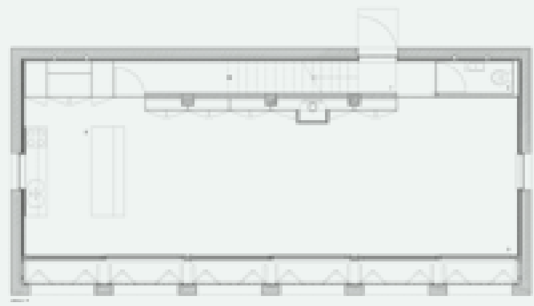
SOCIO-ECONOMIC PRINCIPLES

■ to support autonomy ■ to promote local activities ■ to optimise construction efforts ■ to extend building's lifetime ■ to save resources

This case study is situated in the village of Urgezes, near the city of Guimarães, Portugal. The architects José Gigante and Vítor Silva developed the project's contemporary recuperation.

The design of the contemporary house is based on the use of a pre-existing structure, a granary (*sequeiro*), which has been converted into a house dwelling. Constituent materials from the pre-existing structure are reused, as is the case of the granite components. The new construction is implemented on a site next to the old upland, and therefore presents a change of location, in relation to the old granary (Gigante, 2008). The new construction is based on a reinterpretation of the granary, which emerges through the construction of two modules.

Essentially, it is a model characterised by a broadly open façade, which also concurs for the passive energy resources of the building. By directing the façade towards the south, and retreating the transparent surfaces sufficiently, it benefits, in the hottest period, from the shade provided by the construction body itself (Gigante, 2008). Renouncing to the literal adoption of the existing model, the design of the shutters responds to new demands of functionality and comfort, providing full or partial openings. By inserting a counter batten in the shutters, better ventilation conditions were also provided. Moreover, these counter battens were spread all over the façade, so that the reading of the façade incorporates subtle variations of light.



First floor and main facede drawings (drawings: José Gigante and Vítor Silva).

Exterior views (photo: José Gigante and Vítor Silva).

La Larronière, Bretagne, France
(photo: E. Sevillano).

Roof shapes design

Hubert Guillaud
CRAterre-ENSAG, Grenoble, France

Main features of roof shape design strategies

The roofing of a building constitutes a covering erected above its walls, the main purpose of which is to protect it. Where vernacular architecture is concerned, the morphology of roofs studied in Mediterranean countries, whether Spain and Portugal or Italy and France, is highly diverse.

The shape of a roof is directly correlated to that of the building itself–its architectural typology, the plan of the spaces within it and their functionality (living spaces, spaces dedicated to utilities as well as agricultural, artisanal and sometimes industrial economic spaces). Moreover, it is also strongly determined by its physical environment which, depending on the latitude, ranging from between the 36th parallel north in the south of Spain and the 50th parallel north in the most northerly region of France, encompassing highly varied climates. Roofing mainly provides protection against the elements: rain, snow (in mountainous regions), wind and sometimes sun when shade is required (this generally refers to canopies or eaves, or sometimes galleries erected against walls). However, those factors which define the shapes of roofs would not be complete without evoking the direct relation between the types of structures that support them, whether frameworks (for one, two or more pitched roofs), structures used for flooring (flat roofs), or arches and domes frequently found in the territories in question.

The contributions of Human Geography

The main morphological features of roofs observed on vernacular houses in European countries (notably in France) which may be cited here as an example, were noted in geographical studies in the first half of the 20th Century. This refers notably to the impetus given in the works of Paul Vidal de La Blache (1845-1918)[1], which were later developed by some of his students who foreran the study of rural housing, such as Albert Demangeon (1872-1940), Maximilien Sorre (1880-1962), or Pierre Deffontaines (1894-1978), the historian Marc Bloch (1886-1944), or Osvaldo Baldacci (1914-2007) in Italy.

The tradition of studying rural housing in conjunction with human geography was also developed by agronomical engineers in Spain.

In France, Demangeon established a clear dividing line between the southern and northern regions of the country, following a diagonal line running from the Loire estuary to the Jura massif, from gently sloping roofs (south facing) to steep sloping ones (north facing). This distinction is in accordance with the difference observed[2] between farms with 'piled up roof frames' (south facing) and those with 'triangulated roofs' (north facing). Thus, the *milieu* and the 'location' have an obvious morphogenetic influence on the appearance of roofs.

The morphological features of roofs in France, as an example

The study of rural architecture has given rise to a large number of publications, notably in the second half of the 20th Century. Some authors stand out from the general profusion, especially Georges Doyon and Robert Hubrecht (1979, p. 12)[3]: "These buildings are always capped with roofs [...]. It should be observed that roofs have an unfortunate tendency to be complicated, strictly following the plan, absorbing and amplifying every projection and overhang. There are also skylights and chimney stacks [...]. And rooftops that jut up into the sky [...]. A complication of plane-parallel volumes [...]. Amplified by roofs this complication looks like a mistake. [...] Our former houses, whether with sloping or flat roofs, were always designed with uncomplicated forms and very elementary volumes: two slopes and two gables or pediments; four slopes, a pyramid, a cone, a half-sphere and their derived shapes. All buildings are first and foremost comprised of two elements: walls and a roof".

Those brief words state the morphology of roofs in very simple terms, and it should also be observed that the authors express their preference for simple roofs that are 'economical' and easy to maintain.

Local building cultures and forms

The general appearance of roofs in our vernacular architectures, whatever the region, also confirms well-reasoned utilization of the

[1] Founder in 1891, along with Lucien Gallois, of the famous *Annales de Géographie* that were to comprise the basis of the French School of Geography.

[2] Since then, the housing landscape has been transformed with more commonplace forms, even if neo-vernacular folk-type trends take their inspiration from regional vernacular types.

[3] One of them is a specialist in civil architecture and national Palaces and the other is a member of Academy of Architecture who published *L'Architecture rurale et bourgeoise en France* (Rural and Bourgeois Architecture in France). This quotation on building masses and their roofs is from Chapter II of their book.

M. Correia, L. Dipasquale, S. Mecca (edited by), *VERSUS: Heritage for Tomorrow. Vernacular Knowledge for Sustainable Architecture*, ISBN (online) 978-88-6655-742-5, ISBN (print) 978-88-6655-741-8, CC BY-SA 4.0, 2014 Firenze University Press

Fig. 1 Roof in *lauzes* (stone-slates) at Le-Pont-de-Montvert, Cévennes, France (photo: H. Guillaud).

resources existing on-site. Vernacular builders made the best possible use of the materials at hand and also endeavoured to limit the transformation of available resources. They strived to be 'concretely effective' without it being too costly or requiring too much effort in terms of implementation. Their rule of thumb was economy in a frugal, non-wasteful sense, with frequent recycling (recuperated materials, beams, rafters and battens, and parts of frameworks from ruined buildings).

For building frameworks, they used locally-sourced wood such as pine, spruce or poplar for the more modest buildings (simple long houses for farm workers, day labourers or tenant farmers), or oak, chestnut for the more elaborate buildings (farms built on high ground or with open or closed courtyards for cultivator-labourers or farmer-landowners). Wood from forests was also used to cover roofs, especially in high altitude or mountainous regions. Those old roofs, which are still covered with various types of shingle (*essentes* or *tavaillons*) or small flat wooden tiles (*essendolles*), can still be seen in the Alpine regions of France (Savoy, the Briançon area and the hinterland of Nice). Similarly, the walls of rural buildings were built with large stones (used in Cyclopean masonry or as decorative facings[4]), or with stones found in fields while ploughing. Those stone materials were also used to cover roofs, either with schist, volcanic tuff, limestone or sandstone – all local materials prepared on building sites after being carted there from working sites, quarries, outcrops and various rocky massifs. Because sloping roofs in schistose lauze slates are very heavy and need sturdy frames, alternative solutions in the form of limestone arches and domes are frequent in vernacular buildings in Mediterranean Europe. The territorial extension of this dry stone building culture is surprising in that it extends to northern regions as far as the River Loire in France. They can be observed on houses in the Cévennes (fig. 1) or southern Ardèche with their strong tradition of agricultural or 'coal-miners' huts' or on 'bories' in Haute Provence[5] (around Gordes) and on houses in

[4] In the north of the Isère department, in Dauphiné, France, a large number of buildings, farms, village houses and churches with magnificent pebble facades in the form of fishbones (*opus spicatum*) that alternate with bands of fired bricks, can be found.

[5] Among the most elaborate are the *nef gordoise* type bories, independent rectangular or trapeze-shaped buildings with limestone roofs in the shape of a ship's hull cantilevered from the four sides of the plan. Other bories are square or circular shaped.

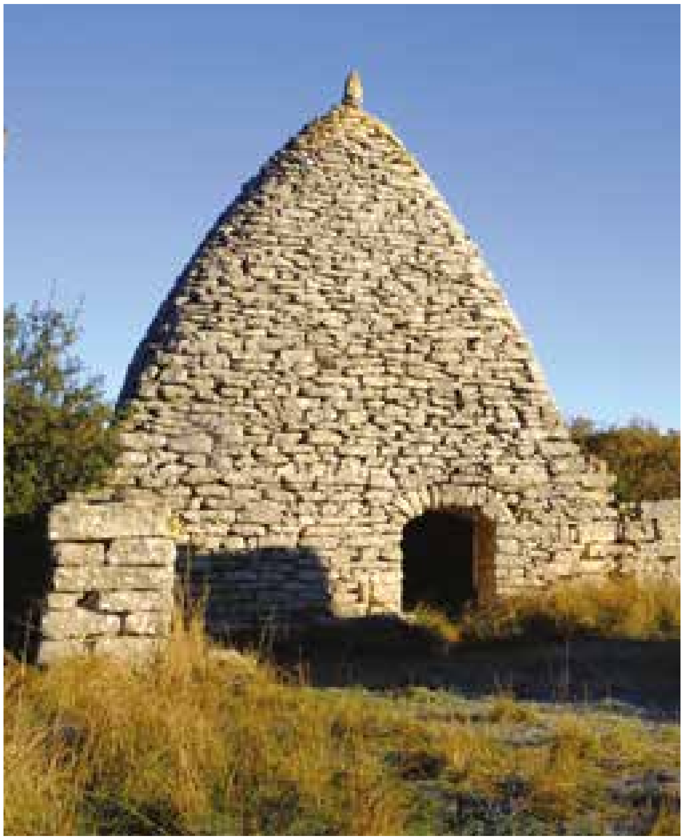


Fig. 2 Borie near Gordes, Luberon, Vaucluse, France (photo: N. Sánchez).

Fig.3 Roof shapes and local materials. Trulli, Alberobello, Region of Apulia, Italy (photo: B. Özel).

Cap Corse in France, on *trulli*[6] with cone-shaped roofs in the Pouilles in Italy, or *chozos* or farm shelters in the Spanish countryside (fig. 2, 3). The same tradition applied to old-style slate roofs, which were initially quite thick but were replaced in the 19th Century with thinner slates. Many of these can still be found in the extreme south-west of France, in Gascony and the Hautes-Pyrénées, the Perigord, the Loire Valley (Touraine), some parts of the Central Massif (Creuse and Corrèze) and as far as Brittany, Upper-Normandy and Picardy.

Similarly, vegetable matter, straw from cereals (wheat or rye), reeds and rushes from the banks of ponds and marshes and various heathers and brooms were used over a period of time as roof coverings. Straws and local grasses were also cut into strands of varying lengths for mixing with clay soil to form wattle and daub for wood-framed houses. Roofing made from vegetation, otherwise known as 'thatched saddleback roofs', dominated the rural vernacular building scene over a long period but was particularly dominant in the northern regions of the Mediterranean Basin. In France, *bourrines* (traditional whitewashed thatched cottages) in the marshland of Vendée (south of the Loire estuary), houses in the Grande-Brière and several parts of Normandy continue to illustrate this long-standing tradition. Other similar traditional dwellings, such as *cabanes des gardians* (fig. 4) in the Camargue (south of France, Rhône delta), have completely disappeared. Finally, traditional vegetated roofs, a typology of outbuildings mainly used for storage or traditional shepherds' huts, can still be found in Mediterranean islands such as Corsica (fig. 5) and Sardinia, as well as in high-altitude pasture lands in the Alps. These are generally buildings of locally-sourced stone, made with loam mortar and frequently covered with stone arches, and covered over with earth in which grass and other local plants grow.

Later, from the mid 19th Century, 'native' materials used for the roofing of vernacular houses (vegetable roofing or wooden shingles, that notably constituted a fire hazard) were gradually replaced by other materials such as round clay tiles, but also flat or scale-shaped tiles (still typically found in the Dauphiné region of France) (fig. 6), and interlocking tiles from the *Marseillaise* tradition, a remarkable inven-

[6] Traditional *trulli* are found in the south of Italy on the Adriatic Sea, between the towns of Bari and Brindisi, on the Murgie plateau. The most modest of these are farmers' and farm hands' houses. A tradition of houses grouped into settlements, such as Alberbello in the Bari province, can also be found.

Fig. 4 'Cabane de Gardian', Camargue, Bouches-du-Rhône, France (photo: T. Joffroy).
Fig. 5 Shepered's shelter at Farinole, Corsica, France (photo: E. Sevillano).
Fig.6 Rammed earth Barn roofed with scale-shaped tiles, Rhone-Alps region, France (photo: P. Doat).

tion from the mid 19th Century that spread worldwide; and finally and more recently, corrugated iron (which frequently covers vernacular mountain dwellings).

Thus from a particular point of view, the local and regional natures of building cultures, that contribute to the visual identity of the morphology of vernacular building in various regions from north to south and east to west, have a direct impact on the shape of roofs.

Roof shaping and contribution to sustainability

Such well-reasoned and very local utilisation of resources for building both the walls and roofs of vernacular houses responds to several principles of sustainability now being promoted as the most efficient system possible in terms of environmental life cycle analysis and carbon footprint. This use of resources also makes a better social, cultural and economic impact (fig. 7).

From an environmental standpoint, the use of local resources for building walls and roofs aids integration into the site, respects the environment and enables the recovery and recycling of local 'natural' materials (earth, stone and wood) from ruined or deteriorated buildings – which themselves become resources – reducing the use of industrial materials and various forms of 'incoming' external pollution. From a social and cultural standpoint, such use of local resources contributes to the preservation of a *continuum* of the identity of a landscape within a territory and of its building culture – still frequently visible in the aesthetics of roofs standing out in built-up areas – but also to the transmission of material and immaterial values that are part of its heritage and maintained by the handing down of traditional knowledge and know-how, or by small enterprises specializing in structures and roofing.

Finally, from a social and economical standpoint, such use of local resources contributes to sustainability by enabling considerable saving of the embodied energy necessary for transformation and production, the materials most frequently being used in their original state or barely transformed, as well as to economy in transportation energy since the materials are collected on-site and only transported over short distances. This *topos* logic is also beneficial from an economical standpoint. It contributes to the development of local and regional sectors for the production of materials and the maintaining of artisanal professions and small and medium-sized spe-

Fig. 7 Using locally available, natural materials; Casone Lagunare, Veneto, Italy (photo: S. Onnis).

cialist enterprises. It is a significant factor in the generation of jobs, the preservation of professions that transform resources into materials and other structural components and roofing for buildings and also contribute to the preservation, restoration and rehabilitation of the building heritage – comprising a huge reserve of potential dwellings – as would a modern building reusing such resources in a creative and innovative way. This all comes under intelligent management of territories in the perspective of sustainability. Reverting to traditional roofing solutions in the application of the paradigm of sustainability is becoming more and more apparent and is vernacular-inspired. Thus thatched roofs (fig. 9) are again being developed, as are straw-made buildings proposed by some contemporary architects such as the Wingårdhs Agency in Sweden. Heavy roof forms, which contribute to reinforcing the inertia of buildings and are a factor of comfort in regions of contrasting climate and temperatures, are making a comeback. Serious interest is being taken in vegetated roofing, which also contributes to an increase in green and floral surfaces, notably in urban areas, not only enhancing their appearance but reducing the level of air pollution. Finally, it should be noted that the development of a veritable industry in wooden roofing, which is considered the best insulator, is a huge plus in the current context of eco-dwelling.

Fig.8 Thatched roofs in the fishermen's village of Meneham, Bretagne, France (photo: H. Guillaud).

DAMMUSI
PANTELLERIA, ITALY

author
Letizia Dipasquale

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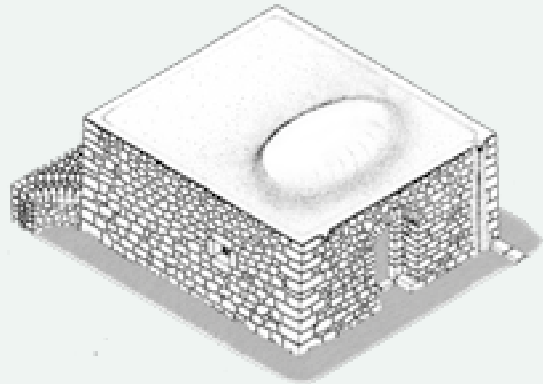
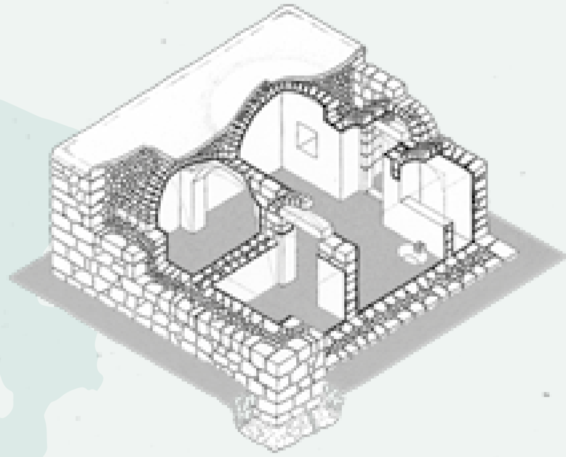
Pantelleria (from the Arabic *Bent-el Rhia*, Daughter of the Wind) is an island emerging in the Strait of Sicily, about 110 km from the Italian coast and 70 from Tunisia. The island has a semi-arid climate, with high temperatures (over the year the average temperature varies from 10°C to 26°C), and low levels of rainfall. As the origin of the name might suggest, the climate is dominated by strong winds.

The traditional buildings of the island, called *dammusi*, were first built in the 10th Century during Maghreb dominion, taking their name from the Arabic word *mdamnes*, which means 'to build a vaulted structure'. The building technique was born in a rural context as a temporary shelter for vineyard workers and it evolved as a response to the need for providing protection from the summer heat and the winds, as well as for collecting rain. Today this kind of building is diffused in urban and rural contexts and it is used as dwelling by the locals, as well as for providing accommodation for tourists. The volcanic stone walls, with a thickness varying between 80 and 200 cm, have a high thermal inertia, keeping the rooms cool in the summer and warm in the winter.

The characteristic roof of *dammuso* consists of a barrel vault, shaped to collect and canalize rainwater into underground cisterns, which are situated in close proximity to the building. The bearing structure of the vault is made of volcanic stone, walled with an earthen mortar (locally called *tajo*). The construction technique involves the use of a wooden centring for the positioning of the volcanic stones. Above the stone vault a layer of earth is applied to level the surface. The exterior layer is made with a mixture of lime, volcanic lapilli and red tuff (before putting the lapilli in place they are dipped into water and lime for 15 days), with a thickness of 7 cm, which after being beaten with wooden bats, decreases to 4 cm. The final cover has a total thickness of 30-40 cm. It is waterproof and it allows internal moisture to transpire outward.





Dammusi axonometric and cutaway views (elaborated by L. Dipasquale after M.P.Minardi).

General and detailed views of the buildings with *dammusi*, Pantelleria, Italy (photo: B. Bonanno).

ECOMUSEUM BOURRINE DU BOIS-JUQUAUD

SAINT-HILAIRE-DE-RIEZ, PAYS DE LA LOIRE, FRANCE

authors
Nuria Sánchez, Enrique Sevillano

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The *bourrine* is a traditional house typology from two North-West coastal regions of France: Brittany and Vendée. They are a real tribute to simplicity and sobriety, and an incredible lesson in economy, since they cover all the needs of its inhabitants despite an outstanding simplicity of means.

The roof structure was made out of wood from trees that come from a nearby forest (elms, willows or poplars). Since a forest was planted in the area in the second half of the 19th Century, pine trees also became available. Timber structure rested directly on the earth wall with no other reinforcing pieces apart from principal trusses and rafters, supported by wood pillars placed inside the wall. For these main pieces, builders normally used the most curved logs available as though they were pre-stressed beams which also helped clear the interior space.

In order to cover the roof structure, they placed bunches of reeds (taken from nearby marshes) beginning from the lowest part up to the very top, and tied them to the structure's battens. When the first row was set, they proceeded to cut all loose ends, giving it the characteristic bourrines' shape. Once the top of the roof was reached, they folded one side over the other, and set a layer of soil with a variety of cacti known as prickly pear, or *nopal*, planted to protect the roof from rain water leaks.

West elevations have an aerodynamic curve to avoid damages caused by the frequent strong winds coming from the nearby ocean, whereas east elevations are just flat.

→ Internal view of the timber structure of the *bourrine* (photo: E. Sevillano).

↓ Particular of the cover of the roof: bunches of reeds.
The *bourrine* (photo: N. Sánchez).

SARDINIAN VERNACULAR ROOFS

SARDINIA, ITALY

author
Leonardo G. F. Cannas

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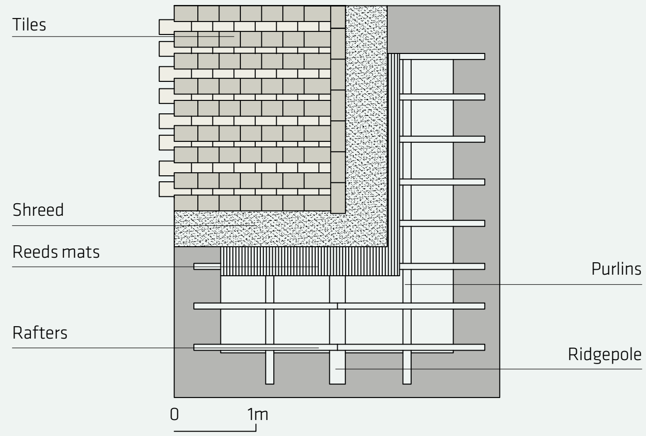
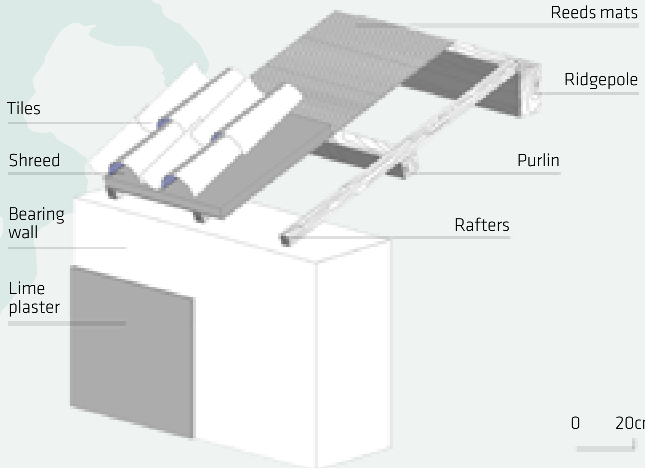
Sardinia is a Mediterranean island. In general terms, Sardinia presents very different geographic contexts and each one has its peculiar building cultures. According to the scientific literature (Baldacci, 1952) these were: the earthen courtyard house tradition in the plains devoted to agriculture, the compact multi-storey stone houses in mountainous areas devoted tosheep farming, stone row houses in the north, and other additional examples in dispersed settlements.

Despite such different building traditions, the same roofing building techniques were commonly adopted in the whole regional territory (Atzeni, 2009). Regardless of the geometry of the roof that could be single pitch, double pitch or hipped), the roof structure had a single or double timber roof framing. The former was made by a ridge-pole, spanning within load-bearing walls, which supported rafters. The latter had purlins in addition, parallel to the ridge-pole. In case of particular buildings, such as big warehouses, truss provided an intermediate support for the ridge-pole. Rafters were covered by reeds mats or planks of timber, due to the local availability of materials. The waterproof finishing was made of tiles. They were directly placed above reeds mats (or planks), or above a thin 4 cm earthen screed. This provided a better thermal insulation and air-tightness.

This roofing technology met the need of providing shelter for the inhabitants in a practical way. Sardinian vernacular roofs were adapted to local climatic conditions, were realized by assembling easily available local materials and were relatively easy to be built.





➔ Sardinian vernacular roof schematic plan and axonometry (drawings: L.G.F. Cannas, based on *Manuali del Recupero dei Centri Storici della Sardegna*).

↓ Sardinian vernacular roof with reeds mats finishing, Samassi (photo: Associazione Nazionale Città della Terra Cruda).

Juniper historical truss with unusual hollow flat tiles finishing, Cagliari (photo: L. G. F. Cannas).

Sardinian vernacular roof timber planks completion, Pabillonis (photo: Associazione Nazionale Città della Terra Cruda).

LE CLOS DES FÉES HOUSING PROJECT AT CONTEVILLE

UPPER-NORMANDY, FRANCE.

Architects: CoBe Architecte | Landscaping: Mutabilis

authors
Nuria Sánchez, Enrique Sevillano

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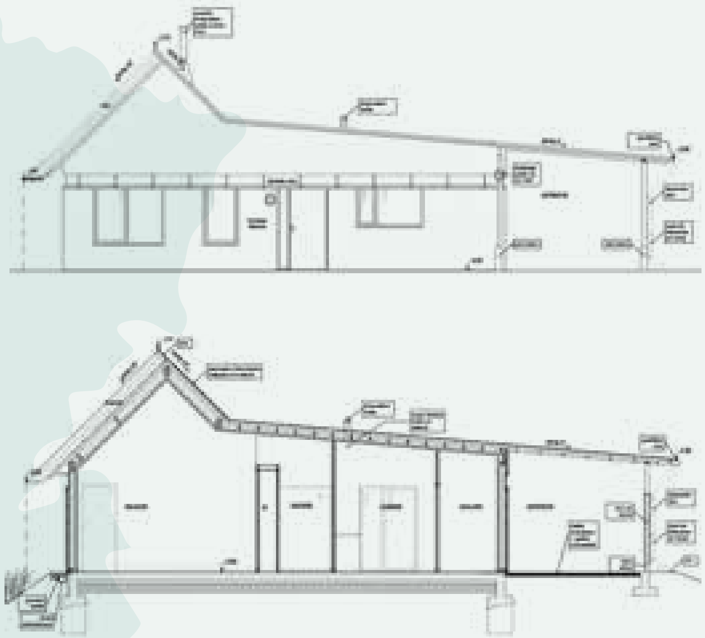
This is a housing project in Conteville, a village of about 500 inhabitants installed on top of a 70m cliff on the coast of Normandy.
The whole place is conceived as an eco-district. Apart from its eighteen houses, it has a community house, three workshops, two hostels and 2ha of landscaping work. All these facilities, together with the use of local materials, seek to attract the nearby population and promote the local economy.
These houses have been inspired on vernacular ones. They are oriented and shaped against the north wind. As in traditional local houses, their roofs are built with a timber structure and covered with local reeds. But here they use two different materials depending on which side of the slope they are located: thatched if they face north, because that is there where a higher capacity of thermal insulation is needed, while the side facing south is covered with zinc, a long lasting material that helps prevent premature wear and tear. This side is also provided with solar panels to heat water.
Rain water is collected from roofs and canalised around the plot in order to water the groves (used instead of walls) as well as three parks, which also serve the purpose of attracting people and raising awareness about environmental matters.
The use of vernacular techniques such as thatched roofs, helps reactivate a net of local artisans and entrepreneurs who can be active in a construction sector with a high ecological value.



Schematic cross section and West façade of the house. (drawings: L. Boegly)

Detailed view of the roof structure.
View of Le Clos des Fées village.
General view of the houses of Le Clos des Fées village.
(photos: L. Boegly)

In-between spaces in islamic cities, Medina of Larache, Morocco (photo: F. Vegas, C. Mileto).

In-between spaces, borderline places

Fernando Vegas, Camilla Mileto, Juan María Songel, Juan Fco. Noguera
Universitat Politècnica de València, Valencia, Spain

A filter space constitutes an architectural place resulting from a crossroads of ambivalent elements that can establish a relationship of reciprocity among themselves: a crossroads of ambiences (indoors/outdoors); spheres (private/public); functions (trade/dwelling, etc.); media (water/land, etc.); surroundings (artificial/natural), etc. Therefore they are not so much filter spaces arising only from requirements of shelter from the elements – a portico may be conceived merely to provide a private shelter and windbreak rather than for any other social reason – but in-between spaces that generate relationships, places for sociocultural exchange. Just as it occurs in nature, where life does not flourish as much in a homogeneous habitat as on the borderline between two different habitats, they are architectural sites with a great wealth of cultural and social activity, which often foster life and promote personal, familial, social and other relationships (fig. 1). Below follows a detailed description of some of the variants of these in-between spaces.

In-between spaces joining the public and private spheres

Unlike cities of other cultures where the threshold of a dwelling represents a drastic border between the public and the private space, an Islamic city is characterised by several transition levels between the public space proper and the strictly private space. It is an arboreal division between important thoroughfares and little *cul-de-sacs*, often with a progressive change of sections, scarcely wide enough for two people to pass. This maze of lanes gets narrower and narrower as they wind and wend from the broad public space towards the private, ending up in dead ends or private paths into the houses.

These are a series of filters, sudden bends, twists and porticoes that protect the sacredness of the house. Apart from the change in section, these successive stages of space are determined by frontiers that often go unnoticed by strangers but are crystal clear to their inhabitants. These filters successively protect the sacredness of the house with a broad range of resources: porches, thresholds, sheds, passageways, steps, stairs, changes of pavement, fences, pergolas, raised platforms, etc. The urban structure of the private and public poles involves a progressive separation of spaces, where there is no clear and immediate differentiation between public and private but an infinite range of possibilities. The Mediterranean cities that were under Islamic rule for a certain length of time often maintain in their layout some of these urban filters that create this transition sequence from the public to the private space, with in-between spaces full of local culture and rich in social relations (Vegas et al., 2013, pp. 92-97, 103).

In general, modern architecture has accentuated the division between the public and the private space in such a way that it has not fostered social relations and cultural and social exchange. There are very early exceptions, like the block of flats in the Spangen Quarter (1921) in Rotterdam by Michiel Brinkman (Sherwood, 1983, pp. 100-103), which managed to create several in-between degrees of privacy, social meeting places and relations between the public space in the street and the private space of the dwelling, with the filters of entrances, gardens, terrace-cum-corridors, etc. This line was followed by another Dutch architect, Aldo van Eyck (Van Eyck, 1962), who was especially interested in researching the in-between realms from many points of view and applied them in his buildings, such as the Amsterdam Municipal Orphanage (1960) (Van Eyck, et al., 1999, pp. 88-109). Finally, although it is a modest example of this kind of transition, it is worth mentioning some architectural mechanisms

Fig. 1 The historic centers of Mediterranean cities are filled with in-between spaces that appear as an outdoor extension of each dwelling where social relationships flourish. Chelva, Spain. (photo: F. Vegas, C. Mileto)

M. Correia, L. Dipasquale, S. Mecca (edited by), *VERSUS: Heritage for Tomorrow. Vernacular Knowledge for Sustainable Architecture*, ISBN (online) 978-88-6655-742-5, ISBN (print) 978-88-6655-741-8, CC BY-SA 4.0, 2014 Firenze University Press

Fig. 2 Street arcade of the historical center of Tarragona, with an open market sheltered on the ground level and dwellings over this busy trade. Tarragona, Spain (photo: F. Vegas, C. Mileto).

such as canopies, corbels or awnings used to create shade, which serve at the same time to delimit an area of influence or extension of the interior space to the exterior, an in-between space between the private space and the public one, especially in shops, businesses, cafés, etc.

In-between spaces with combined functions

As in the case of the Islamic cities mentioned above, many medieval cities in Europe were characterised by the cohabitation, coexistence or intermingling of different functions even in one building, starting with the dwelling, which often contained a craftsman's workshop on the ground floor and living quarters on the first floor, that is, work and residence in the same place, with no need to move. In fact, overlapping functions was one of their major features: medieval loggias along the Mediterranean had a portico on the ground floor for the local market and a representative space on the floor above; the streets with the arcade held an open market sheltered from the elements and the dwellings over this busy trade (fig. 2); the market squares were used for events, processions, executions, bull fights, etc. For example, in the Islamic world the mosque is a place of worship, but it also has the role of a public space, a centre for business, leisure, recreation for children, etc.

These features continued to exist in our cities up to a point until the end of the 19th Century. On the contrary, the *Modern Movement* insisted on separating functions both at the urban level, with strict divisions that forced people to move about a great deal, at the architectural level, separating the dwelling from the workplace, and at the functional level, avoiding the miscellaneous functions in the same buildings that had made life and work easier in the past. In fact, this is one of the main criticisms regarding the failure of the modern city, to the extent that contemporary urbanism has attempted to learn from the lessons of combining functions taught by the cities of the past and incorporate this knowledge in their new designs.

In-between spaces, a combination of media

These are characterised by the sharing of two different media, using one of them as a place of refuge or shelter and taking the opportunity of finding means of subsistence in both of them, often by means of the richness of flora and fauna typical of the borderline areas that exist in nature. Below we provide examples of in-between spaces that have stemmed from a combination of earth and water, earth and air, as well as water and air.

Combination of earth and water

These are constructions erected on small natural or artificial islands in rivers, lakes or tranquil lagoons, which fundamentally offer shelter and grant the opportunity to find food either in the liquid medium on which they stand or on land, never very far away (fig. 3). The reed houses built on islands of the same material by the Marsh Arabs in Iraq (Esteva, 2006), deserve special mention, as well as the floating *totora* reed dwellings built by the Uros people on Lake Titicaca in Peru (May, 2010, pp. 36, 148-149) (fig. 4).

The houses of the Caboclos along the Amazon River are also extraordinary, built of timber on floating logs and anchored with a rope and a large stone to the bottom of the river, which allows them to withstand the fluctuations of the river water and even move their houses easily from their original positions, giving rise to an interesting changing urbanism. It was precisely the fluctuations of several metres in the Amazon River that brought about the floating docks in Manaus, Santarem and other smaller towns, which allowed boats to be berthed whatever height the waters had reached at a given time of the year.

The presence of lagoons, canals or watercourses generates at times not so much settlements on the water as floating markets, which are found in many parts of the world, but especially in Southeast Asia. This is the case of the markets at Srinagar (India), Damnoen

Fig. 3 House in the lagoon of Valencia, sharing two medias: earth and water, Spain (photo: F. Vegas, C. Mileto).

Fig. 4 Floating totora reed dwelling of the Uros people on Lake Titicaca (photo: F. Vegas, C. Mileto)

Saduak in Bangkok and Amphawa on the Tha Chin River (Thailand), Cai Rang, Can Tho, and others, in the Mekong Delta (Vietnam), etc.

Other aquatic towns that grew up and became consolidated over the years are, above all, Venice and, to a certain extent, Amsterdam, Hamburg, Stockholm and even Milan, although its *navigli* were largely buried from the late 19th Century onwards. In Venice, planning was developed based upon the presence of water as the major means of transport, giving access to ground floor warehouses through porticoes, respecting a way out to the canals from the typical courtyards, (Mileto, at al., 2010, pp. 349-356), etc.

Modern architecture has not created many in-between spaces between land and water, but it has frequently had recourse to the metaphor of the transatlantic schooner for the design of a new architecture. Le Corbusier's reference to the schooner for modern architecture is well-known (Corbusier, 1923).

Less well-known is the reference the architect Frank Lloyd Wright made the same year to explain the design of the Imperial Hotel in Tokyo (Wright, 1923, p. 41, and 1925, pp. 134-139). Outside these poetic references, we can mention the utopian projects for the construction of dwellings in Tokyo Bay by members of the Japanese Metabolism Movement in the Fifties and Sixties; Aldo Rossi's floating Teatro del Mondo (1979) on the lagoon in Venice as a linguistic experiment (Braghieri, 1993, pp. 108-113); the restoration of old 'aquatic' cities like Speicherstadt (1895) in Hamburg with the incorporation of new buildings at water level, like the new Philharmonic Hall (2003-17) by Herzog and De Meuron; or the creation of great infrastructures on landfills, such as Kansai International Airport.

Combination of earth and air

Building a dwelling raised above ground level has always been a strategy for protection and defence and, at the same time, a way of escaping from the damp and from attacks by rodents and other vermin. Among the most extreme cases are tree houses, which were common in many parts of the world in the past, even in forest areas of Central Europe or the British Isles, mainly as a means of camouflage and defence. Today we can find isolated examples of this type in the North of India, Equatorial Africa and South America. Some of the most outstanding are the tree houses of the Korowai (May, 2010, pp. 160-161) and Kombai tribes deep in the jungle of West Papua (Indonesia). These houses are built around a tree on stilts or struts that can be up to 50 metres high, with a floor made of branches, walls of bark and roofs of leaves. Similar slightly less extreme examples can be found in Papua New Guinea.

Aerial houses built on pillars are among the most common and widespread of these, often used as granaries to store cereal and other foodstuffs safe from dampness and animals (fig. 5). In 1918, the Polish anthropologist Eugeniusz Frankowsky (Frankowski, E., 1986) recorded the use of this type of granary to conserve cereal in the north of the Iberian Peninsula, the Scandinavian Peninsula, the Alps region, the Balkans, Sub-Saharan Africa, Japan, the Kamchatka Peninsula and some areas of the Bering Strait. In some of these places, these aerial constructions were also used as dwellings, especially in South East Asia (the Torajans' *tongkonan*), or even as religious temples housing sacred relics (the Ise Shrine in Japan) (Vegas et al., 2003, pp. 14-41).

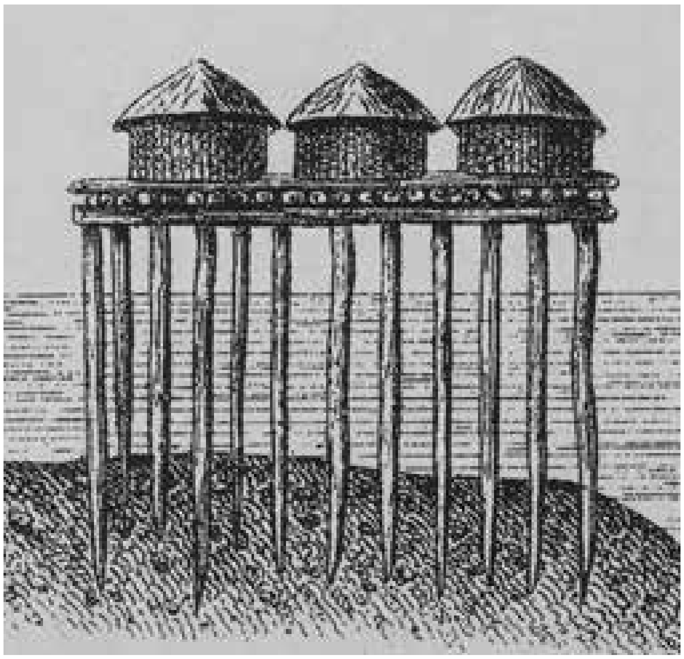


Fig. 5 Granaries on stilts in Asturias, sharing two media: earth and air. Asturias, Spain (photo: F. Vegas, C. Mileto).

Fig. 6 Reconstruction of prehistoric houses on stilts in the lakes of Switzerland (Troyon, F. 1860), just after the discovery of the first palafittes in the country in 1854, a type of dwelling that seems to have had an enormous influence in Le Corbusier's architecture on pilotis.

Fig. 7 The Ponte Vecchio with its dwellings on top of it, another clear case of architecture built between earth and water. Florence, Italy (photo: M. Giuliotti).

Fig. 8 In-between places belong to both private and public spaces. A balcony in Bordeaux, France (photo: F. Vegas, C. Mileto).

Houses built on pilotis, forming part of their surroundings but, at the same time, standing out from it, were very popular in the Modern Movement, especially based on Le Corbusier's theories and certain paradigmatic examples like Villa Savoye in Poissy (France, 1929), by the same architect, or in a version with shorter pilotis, Farnsworth House (1951) in Plano (Illinois, USA), by Mies van der Rohe.

Combination of water and/air

Palafittes are constructions erected on posts or pilotis driven into the bed of lakes, lagoons, tranquil river mouths or even on the sea shore. The main reason for building palafittes or stilt houses is believed to have been to protect or defend their dwellers from potential enemies or predators, as well as for the supply of water and game, fish and foodstuffs in general provided by the aquatic milieu they were built on. This type of dwelling can still be found, sometimes even by the thousands, such as in Ganvié village on Lake Nokoue (Benin); in several towns on Lake Inle (Burma); Siem Reap on Lake Tonlé Sap (Cambodia); Amarales on the Pacific Coast or Nueva Venecia on the Ciénaga Grande de Santa Marta (Colombia), among other villages in this country; in the Chiloé Province (Chile); in the Belén de Iquitos district (Peru); on Lake Maracaibo, Sinamaica Lagoon and the delta of the Orinoco River (Venezuela); on Chacahua Lake (Mexico); Kampung (Brunei); etc. This type of dwelling was very common in primitive Europe (fig. 6), as attested by archaeological traces found in Germany (Unteruhldingen), Poland (Biskupin), Switzerland (the lagoons of Neuchâtel and Zurich, Laténium, Gletterens, Wauwil), Slovenia (Iscika), palafittes in France, Lithuania and Latvia and *crannoges* in Scotland, Wales and Ireland, usually located near lakes or wetlands. Over a thousand of this kind of lake villages are known to have existed in the Alpine region. Furthermore, palafittes built on an interesting network of canals were recently discovered at the mouth of the Sarno River, near the port of Pompeii. Some palafittes still exist on the sea shore of Nisyros Island (Greece) (Vegas López-Manzanares, 1999, pp.89-96) or on Arcachon Lagoon (France), among other isolated examples. Finally, it is interesting to mention, regarding this in-between habitat between the air and the water, the widespread ancient custom of erecting dwellings and shops on urban bridges, examples of which that have survived until the present day are the Ponte Vecchio in Florence and Ponte Rialto in Venice (fig. 7).

It is interesting to note the possible relationship between the discovery of the prehistoric palafittes in Switzerland after 1854 and the identifying character of this type of structure in the formation of the Swiss nation (Vogt, 1998; Troyon, 1860), in Le Corbusier's architecture on pilotis (he also spoke in his notebooks about the *crannoges* in Ireland and, when he was young, he used to spend his summers on Arcachon Lagoon). One of the last of Le Corbusier's great projects was precisely a palafitte hospital for the Venice Lagoon which reflected many of his ideas about the matter although, illuminated as it was by skylights, it lacked a link with the surrounding lagoon which could have been enhanced with in-between spaces (Vogt, 1998, pp. 329-331; Farinati, 1999; Dubbini et al. 1999). Other examples of contemporary palafittes are the Nordic Watercolour Museum in Skärhamn (Sweden, 2000) by Niels Bruun and Henrik Corfitsen; *La Balla* in Genoa (Italy, 2001) by Renzo Piano; the camping site of La Torerera in Calañas (Spain, 2001) by Ubaldo García Torrente; the Octospider in Bangkok (Thailand, 2003) by Exposure Architects, which is in itself a reinterpretation of the local palafittes (Bahamón et al. 2009), etc.

In-between spaces combining interior and exterior

An in-between space or a place located on the borderline between indoors and outdoors. It occurs when the threshold of the building expands and stretches, becoming large enough to create an ambit that can hold life. It is a place that is partially exposed to the open air and partially sheltered by the building. Historically, it has taken the shape of courtyards, porches, porticoes, terraces, pergolas, etc.

Private spaces looking on to the public space: This is the typical case of bay windows, balconies, half or full railings, terraces, porches, raised platforms, etc., that is, elements either cantilevered or annexed to the building in an attempt to form part of the world outside. They may or may not have roofs. They have myriad functions and interpretations: their existence is associated with a need to illuminate and ventilate the building; they allow to see out from the inside and only partially to see in from the outside; they foster social relations in the neighbourhood, allowing the residents to establish a dialogue with the exterior, etc. (Privitera, 2011) (fig. 8).

Modern architecture has not been too lavish in the use of balconies,

Fig. 9 The *toguna* of the Dogon people are public buildings built on pillars. Mali (photo: F. Vegas, C. Mileto).

whereas it has resorted to terraces and flat roofs as a compositional element and a place to sunbathe and breathe fresh air. Suffice it to recall the fifth of Le Corbusier's points for a new architecture (1926) (Boesiger, 1991, p. 30), which recommended the incorporation of gardened terraces as a means of returning to nature the surface occupied by the building in the form of a roof garden. Another person who included a large number of terraces in his dwellings, hospitals and public buildings, in spite of the harsh Nordic weather, was the Finnish architect Alvar Aalto (Schildt, 1996; Sherwood, 1983, pp. 108-111).

Public buildings with protection: These are pergolas, arbours, pavilions or public kiosks, awnings, etc., that is, light open-roofed buildings or structures located in public spaces. There are infinite examples of this type of construction, especially in warm climates: sheds on pilotis with vegetable roofs, common in the Pacific, India and South East Asia, the post-and-beam structures of the Pueblo Indians, the *toguna* of the Dogon people (fig. 9), the pergolas and canopies of Mediterranean plazas and streets or the impressive *shabono* of the Yanomami tribe, a communal circular pergola built on logs and covered with palm leaves (May, 2010, pp. 30, 144-145).

In modern architecture, after preliminary experiments and tests with light protection made basically for the roofs of railway station platforms, *porte-cochères* and canopies leading into buildings, examples were created like the Swiss Pavilion for the City University of Paris (1933) by Le Corbusier, standing on pilotis, which becomes a pergola leading into the entrance hall located in an auxiliary building; or Villa Shodan by the same architect in Ahmedabad (1956); the Palace of Justice in Chandigarh (1952) (fig. 10), both in India, and the Heide Weber Pavilion in Zurich (1965), large parasols underneath which the buildings proper emerge; or the canopy in the project for the Japanese pavilion in Auroville (1968) by Antonin Raymond, as a reference to the curved roofs of Japanese architecture.

Dynamic pergolas to protect passers-by from the sun, rain, hail or snow have also been a recurrent element in university campuses, as in Nanzan University (1964) by Antonin Raymond or the University of Alcalá de Henares (2000) by Eladio Dieste; as well as in walkways such as the pergolas of the Parc de Diagonal Mar (2001) by Enric Miralles. The architecture of the last few decades has often used this sort of static pergola over public spaces as a compositional device, especially in hot climates like Spain. Thus we can cite the canopies over the Plaza de los Países Catalanes (1983) by Albert Viaplana and Helio Piñon, the photovoltaic pergola of the Barcelona Forum (2004), by Elías Torres and José Antonio Martínez La Peña, or the structure of the Metropol Parasol in Seville (2011) by Jürgen Mayer.

Fig. 10 The Palace of Justice in Chandigahr (1952), designed by Le Corbusier as a big parasol underneath which the building proper emerge. India.

Fig. 11 A portico represents an act of generosity towards the city, since the building grants part of its private lot for public use. Street arcade in Montréal, Aude, France.

Fig. 12 A private space with protection, annexed to the dwelling so that it prolongs the protection afforded by the roof of the house, offers a very comfortable relief from the heat. Shed in Lanzarote island.

(photos: F. Vegas, C. Mileto)

Public spaces underneath private spaces: This refers fundamentally to porticoes, colonnades, work loggias or, less frequently, buildings erected on pilotis so that the ground floor can be used. Public porticoes in the street with dwellings built over them are common not only mild climates, but also in cold and snowy weathers allowing people to walk protected from the inclemencies of the elements (fig. 11). In modern architecture, among other architects who worked on this type of elements, the Italian architect Aldo Rossi theorised about the reinterpretation of the historic city for the design of contemporary architecture and this attitude led him to the abstract reproduction of various elements typical of traditional architecture, which included porticoes of columns or screens, usually linked to passages underneath buildings, which he used repeatedly throughout his professional career, regardless of the metaphysical or impersonal character of his spaces, which did not always favour human habitation (Braghieri, 1993).

Private spaces with protection: These are usually elements annexed to the dwelling that prolong the protection afforded by the roof, such as large eaves, porches, pergolas, arbours, or half-open work sheds. It is the case, for example, of the *barchesse* of the Veneto villas (Mileto 2002, pp. 5-33; Mileto 2008, pp. 169-195) (fig. 12). These in-between spaces can be found in many sorts of dwelling, both in warm and cool climates, although they are more common in places with very hot, sunny summers. In this way, they are frequently found in Mediterranean (Couceiro Núñez, 2001) and tropical (De Oliveira Pereira, 2012) climates, but also in climates with extremely harsh winters and summers, such as the East Coast of the United States or Japan (Nishi et al., 1996). The enrichment of the relationship with the exterior is guaranteed by the presence of these elements, but this exterior is in many cases a private garden or yard surrounded by a fence or a hedge. In contemporary architecture, apart from innumerable examples that have applied the strategy of historic houses to modern ones, there is one that deserves special mention: the skyscraper of the Commerzbank Headquarters in Frankfurt (1997), designed by Norman Foster, which alternates large terraces laid out in a spiral, exposed to the elements, but protected by the floors above, as a system of introducing nature into the building and, at the same time, guaranteeing cross ventilation in the central courtyard.

Fig. 13 The *caranvaserai* is a communal patio for work, storage and living, both exterior and somehow interior to the building. Corral del Carbón, Spain (photo: F. Vegas, C. Mileto).

Private spaces with no protection: These are spaces located outdoors but next or close to indoor spaces. This is the case of inner patios in houses, gardens or around the outer walls. The tradition of the patio dates back to the distant past, with Greek or Roman houses as prime examples, although they are by no means the oldest. Patios have been useful in many of these buildings not only to provide light and ventilation, but as an element articulating communication and life within the house, as is the case of *corralas* or *caravanserais* with corridors around them (fig. 13), or the courtyards of the Crown of Aragón which at a time were found all over the Mediterranean basin.

In colder climates, this concept of an inner courtyard with several independent buildings around it was less common, but we can find the *corte* in the North of Italy, the yard in England, the *piha* in Finland, etc., which were in-between open-air spaces for meetings, work and social relationships. These unusual courtyards surrounded by independent constructions may have a protective fence around them, depending on the culture and the circumstances.

Theoretical overview of in-between interior-exterior spaces in the last 50 years

Since the mid 20th Century, there have been many architect theoreticians who defended the in-between space in architecture as an essential factor to enhance the project with a view to creating not so much 'spaces', but inhabitable 'places' conceived according to the most human needs.

Many of them belonged to the European Team 10 or the group of Japanese architects in the 'Metabolism Movement'. One of these was the above mentioned Aldo van Eyck, (Lammers, 2012; Farhadyet al. 2009, pp. 17-23) who borrowed from Martin Buber (*das Reich des Zwischen*) (Buber, 1943) the philosophical approach to the in-between realm as a manifestation of coexistence, a twin phenomena (Van Eyck 1962, pp. 58-63) that he converted into architectural terms, making it one of the major points of reference of his thinking and oeuvre; another was the also Dutch architect, Herman Hertzberger (Hertzberger 1991, pp. 32-39 and 176-189), who uses the term *threshold*, for an 'in-between' place or for the 'inhabitable space be-

Fig. 14 These pavilions represent a sort of outdoor room after Christopher Alexander, i.e., a space that is open and closed at the same time, where people behave as though they were indoors although they are outdoors. Bikaner, India (photo: F. Vegas, C. Mileto).

tween things' in order to analyse more deeply transition spaces as territories with different uses; Louis Kahn (Wurman 1986, p. 210), who theorises about the relationship and communicative potential between interior and exterior; Yoshinobu Ashihara, who proposes the existence of two spaces: the *N-space* (negative or content) and the *P-space* (positive or 'form') and immediately goes on to define the *PN-space* or spaces where architecture is capable of permeating the exterior space or vice versa (Ashihara, 1981); Arata Isozaki sees the in-between space as an interval in time and space that evokes the Buddhist concept of *ma* (Isozaki, 2006, p.95); or Kisho Kurokawa works on the concept of symbiosis applied in general to architecture and in particular to the symbiosis between the interior and exterior spaces (Kurokawa, 1988, and 1987). Other architects, like the Spaniards José Antonio Coderch or Alejandro de la Sota, fashioned these spaces as interstices, according to Andrés Martínez (Martínez, 2011).

From a theoretical point of view, Christopher Alexander also addressed what he called 'outdoor rooms', that is, spaces that were open and closed at the same time, where people behave as though they were indoors although they enjoy the additional advantage of wind, smells, sunshine and 'the rustling of leaves' (fig. 14). In his case, these 'outdoor rooms' must not be confused, for example, with an open-air garden, but must have some sort of roof: "a garden is a place for lying on the grass, having a swing [...], planting flowers, throwing your dog a ball [...], but there is another way of being outdoors, and a garden does not satisfy that need in the least" (Alexander et al. 1980, pp. 671-674).

For his part, Bernard Rudofsky calls them 'decorated outdoor rooms' (Rudofsky, 1955, pp. 157-159) and does not necessarily associate them as Alexander does to the existence of a roof but to the habitability and privacy of the space as a continuation of the house, even when they are completely in the open air (fig. 15).

In a similar way, Pere Fuertes and Xavier Monteys (Fuertes et al., 2001, p. 134) have recently defended afresh the concept of outdoor room, as an idea to humanise, enhance and vitalise the urban sphere.

Fig. 15 This patio may represent what Bernard Rudofsky meant by decorated outer room, not necessarily a covered space but an inhabitable and private exterior space, conceived as a continuation of the house. Cordoba, Spain (photo: F. Vegas).

Fig. 16 Historic centers have outdoors spaces conceived and designed as in-between space between houses, conferring the urban space with a extraordinary quality of living standard. A village street in Alicante, Valencia, Spain (photo: F. Vegas, C. Mileto).

The in-between space, a catalyst of sustainability in architecture

Fascination for these in-between spaces, half-way between indoors and outdoors, has marked all the history of architecture in the work of some architects who have used this ambiguity as a compositional device, creating indoor spaces that look like outdoor ones and vice versa. We can cite the staircase at the entrance to the Laurentian Library (1527) by Michelangelo Buonarroti, which is conceived as though it were an outdoor space with its urban façades. Architects like John Soane not only used natural light in vaulted spaces as a device to project outdoor spaces onto indoor rooms, but even designed their own houses as an urban landscape with multiple crossed views (Montaner, 1997, p. 29) The use of courtyards and skylights in indoor spaces conceived as outdoors and vice versa is a recurrent resource in Alvar Aalto's early work (Paavilainen 1990, pp. 7-53; Noguera Giménez et al. 1997, pp. 30-31) or even in the buildings of his master Gunnar Asplund (López-Peláez 2002, p. 137), fascinated as they both were by outdoor life in Mediterranean climates.

In his writings, Aldo van Eyck argues that indoors and outdoors are not extreme polarities but ambivalent realities that form twin phenomena, and that they are perfectly reconcilable. In the same way as the nature of man fluctuates between the need for protection and the desire for freedom, it is necessary to achieve coherence in the articulation of the parts of a building by means of psychological transition spaces, thresholds, spaces for meeting and socialising, more or less open or private. These in-between spaces represent the real luxuriance of architecture (Van Eyck 1960, pp. 107-121).

Furthermore, if we were capable of changing the scale of work and designing the urban space not so much as an outdoor space but as an in-between space between houses, as often happens in the best-conserved historic centres (fig. 16), or, what amounts to the same thing, conceiving at the same time house-like cities and city-like houses, with their respective abundance of in-between spaces, the urban environment would acquire an extraordinary quality of life. And the fact is, as we pointed out at the beginning of the text, as it is with nature, life and sociocultural relationships seem to prefer, flourish and prosper in these in-between spaces, which become a meeting point either because they provide human warmth and shelter, or because of their bioclimatic and environmental virtues, or else due to their privileged position between several milieus, or the flexibility of their uses and functions. Even so, the architecture of the last hundred years has often lost sight of these lessons in sustainability. Opposed to the unidirectional determinism of exclusionary options ('either this or that') and to the diametrically opposite alternatives typical of an important sector of contemporary architecture, the spatial richness in inclusionary options ('this and that') and this range of greys or spectrum of in-between options of vernacular architecture should pave the way to a more articulated contemporary architecture, richer in content and, in a word, more sustainable.

PORTICOS
MEDITERRANEAN REGION

authors
Fernando Vegas, Camilla Mileto

ENVIRONMENTAL PRINCIPLES

to respect environmental context and landscape · to benefit of natural and climatic resources · to reduce pollution and waste materials · to contribute to human health and welfare · to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

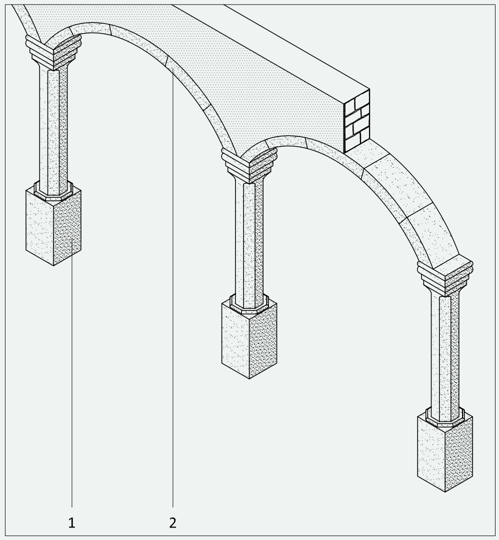
to protect the cultural landscape · to transfer construction cultures · to enhance innovative and creative solutions · to recognise intangible values · to encourage social cohesion

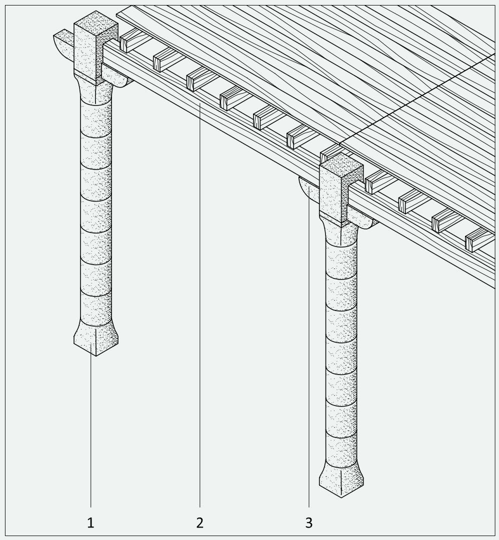
SOCIO-ECONOMIC PRINCIPLES

to support autonomy · to promote local activities · to optimise construction efforts · to extend building's lifetime · to save resources

A portico is a covered walkway enclosed by a line of arches or linteled openings supported by columns or piers on one side that provide shelter for pedestrians from the inclemencies of the weather. A portico is an act of generosity towards the city, since the building grants part of its private site for public use. They are common above all in mild climates, like the Mediterranean basin, but they also exist in cold Alpine climes, such as in mountain towns or in more important cities like Berne, the capital of Switzerland, where they allow people to walk along without stepping in the snow, which is at a lower level because the porticoes have a raised plinth with steps leading up to it. Bologna in Italy is said to have over 45 km of streets with porticos.

Covered walkways or porticoes were widely used in Ancient Greece were they were called stoae. Since then, they have been used during history in many cultures of the world in many places of the city, but especially surrounding marketplaces, serving like a kind of fixed built awning for merchants, protecting them from the sun and the rain. Porticoes share certain similar features and functions with the arcades of religious cloisters and the patios of mosques. Furthermore, some porticos at the entrance of European churches had some civil functions as well, especially as a place for citizens to meet. 20th Century architecture, particularly post-modern buildings but not only, have also made a wide use of this type of porticoes, built with modern shapes, materials and techniques.





➔ Type of portico with arches; type of portico with lintel (drawings: F. Vegas, C. Mileto).

↓ Street with portico at Gordes, France; street with portico at Menorca, Spain; Villa Giusti Bianchini, Veneto, Italy. (photos: F. Vegas, C. Mileto).

THE CITY OF VENICE

VENETO, ITALY

authors
Fernando Vegas, Camilla Mileto

ENVIRONMENTAL PRINCIPLES

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The city of Venice owes a great deal of its charm to the extraordinary richness of in-between realms with binomials such as water/earth (the city itself with its buildings), water/air (the bridges), earth/air (the porticoed market and the many arcades and stilted terraces, called *altane*), indoors/outdoors (porches, porticoes, patios, terraces, etc.), private/public (different steps of privacy involved in the name of the streets like *campo, campiello, calle, calletta, ruga, ramo, corte*, etc.), trade/dwelling (trade shops, workshops, *cantine*, etc.), artificial/natural (lagoon, canals, park, gardens, etc.) and many hybrid and intermediate degrees between all of them.

Venice is not the only aquatic town, but it is probably the best conserved in its urban design and configuration. In Venice planning was developed considering the presence of water as the major means of transportation, giving access to ground floor warehouses through porticoes, respecting a way out to the canals through the typical routes, etc. There are many bridges spread all throughout the city that cross the sky covering the water gap between built grounds, and one of them, Rialto bridge, even has shops built on it, showing an in-between habitat between the air and the water.

Furthermore, the maze of walking streets incorporates subtle codes that progressively filter from the open public space to the most private one. This richness of variations between public and private spaces that may arrive in some cases to the meeting of four different intermediate spaces at once, does not only belong to Venice, since there are many other traditional cities that can boast of this richness (as is the case with many Islamic cities, for example), but it has certainly been very well preserved in this city.

↑ Semi-open stairway, Palace Contarini del Bovolo.

↓ Grand Canale with Rialto bridge on the back, Venice; typical inner private courtyard Venice; typical semiprivate corte at Venice.

(photos: F. Vegas, C. Mileto)

INDIAN INSTITUTE OF MANAGEMENT

AHMEDABAD, INDIA.

Architect: Louis I. Kahn

authors
Fernando Vegas, Camilla Mileto

ENVIRONMENTAL PRINCIPLES

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In modern architecture, Louis Kahn (May, 2010) created interesting in-between spaces in many of his projects. This architect considered that walls were made of two layers, an inner and an outer one, with an in-between space of variable thickness that acted as insulation, if it was not very thick, or as a semi-exterior space if it was. This space was illuminated by bays opened in the inner layer combined with bays opened either above or opposite the opening in the inner layer. This double wall was very useful in letting air circulate and protecting from light and high temperatures, especially in the buildings he erected in India and Bangladesh. Furthermore, Louis Kahn (Wurman, 1986) theorised about the relationship and communicative potential between interior and exterior spaces and worked on the concept of layered exterior walls that served not only to wrap the buildings with 'thick' exterior façades but also to accommodate service elements or window seats for the interior rooms as well as to modulate the sunlight within this folded depth of the walls. He was in touch with Aldo van Eyck and other architects of Team 10 since their first meeting in 1959, when he was invited to lecture, so he was quite aware of the concepts of 'threshold' and 'in-between realm' that were being developed by the Dutch architects of that group. In the Indian Institute of Management in Ahmedabad (India), as in many other buildings, and especially in hot climates, he enriched his project with many in-between spaces, mainly in the shape of corridors, arcades, porticoes and double-height spaces.

→ View of semi-open staircases of Indian The Institute of Management building.

↓ Various views from in-between spaces from Indian The Institute of Management building.
(photos: F. Vegas, C. Mileto)

Natural air conditioning design

Pool and Wind Tower, Borujerdi House, Kashan, Iran (photo: J. Maudlin).

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Natural air conditioning design is a sustainable strategy to meet the need of ensuring indoor environmental quality, by helping to establish indoor temperatures and humidity levels within acceptable values and guaranteeing an adequate natural ventilation flow rate.
The adjective 'natural' is to indicate that, according to the holistic perspective of sustainability, having indoor environmental quality conditions must necessarily be accomplished through passive strategies, so as to minimize the contribution of machines powered by pollutant sources. In this way the three sustainable pillars will be simultaneously met: the social, by promoting the well-being and the satisfaction of basic needs; the environmental, by preserving the biological quality; the economic, through the exploitation of natural, free and renewable resources.
Natural air conditioning design can be metaphorically defined as a dialogue: between human living and comfort needs, on the one side, and the natural climatic constrains on the other. The natural conditioned (or free running) building is the mediator who tries to reconcile the positions of the contenders.

Design architecture with natural air conditioning solution

Designing natural air conditioning means making choices about specific design variables on which the activation of the passive mechanisms that guarantee the comfort status regarding climatic conditions depend. According to scientific literature (Givoni, 1976; Szokolay, 2006; Wienke, 2008), these passive mechanisms are:

- *Building envelope / Control of environmental heat transfer*: to optimize building heat gain and loss through the building envelope.
- *Sun control*: to determine when to permit the penetration of solar radiation, to meet the heating needs, and when to prevent it, to avoid overheating in the warmest seasons.
- *Natural ventilation:* to control and promote the intake of external air without using mechanical ventilation, it has the threefold purpose of:
  1. maintaining the air healthiness (pollution, relative humidity);
  2. refreshing air and removing heat from building structures (night ventilation in the warmest seasons);
  3. enhancing thermal comfort by providing perceptible air movement (Royal Institute of British Architects, 2010).
- *Moisture control*: to prevent condensation and other phenomena of discomfort by decreasing the moisture content in confined environments, increasing the rate of moisture evaporation in hot-dry climates improves the thermal comfort sensation and the air healthiness.

Bellow are some of the design variables that influence the above mentioned passive mechanisms:

- *Building site*: the building's surroundings affect the passive mechanisms in many ways. Among those the most significant are protecting from or exposing to the prevailing winds, shadowing, or increasing relative humidity (Consortium RehabiMed, 2007) (fig. 1).
- *Building shape and orientation*: this is the external surface/volume enclosed ratio of the building envelope, also known as index of compactness, and the prevailing orientation and length in plant of the building sides in respect to the sun's motion; both these variables affect the intensity of the heat transfers between building and environment (fig. 2) (Grosso, 2005; Szokolay, 2006; Wienke, 2008).
- *Envelope materials and colours:* this refers to the thermal properties of the building's envelope in terms of thermal insulation and thermal inertia (Consortium RehabiMed, 2007; Grosso, 2005; Oliver, 2003; Szokolay, 2006). The thermal properties of the building's envelope are also determined by its finishing color, which has specific properties of absorption or reflectance of the solar heat (fig. 3) (Oliver, 2003; Szokolay, 2006).
- *Internal organization and functional distributions:* these variables regard awareness of the relationship between level and type of occupancy of a space and its geometrical characteristics, such as size and orientation (Grosso, 2005; Wienke, 2008).
  North exposed rooms are always colder than south exposed ones and east or west exposed rooms are lit and heated by the sun in particular moments of the day (Wienke, 2008).
  Orientation of rooms also determines the exposition to prevailing winds, which means activation of natural ventilation (Grosso, 2008; Royal Institute of British Architects, 2010) or thermal loss. The internal subdivision affects the ventilation, too, with respect to the greater or lesser number of obstacles encountered by the air flow passage, (Grosso, 2008; Royal Institute of British Architects, 2010).

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- *Openings*: openings are the most sensitive building elements in terms of heat transfer, both due to the low insulation capability of windows and the air input (Grosso, 2005). They guarantee the maximum exploitation of solar heat gains, (Wienke, 2008), and they also determine the activation of a natural ventilation mechanism (Grosso, 2008).
- *Special architectural elements:* architectural elements that are designed to provide bio-climatic contributions in addition to the strategies that can be adopted by the basic design variables of a building.
- In this category are listed: shadowing systems (porches, blinds, greenery, hit and miss brickwork), semi-open spaces to allow outdoor living in mild climates (courtyards, porches, galleries) wind-catcher and moisture control systems for hot arid climates (Iranian *malqaf*, greenery, ponds, fountains) and many others (Consortium RehabiMed, 2007; Fathy, 1986; Oliver, 2003) (fig. 6, 7, 8).

Climate characters and urban morphology in the Mediterranean region

By studying the Mediterranean vernacular settlements we find ourselves confronted with an extraordinary amount of lessons on the theme of living in harmonious balance with nature. The 'traditional knowledge system' (Laureano, 1995), which is a large amount of knowledge accumulated in time by the Mediterraneans through expertise, was subjected to continuous improvements and enhancements, with the purpose of trying to make the most of the weather conditions and the natural elements, if possible to turn them to their advantage, even where these conditions seemed to be extremely hostile, as in the case of deserts. Studying the Mediterranean vernacular settlements and discovering both how to face and how to stay in balance with the natural environment (natural form, climate, terrain) is a first step towards the resumption of the old continuity. Mediterranean regions, in relation to W. Koppen's classification of climatic zones (Olgyay & Olgyay, 1963) include both areas with mild climate and areas with warm-dry climate. Studies carried out in relation to different climatic zones (Dolllfus, 1954) indicate that environmental issues are more characteristic than those given by the geographic region. This assumption defines an overriding importance of the relationship between built form and climatic instances. Let's consider for example the roofs of buildings, as they are charac-

Fig. 1 Below slope houses in Setenil de las Bodegas, Spain (photo: L. G. F. Cannas).

Fig. 2 Courtyard houses oriented toward South, Quartu S.Elena, Sardinia, Italy (photo: A. Sanna).

Fig. 3 Bright buildings envelope colors in Procida, Italy (photo: M. Achenza).

Fig. 4 Below ground warehouse, Ischia, Italy (photo: M. Achenza).

Fig. 5 Different openings distribution regarding different oriented façades, San Gavino, Sardinia, Italy (photo: Ass. Naz. Città della Terra Cruda).

Fig.6 South side porch as sun control system in a courtyard house in Samassi, Sardinia, Italy (photo: Ass. Naz. Città della Terra Cruda).

terized in different climatic areas rather than in regional identities. Since belonging to a particular climate zone necessarily involves the assumption of identifying characteristics in the construction of the shape, it is interesting to note that in the two Mediterranean climatic zones the shape and type of the settlements arise in connection to the sun-wind relation, particularly in two urban structures: the compact city in hot-arid regions and the city of Hippodamian derivation in mild climatic zones.

In hot arid climates, such as the Mediterranean regions of North Africa, the Sahara desert oases in Egyptian, Libyan, but also Moroccan territories, settlements take a compact form. It is a city-building that takes advantage of the volume effect to mitigate high temperatures, that is able to interact with a climate characterized by a fairly long hyper-heated yearly period, with dry air and severe daily heat excursion. The use of water in public and private spaces is important for the effects of evaporation, which mitigates the very high temperatures. In these regions, houses tend to have a cubic shape, high thermal inertia and heavy building materials. The patio type is the most suitable for this climate, the courts are in fact reserves of fresh air, where cooling wells and gardens serve as the lungs of urban life. The walls of the introverted houses provide shade to the living spaces and to the narrow, winding and sometimes covered roads. The covered road is an important urban design element as it responds to the need to avoid glare and provide shaded and cool breaks around the village. Covering the roads also favors the creation of zones of low and high pressure that give rise to air motions triggering the Venturi effect.

The need of fresh air governs the plan of the city in places such as Marrakesh, Tunis, Damascus, where the narrow winding streets assume the same function as the courts, retaining all possible breaths of fresh air that settle during the night, in the same way as it happens in chessboard cities with wide boulevards (Fathy, 1986). While this first type of urban structure is completely adherent to the character of hot-arid climates (not surprisingly it has traditionally characterized the historical city fabric), the same cannot be said of chessboard urban planning because of the needs related to traffic, nonetheless it is widely used in contemporary urban design.

The main wind types in urban areas are: high winds, micro-climatic winds influenced by the topography and the configuration of the

Fig.7 Old *bagdir* in Fahraj, Iran (photo: F Pecchio).

city, and wind movements created by the city itself. It is clear that the last two are the usable winds, that can be canalized and deviated, and increased through architectural forms and the mutual relations between them. The more the center of the city is subject to overheating the more convective motions tend to make the air raise, and if the urban plan is a chessboard without sufficient green areas, which may serve as healthy lungs, the hot air full of dust and car fumes form a dome of pollution above the city center (Fathy, 1986): what today we call a 'heat island', a phenomenon unfortunately well known to contemporary cities.

Natural ventilation strategies in mild climate zones and Hippodamian cities

Many Mediterranean regions have a temperate climate, which is characterized by significant seasonal variations, with the consequent need to capture solar radiation and protect from winds in winter and to provide shelter from the sun and catch the breeze in summer. From the theoretical point of view this climate zone has the opportunity of taking advantage of a free urban plan, with buildings that blend with nature and open spaces (Olgyay, 1963).

It is interesting to note that Hippodamian planning has been applied since ancient times both in arid regions with a hot-dry climate and in regions with mild climates (Ischia, Cumae, Sicily, Naples). Of course the choice was not made following climatic characters, as it happened in the case of the compact city. And to understand the appropriateness we need to match the orthogonal grid to the choice of the orientation of the Cardo-Decumanus system, and then, consequently, of the rows of terrace houses. It is generally accepted today that the optimal orientation of houses in these climates is facing south, because this provides the best exposure to sunlight during the winter and allows easy shading in summer. Such an approach requires streets, the Cardi, and rows of terrace houses extended along a east-west direction, and main arteries, the Decumani, aligned in north-south direction. We find only in some cities an orientation of the streets (and rows of houses) from east to west, for example in Heraclea on Latmos (Asia Minor), Apamea (Syria), Olynthus, Priene and Rhodes.

In many other cities the orientation is different, and it is also observed how the urban scheme has been applied indiscriminately to sites in strong and medium slopes as well as to those on plains, near the coast or on a low hill. The problem of the orientation of the roads with respect to the wind has been considered by Hippocrates but also by Vitruvius, who indicated also an operational mode, actually very approximate, showing the recognition of a problem evidently not yet solved, and delegated only to passive cooling systems applied to individual buildings.

The city of Priene, called 'Solar City', with its north-south Cardi and east-west Decumani, must have certainly adopted into the buildings technical-constructional devices able to mitigate the effects of the excessive solar radiation due to exposure to the south, creating situations of comfortable environmental micro-climate.

Indoor air movements in vernacular architecture

The study of vernacular architecture gives us essentially two possible ways to produce natural air ventilation in buildings:

1. Use flows generated by pressure differences

The wind that hits a building determines areas of high and low pressure between upwind and downwind sides, with a pattern of flows that depends on the geometry and size of the building rather than on the air velocity. In vernacular architectures we can observe how these pressure differences are used to channel and change the air flows, essentially in two ways:

Fig8 Moisture control and shading system in a patio, Andalusia, Spain (photo: L. G. F. Cannas).

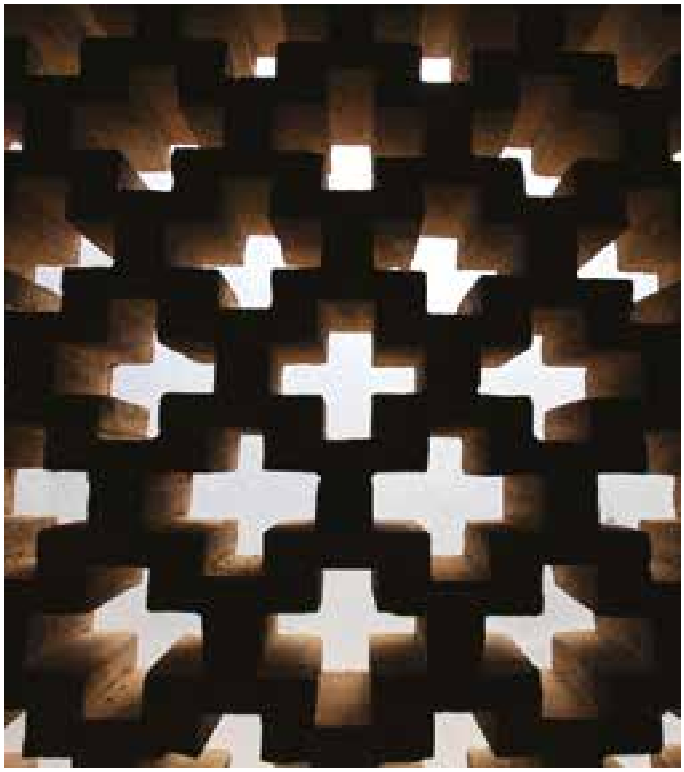


Fig.9 *Harouniye Mashrabiya* A adobe screen inside the Harouniye just outside Mashhad, Iran (photo: S. Alnuweiri).

a) by obtaining specific flows of the internal ventilation (cross ventilation): the ventilation flows between the upwind and downwind sides are directed through the external configuration of the openings, and are obviously more effective when the entry openings are in the high pressure side and the out openings in the low pressure side: the greater the pressure difference the faster is the flow. Except the size, also the position of the openings and the internal partitions that interact with the air flow are determinant. The air flow analysis in vernacular architecture often determines shapes and proportions of entire sections of buildings.

b) by taking advantage of the 'Venturi' effect: the Venturi effect is obtained when the pressures between inlet and outlet have the maximum possible difference, producing therefore the maximum air flow speed, or using a small low opening upwind and an very large upper opening downwind. There are very interesting solutions designed in vernacular architecture after this principle, and in particular: the lodges (*maqaad*) between the courtyards of the palatial architecture in Cairo and a very interesting use made by Fathy for the project of a *loggia* in the village of New Gourna. The *loggia* opens into a courtyard on the downwind side and is almost closed in the upwind side with a wall having two rows of small openings. The airflow over and around the building produces a low-pressure area on the downwind side while inside the lodge air suction is caused by the Venturi effect. For the same purpose a sequence of small holes, called *claustra*, are often used in vernacular architecture in all Mediterranean countries, offering various decorative patterns according to the different regions. They represent the precursors of the screening panels in use in contemporary architecture.

2. Exploiting convective flows

The convective flow exploits temperature differences, generating a 'chimney effect', which is most powerful the bigger the temperature difference and the bigger the difference in height between the point of release and that of air expulsion. The most interesting example of the usage of this principle in vernacular architecture is certainly the *malqaf-Qa'a* system in the Arabic-Egyptian house, which has also given rise to various experiments in contemporary architecture.

The need for a device especially designed to capture the prevailing breezes evidently arises when the orientation and placement of the house does not allow flows generated after pressure differences. It is no coincidence that these devices are present mostly in urban en-

Fig. 10 Procida, Italy (photo: M Achenza).

vironments, where the location, placement and volume of buildings is predetermined, or in buildings where the optimal sun orientation collides with the proper one in respect to the winds. The malqaf has ancient origins (it dates back to the Eighth century. BC, and was certainly used by ancient Egyptians). It raises to catch the high winds of the city and consists in a high turret, which can be single-or multi-directional depending on the direction of the breezes and regional traditions.

In the system of the house in Cairo the air that the *malqaf* picks up becomes a flow thanks to the extractive function done by the *Qa'a*, the central space of the house, whose roof and section are designed to operate as a powerful wind-escape. The flow is enhanced and accelerated along the way, through a large number of accelerator mechanisms placed on the stream channel of the malqaf, but also within the Qa'a (it is worth noting the important role played by water in the basins and fountains, which also bear a strong symbolic value). On the other hand one of the examples of a primitive use of convective air flows, less sophisticated but equally effective, can be found in the Roman house, in particular in the *tablinum*, crossed by the breezes whose flow is accelerated by temperature differences that are created between the sunny and shady peristyle atrium, as it is in the takhtabush, between the courts of the houses of medieval Cairo, which, not coincidentally, were always one shady and humidified by the vegetation and the other sunny and warm.

Lessons from vernacular heritage to contemporary natural conditioned buildings

It is not appropriate to blind copy the example of the historical vernacular architecture for the natural air conditioning design. The historical vernacular buildings were the product of social and technological conditions very different from those of today, designed to meet comfort standards that were also quite different. For example, regarding the average climate of the Mediterranean basin, Butera says that the comfort temperature for inner winter conditions was 16°C, in contrast to the 21-22 °C we find necessary today (Grosso, 2008). This was due essentially to the much more active lifestyle (Grosso, 2008). Beyond questions of detail, it is possible to take useful indications by studying vernacular architecture for the natural air conditioning design, provided that the designer is able to decline those principles from time to time as a function of peculiar needs. To conclude, it is worth mentioning that the most useful lesson that could be learned from vernacular architecture is the ability to choose the best possible bio-climatic strategies in relation to other constrains. As it is not possible to pursue only the best natural air conditioning strategy, it is necessary to learn the art of compromise with which vernacular architecture skilfully combined social needs (economic activities), techniques (local resources, landscape) and, in fact, climate control.

SIROCCO ROOM

SICILY, ITALY

author
Letizia Dipasquale

ENVIRONMENTAL PRINCIPLES

■ to respect environmental context and landscape ■ to benefit of natural and climatic resources ■ to reduce pollution and waste materials ■ to contribute to human health and welfare ■ to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

■ to protect the cultural landscape ■ to transfer construction cultures ■ to enhance innovative and creative solutions ■ to recognise intangible values ■ to encourage social cohesion

SOCIO-ECONOMIC PRINCIPLES

■ to support autonomy ■ to promote local activities ■ to optimise construction efforts ■ to extend building's lifetime ■ to save resources

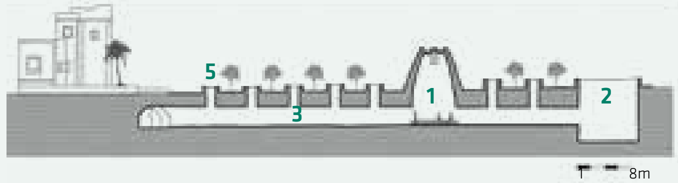
The Sirocco room is a traditional passive cooling system that finds its origins in Sicily, between the XVI and XVIII Centuries.

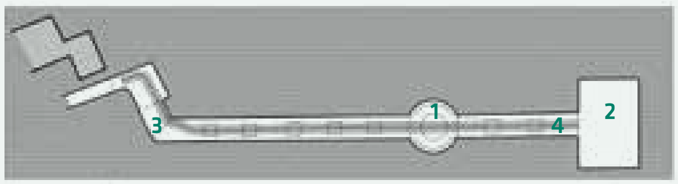
The Sirocco room consist in a vaulted underground room, linked to the rest of the house through long hallways having water canals, and small holes located in the living rooms. The cooling room is dug and connected with either an aquifer or an artificial water channel (called *qanat*). An air well connects the room to the outside, while a staircase assures the access. At the top a hole has the function of drawing the hot air and creating a slight but continuous air flow. This cooling system works using three natural elements: ground, air and water, and their physical behaviour. The combination of this elements lead to thermo physical effects – such as the heat exchange with the underground, the air movement from a cooler to a warmer zone, and the cooling through water evaporation – which creates an efficient air conditioning system.

In some cases – mostly in stately home –, the Sirocco room can be associated with windcatchers (locally called *u toccu*) – such us in Villa Ambleri Naselli Agliata – which allow the outward flow of hot air and the inward flow of fresh one, as in the well know Persian systems. According to oral tradition in the summer months this room was used for informal meetings and banquets. Sometimes there was a low basin, used for bathing (Balocco et al., 2009).

This system reflects the heritage of the Arab building knowledge, and also reminds us of the underground spaces with plenty of water (such as *crypto porticos and nymphaea*) used by Romans.

In Palermo there are more than twenty Sirocco rooms. In other places of Sicily this system is also known and used, while in other Italian regions – such as Emilia Romagna, Tuscany, ect. – traditional cooling systems have been rediscovered that use the same principles.





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Schematic representation of the room of Sirocco in Villa Ambra Naselli Agliata (redrawn by L. Dipasquale after Balocco et al., 2009).

1 Sirocco room
2 Well
3 Underground hallway
4 Artificial water channel (*qanat*).
5 Windcatchers (*toccu*).

↓

From left to right:

A room in a building near Siracusa with trapdoors connecting with the underground Sirocco room (photo: P.Mazzoni).

View of the abandoned Sirocco room of villa Savagnone in Palermo (photo: G. Valenti).

View of the abandoned Sirocco room in *contrada Altarello*, Palermo (photo: G. Di Camillo).

BARIS MARKET

KHARGA OASIS, EGYPT.

Architect: Hassan Fathy, 1970

author
Adelina Picone

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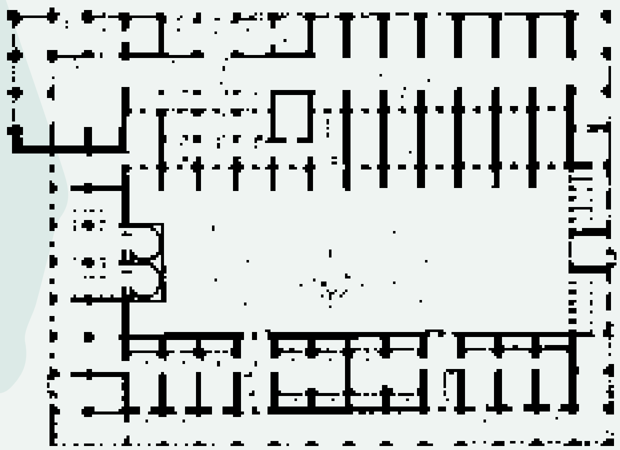
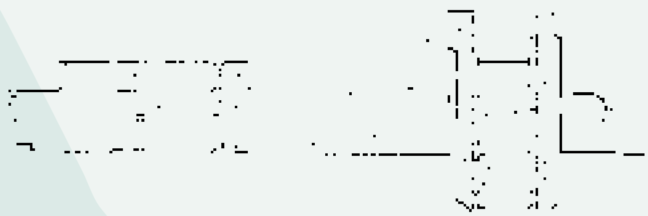
The Market is one of the few buildings that have been built in the village of New Bariz in the Kharga Oasis, in the western Egyptian desert. New Bariz is a project of a new settlement born to serve a population of 5 to 10 thousand people, within a wide urbanisation programme of desert areas that the Egyptian government started during the Sixties.
The climate in Kharga is hot and arid, with temperatures in July and August that reach 48°C in the shade. These extreme climatic conditions led H. Fathy to conceive the village project considering the respect for natural cooling and air movements, in both the town planning and the design of buildings. The project of the market in Bariz represents the higher level of refinement reached by Fathy in applying natural cooling systems and to inspire air movements in indoor spaces. "A new idea of wind catch was tried in Bariz, to cool down food stores in the basement and on the ground floor. It consisted in having two shafts, one with the opening facing the windward side, the other to the lee side with a metal chimney pot with blades leaning downwards to the outside, as can be seen in some places in Italy, to ensure suction by the Venturi action, and painted black to get hot and draw air from below by convection as well. In order to add the cooling effect of this wind catch, it was designed to have sheets of straw-mats hanging inside and wetted by a hand pump drawing water from a basin placed in the basement. The residue of cool water is pumped every now and then to wet the mats adding cooling by evaporation to the system. A friend of mine who visited Bariz last July told me that he was shivering with cold in this basement while the air temperature outside was 46°C. This without the wetted straw-mats" (H. Fathy, 1963, report to the Bariz project).





Exterior views of the market of Bariz (Courtesy of Aga Khan Trust for Culture).

Plants and sections of the market of Bariz with the representation of air flows (Courtesy of Aga Khan Trust for Culture).

LYCÉE FRANÇAIS CHARLES DE GAULLE

DAMASCUS, SYRIA.

Architect: Ateliers Lion Associés, Dagher Hanna and Partners, 2008

author
Adelina Picone

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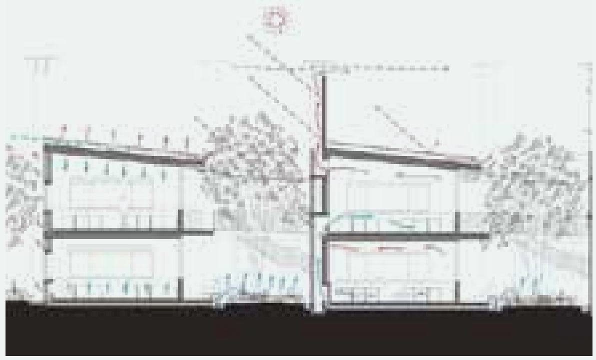
The project is located in Damascus, on one of the hills of the Mezzah area, higher than the rest of Damascus. The site slopes gradually up from south-east to north-west, and in the extreme north-western side the slope becomes rather steep. The area is surrounded by residential blocks in the east and south and a hospital in the north.

The Lycee is a campus with a capacity for 900 students, designed to develop a school concept integrated with the local climate conditions. The aim was to realize a sustainable prototype-project without artificial air conditioning, using only natural ventilation, cooling, and the play between light and shadows. The school complex is made up of small buildings, two-storey patio structures each giving onto a small and sheltered garden. It applies a low-technology solution for ventilation and conditioning of the rooms using local materials as a modern interpretation of the traditional architecture. Syria has a dry desert climate with hot days and cold nights. Wind-assisted solar chimneys are used to drive natural cross-ventilation through the classrooms, thanks to the gardens which are able of creating the micro-climate, feeding cool air into the ventilation system. The chimneys are faced with a polycarbonate sheet to trap solar radiation and enhance the stack effect. During the day, outdoor intake air comes either directly from the shaded micro-climate of the courtyards or is per-cooled using miniature earth ducts made up of pipes embedded in the ground floor slab. During the night, the thermal mass of the chimney releases heat stored during the day and continues to draw air through the open windows and the earth ducts. Cool night air flushes the classrooms, cooling down the thermal mass and providing comfort for the following day.



Plants and sections of the lycéee of Damascus with the representation of air flows (drawings: Ateliers Lion, Paris, France).

Exterior views of the lycéee of Damascus (photo: A. Goula).

Technical and constructive strategies and solutions

Rammed Earth in Alentejo, Portugal (photo: F. Gomes).

Walls of high thermal inertia

Inês Costa Carrapiço, Filipa Gomes, Mariana Correia, Sandra Rocha
CI-ESG, Escola Superior Gallaecia, Vila Nova de Cerveira, Portugal

The use of passive systems is the optimal bioclimatic and simplest way to employ solar energy. Capturing radiant solar energy, through appropriately oriented and dimensioned glazing, reveals itself insufficient to influence indoor thermal comfort. It is thus required to combine the radiation collection, with its absorption and process of transformation by convection, but also by taking advantage of high thermal storage materials and storing energy, either in form of heat or coolness, and by spreading it adequately, during periods of consumption. The heat storage capacity of a material is designated as thermal mass, which is the result of an element's mass multiplied by its specific heat (the ability for a material to store energy within its mass unit) (Neila-González and Bedoya Frutos, 2001; Santamouris and Asimakopoulos, 2001; Donnelly, 2010).

There is an increasing mass-production of higher thermal inertia, regarding a building's envelope, since the specific heat of the building's materials suffers very little variation. Therefore, thermal inertia is closely linked to thermal energy storage and it can be defined as the thermal resistance towards the movement of heat through the wall (Neila-González and Bedoya Frutos, 2001; Donnelly, 2010; Hopfe et al., 2012), but also as the building's overall capacity to store and release heat.

Thermal inertia is expressed in the number of kilocalories or joules needed to raise its temperature by one degree, and it depends on mass, density and specific heat (Neila-González and Bedoya Frutos, 2001) (Neila-González, 2004). Heat transfer rates are variable according to the material, and those of high storage capacity, heavy or dense, within the construction of the building's mass itself, are the ones associated with high thermal inertia. High thermal inertia can be found in vernacular constructions that use stone and earth in their external and internal walls, as well as in their ceilings and floors (Hopfe et al., 2012).

Thermal mass can be applied to achieve two main goals, according to the climatic conditions: firstly, passive solar thermal storage of gains for further release, which decreases the heating needed to consider outdoor temperature reduction, as well as to avoid excess heat temperature peaks; and secondly, improving thermal comfort by contributing to indoor temperature stabilisation against outdoor variations (Shao, 2010; Goulart, 2004; Costa Carrapiço et al., 2014; Donnelly, 2010; Santamouris and Asimakopoulos, 2001; Hopfe et al., 2012).

In order to quantify the impact of a building in the stabilisation of indoor temperature fluctuation, a supplementary concept such as thermal stability is introduced to thermal mass and thermal inertia. Thermal stability, one of the most desired targets when designing a building, is measured by a coefficient, relating the indoor temperature amplitude (the highest temperature minus the lowest one) to the outdoor temperature amplitude (Neila-González and Bedoya Frutos, 2001; Neila-González, 2004). When this coefficient is higher than '1', overheating effects on indoor hygrothermal comfort will be critical, since temperature variations will simultaneously follow outdoor temperatures. Coefficient values close to '1' indicate that the indoor environment will suffer immediate fluctuations resulting from outdoor temperature, and potentially critical overheating effects on indoor hygrothermal comfort due to its low levels of thermal inertia. As for coefficient values under '0, 5', these indicate a high thermal stability, with an indoor impact of less than 50% of outdoor temperature variations (Neila-González and Bedoya Frutos, 2001). A building's thermal stability is linked to the specificity of its heat transfer process: once the envelope's outermost layer is heated, both through solar radiation and outdoor temperature, a slow process of heat transfer by conduction takes place, until the deepest layer is reached. The time difference that characterises this heat flow phenomenon defines the thermal lag of the construction, and the produced delay can last for several hours, dispersing during the night the stored heat into the indoor environment (Santamouris and Asimakopoulos, 2001; Neila-González and Bedoya Frutos, 2001).

The relevant role played by natural ventilation and thermal insulation

Mass can play a determinant role in energy efficiency design, as well as in hygrothermal indoor comfort. However thermal inertia optimisation and effectiveness are determined by supplementary parameters, which go beyond building material properties and techniques: climate conditions, building configuration and orientation, thermophysical properties and thermal insulation of the envelope, rate of occupancy and internal heat gains, glazing to thermal mass ratio, ventilation, shading and walls protection, as well as thermal mass distribution and location. Along with the final outcome of the project, these parameters are all among the most significant ones,

M. Correia, L. Dipasquale, S. Mecca (edited by), *VERSUS: Heritage for Tomorrow. Vernacular Knowledge for Sustainable Architecture*, ISBN (online) 978-88-6655-742-5, ISBN (print) 978-88-6655-741-8, CC BY-SA 4.0, 2014 Firenze University Press

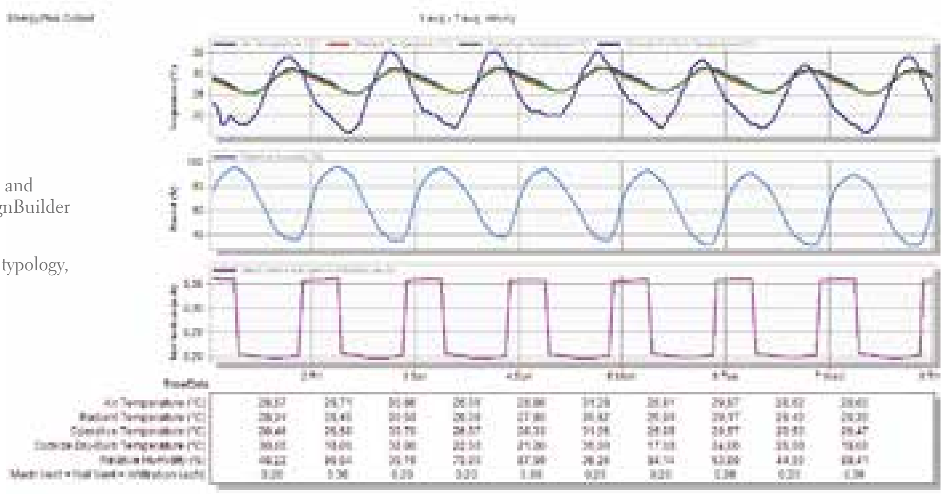
Fig. 1 Rural vernacular settlement of São Vicente in Alentejo, Portugal (photo: I. Costa Carrapiço).

influencing the thermal inertia impact on a building's hygrothermal behaviour and indoor comfort (Goulart, 2004; Kosny et al., n.d.; Neves, 2005; Donnelly, 2010).

In particular, natural night ventilation and thermal insulation play major supplementary roles regarding the strategy of thermal inertia. Mass alone would not be able to provide a level of summer cooling and indoor thermal comfort, as enhanced by the one resulting from its combination with natural night ventilation. This allows the rejection of stored heat by convection (Kosny et al., n.d.; Costa Carrapiço et al., 2014; Shaviv et al., 2001; Neila-González and Bedoya Frutos, 2001; Tuohy et al., 2004). Additionally, an adequate insulation of the building's envelope combined with thermal mass is necessary for the optimisation of indoor comfort conditions, avoiding overheating or heat losses, especially through the roof (Santamouris and Asimakopoulos, 2001; Van Straaten, 1967). In order for the use of thermal insulation to suit the strategy of thermal inertia, and to contribute to the thermal stability of a building as well as to its energy savings, it is imperative that its mass maintains direct contact with the indoor environment, by placing the insulation externally (Neila-González and Bedoya Frutos, 2001).

This strategy presents some variations with reference to the application of high thermal mass walls, encompassing both vernacular construction, with the earth sheltered dwellings, which are the embodiment of thermal inertia efficiency due to the combination of high volumetric heat capacity and thermal conductivity (Hopfe et al., 2012; Neila-González, 2004), as well as high-tech construction, through the development and incorporation of phase change materials (PCM) into the building elements (Shao, 2010).

Finally, this strategy performance is further influenced by the parameter of space occupancy. Due to the specificities of its own heat flow process and thermal lag, the strategy is optimised and more likely to lead to energy saving, when the occupancy is of a continuous nature (Shao, 2010; Neila-González and Bedoya Frutos, 2001). This is opposed to an occasional use of a space, in which case the performance could benefit from resorting to thermal insulation placed on its interior surfaces.



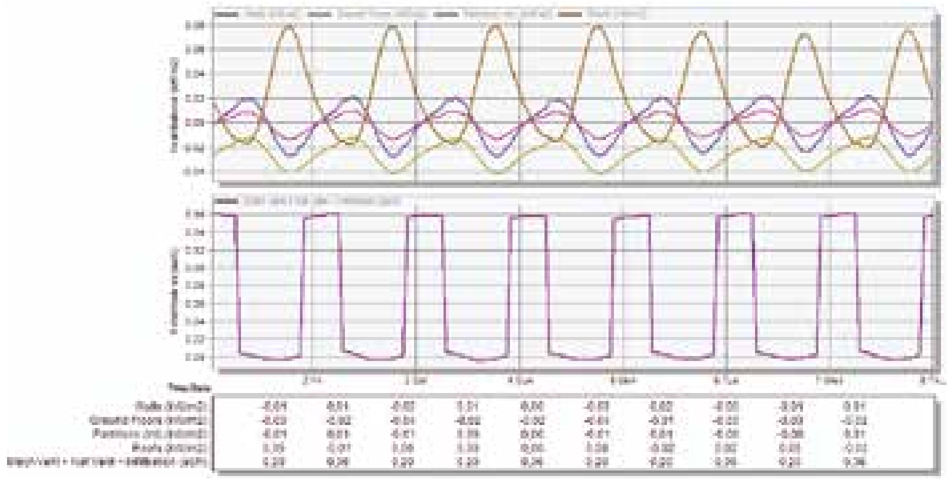


Fig. 2 Simulation of indoor, outdoor temperature fluctuation, and natural ventilation, in SVV dwelling typology. Software DesignBuilder (photo: I. Costa Carrapiço).

Fig. 3 Simulation of heat balance (kW/m2), in SVV dwelling typology, with software DesignBuilder (photo: I. Costa Carrapiço).

Fig. 4 High thermal mass wall in Alentejo, Portugal (photo: I. Costa Carrapiço).

How the strategy meets the general aims

High thermal inertia, as a vernacular strategy, reveals a significant contribution regarding environmental and economic sustainability. Taking into account that the environmental scope should be perceived, in part, as the reduction of a buildings' adverse environmental impacts (Correia et al., 2014), the strategy reviewed meets all the aims/needs determined within it.

It begins by adequately responding to the need of enhancing existing natural resources, by minimising changes in the intervention to the surroundings, due to the fact that vernacular walls of high thermal inertia typically use local and accessible high-density materials, leading to constructions perfectly suited to the site conditions. The use of accessible and recyclable materials further supports the aim of reducing pollution production. This is possible by taking advantage of available energy resources (i.e. through renewable solar energy required for its functioning) and subsequently by optimising the building process resources.

Yet, the two main aims that this strategy fulfils consist of its contribution to indoor environment quality, by efficiently regulating temperature fluctuation and providing indoor thermal stability, in addition to energy spending optimisation throughout the building's life cycle. The latter also embodies a crossing point between both the environmental and economic scopes. Although, the economic scope is set as a comprehensive concept, which integrates quantitative and social matters; high thermal inertia relates most directly to the capability of reducing invested effort regarding several issues, such as: the construction process, the building performance, the maintenance and the impact. Its impact in terms of energy consumption and energy cost savings in the building's life cycle can be significant, due to the provided indoor hygrothermal comfort, the small amount of additional energy consumed and its consequent consumption peaks reduction.

Moreover, the promotion of the usage of local and recyclable materials, assuring minimum transportation efforts, along with low-maintenance construction techniques, results in the reduction of energy levels of the building's life cycle and in a decrease in the consumption of resources, as well as in the overall reduction of operational efforts. Finally, a connection can be drawn between the enhancement

Fig. 5 Rammed earth building in Mértola, Alentejo, Portugal (photo: M. Correia).

Fig. 6 Stone buildings in Civita di Bagnoregio, Lazio, Italy (photo: S. Onnis).

of the local economy and the appliance of high thermal inertia, since the use of endogenous materials and resources is ultimately linked to the need of endogenous workmanship.

Weaknesses and lacks of the vernacular strategy

As previously mentioned, several parameters may have a detrimental or somewhat ineffective input on thermal inertia behaviour. First off, high thermal mass is conventionally linked to hot and arid climates (Santamouris and Asimakopoulos, 2001). Even though recent studies suggest its usefulness for warm and humid climates as well (Goulart, 2004), a large amount of the literature discloses a more challenging use in these types of climates, due to the requirement of a substantial daily thermal amplitude to obtain a useful lowering of the indoor daytime temperature (Van Straaten, 1967; Givoni, 1998; Shaviv et al., 2001; Kemajou, 2012). Furthermore, its correct use is strictly tied up with a comprehensive approach regarding passive solar design principles. This is suggested as a disadvantage regarding spaces used only temporarily (Neila-González and Bedoya Frutos, 2001). As stated within the supplementary features, its performance is largely influenced by its combination with natural night ventilation and the building's air infiltration: if the first one reinforces its desirable thermal performance, the second one is prejudicial when presenting high rate values (Shao, 2010).

Similarly, thermal insulation should be taken into account, as it may enhance or invalidate thermal inertia performance and consequently energy consumption (Santamouris and Asimakopoulos, 2001; Van Straaten, 1967; Shao, 2010). A potential thermal storage wall may behave like an element without any effective storage capacity, due to the insulation placed on its interior side (Neila-González, 2004; Goulart, 2004). Additionally to the building's orientation, thermal mass location and façade finishing colour can be crucial for its proper performance. Thermal mass on a façade with no passive solar gains may not have an important contribution or it may even be counterproductive, as it can absorb indoor heat during the winter. However, solar radiation may also generate an indoor thermal charge on the east or west façades (Santamouris and Asimakopoulos, 2001).

Finally, other features may also weigh on thermal inertia effectiveness. Amongst them are the internal gains caused by appliances, the standardisation of construction and the user behaviour.

Lessons and contributions to contemporary architecture

In a time when energy crisis and global warming raise a growing concern, minimising energy, natural resources and fossil fuel consumption has developed into a full priority and critical challenge, determining political agendas and building design guidelines (Dabaieh, 2013; Schroeder, 2012; Rongen, 2012). According to Yang et al. (2014), buildings are responsible for about 40% of the globally consumed energy, and more than 30% of CO2 emissions. This sets ground for the immense potential that this sector has in the path towards environmental and socio-economic sustainability. Obtaining thermal comfort together with energy efficiency performance, while using renewable energy and reducing its environmental impact through-

Fig. 7-8-9 Contemporary house house by Architect Bartolomeu Costa Cabral, in Beja, Alentejo, Portugal (photo: F. Gomes).

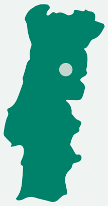
out the building's life cycle, are amongst the most required energy efficient features in contemporary buildings' design.

High-tech and energy efficiency promise buildings that are still far from achieving the performance required in order to face the challenges related to climatic change today (Shao, 2010). Within this context, a growing interest in the sustainability value held by vernacular architecture arises, particularly in its approach to dwellings. Linked to it is the argument according to which models, principles and strategies in vernacular architecture could provide valuable tools for addressing sustainable issues in contemporary architecture. According to several authors, by inheriting its key-elements, the existing social, environmental and cultural global crises could be overcome (Fathy, 1986; Asquith and Vellinga, 2006; Oliver, 2006; Bouchain, 2010; Hall, 2010).

The strategy that is revealed in this chapter is among the wide range of vernacular strategies one could learn from. Based on all its previously mentioned mechanisms, one of the beneficial contributions of high thermal inertia to environmental and economic sustainability consists of its efficient behaviour in regulating indoor temperature fluctuation and subsequent indoor thermal stability, with little or no extra conventional energy consumption (Neila-González and Bedoya Frutos, 2001; Schroeder, 2012; Shao, 2010; Araújo and Almeida, 2006; Hall et al., 2012; Goulart, 2004).

In addition, the improvement of the indoor thermal comfort of buildings can represent a significant impact in terms of its life cycle energy analysis and energy cost savings. This is due to the fact that a significant part of the energy consumption of the building is linked to providing indoor hygrothermal comfort, and that the strategy of thermal inertia allows the reduction of operational energy over its life span and its consumption peaks (Ramesh et al., 2010; Pasupathy et al., 2008; Araújo and Almeida, 2006).

Finally, high thermal inertia has a valuable environmental input, feeding as it does on a renewable solar energy, and thus assisting the reduction of resource depletion, as well as the diminishing of environmental pollution from energy production and energy waste. Nowadays, the energy efficiency and CO2 emission goals of buildings, actually match the premises on which vernacular architecture is based upon. The fact that energy is an increasingly critical theme in our society, due to its excessive consumption, highlights the importance of incorporating lessons from vernacular strategies, such as those from thermal inertia. Considering the impact in hygrothermal comfort and in energy savings, thermal inertia remains one of the most vital strategies for acting, in response to the pressing global matters of fossil fuel dependence and climate change impacts. The awareness related to this topic has been slowly increasing, through a significant boost of scientific research, along with a gradual integration of this strategy in contemporary dwellings, adding progress towards a more sustainable development.



MASONRY IN RURAL DWELLINGS OF ALENTEJO

ALENTEJO, PORTUGAL

author
Inês Costa Carrapiço

ENVIRONMENTAL PRINCIPLES

to respect environmental context and landscape ■ to benefit of natural and climatic resources ■ to reduce pollution and waste materials ■ to contribute to human health and welfare ■ to reduce natural hazards effects

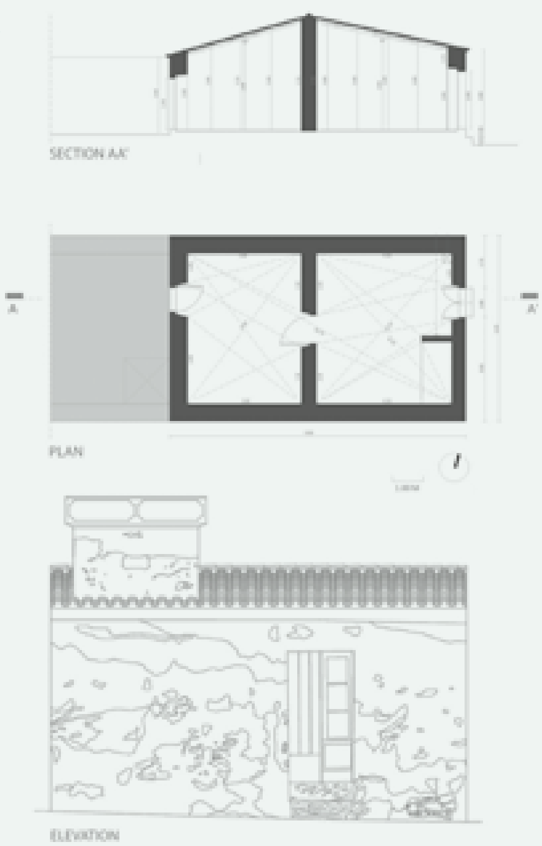
SOCIO-CULTURAL PRINCIPLES

to protect the cultural landscape ■ to transfer construction cultures ■ to enhance innovative and creative solutions ■ to recognise intangible values ■ to encourage social cohesion

SOCIO-ECONOMIC PRINCIPLES

to support autonomy ■ to promote local activities ■ to optimise construction efforts ■ to extend building's lifetime ■ to save resources

This case study is established in the vernacular rural settlement of São Vicente e Ventosa (SVV), in Alentejo, Portugal, located at 38°57'14''N 7°12'46''W, in the sparsely populated extensive plains surrounding Elvas. According to the Köppen Climate Classification, the region holds a temperate climate with dry and/or hot summer (Csa) (AAVV, 2011). Inhabited mainly by former rural workers, this typology is a one-storey dwelling with an average dimension of 6, 00 m wide and 9, 00 m long, composed by two spaces: the most important one, where a traditional fireplace hearth was located for food preparation, and a bedroom. Blind external walls and the preeminent role of the fireplace in the façade are some of its peculiar features. The building systems consist of high thermal mass walls (0, 60m wide of stone and earth masonry) finished with lime coating. Lime wash had an antibacterial functionality, as well as solar radiation protection. There were also considerable high ceilings built in ceramic hollow terracotta, supported by wooden joists; and a fireplace hearth in brick, that provided heating and natural ventilation (Costa Carrapiço, 2013). Based on a triangulation of methods, combining quantitative in situ measurements, qualitative data, and simulation (Costa Carrapiço et al., 2014), hygrothermal results revealed an efficient behavior in regulation of indoor temperature fluctuation, also providing comfort in summer periods. A subtle indoor temperature variation and a very low thermal stability coefficient stressed the strong influence of thermal inertia in indoor comfort, as a perfectly suited strategy to its climatic conditions. Qualitative data analysis supports these results, as 70% of cases assessed positively throughout the summer interior comfort perception, but there was also a near-majority assessed winter conditions that presented negative results. The analysis of vernacular construction presents a fine example of applied strategies regarding thermal inertia walls. This resulted from empirical knowledge passed on from generation to generation, which had very efficient positive outputs on the comfort of daily-life.



↑ Vernacular Dwellings Typology in São Vicente e Ventosa (drawings: I. Costa Carrapiço).

↓ Dwellings in São Vicente e Ventosa: high thermal mass walls of stone and earth masonry (photos: I. Costa Carrapiço).

PERFORMANCES OF ADOBE BUILDING ENVELOPE

SARDINIA, ITALY

authors
Giuseppe Desogus, Stefania Di Benedetto

ENVIRONMENTAL PRINCIPLES

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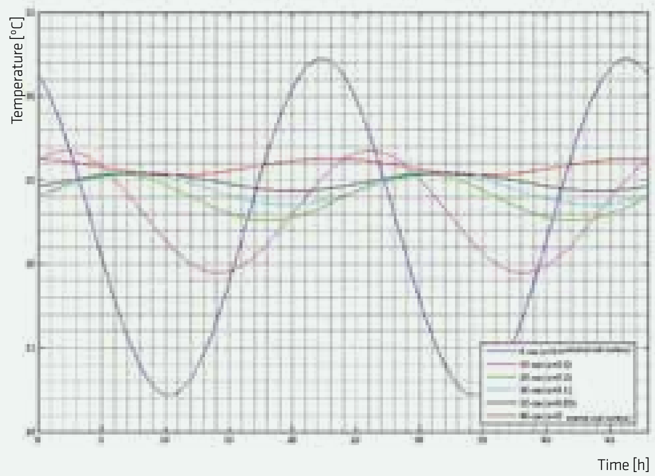
The thermal comfort that traditional earth buildings can provide during the summer season is studied both by designers and researchers. The research data shown below deals with the assessment of thermal comfort perceived in spaces confined by earth walls. Negative and positive performances provided by this kind of massive walls are being investigated in the context of the Mediterranean climate, where high thermal inertia is a key factor. Research has been developed on adobe brick walls in the Sardinian region (su ladiri). It is a traditional construction technique in the historical centres of Medio Campidano. A preliminary analysis has been carried out on the thermo-physical properties of bricks by a qualified Italian institute, the Istituto Giordano. An indoor survey in the summer season has then been performed on a case-study house, Casa Mancosu (Serramanna-VS). The results of an analytical calculation of transient thermal parameters are shown bellow. The massive earth walls are well beyond the thermal code requirements. Also the micro-climatic monitoring, carried out according to both Fanger's classic theory and the adaptive comfort models, shows that an earth house can provide suitable indoor conditions during the summer without the need for air conditioning, provided that the envelope elements are correctly designed or refurbished. Concerning the performance of earthen envelopes during winter, the measurements carried out on the case-study show a U-value of about 0, 8 W/m²K. Among traditional masonry materials, earth, due to the presence of straw, is probably the one with the best insulating capacity.



Temporal evolution of temperature inside an adobe masonry wall

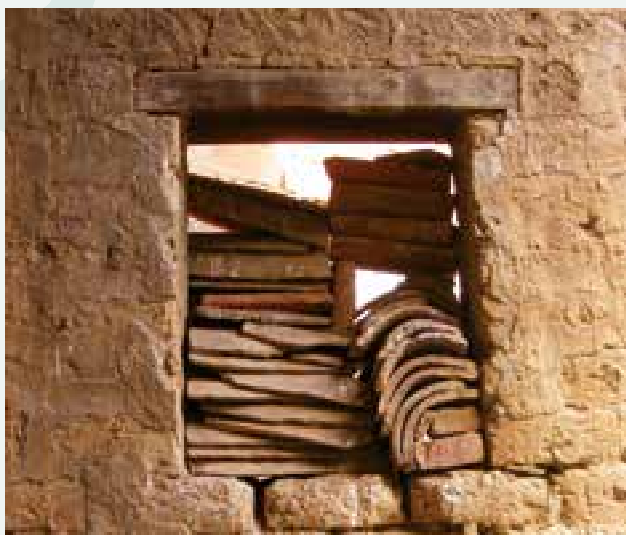
Property	Unit	Value
Mass density	kg/m^3	1842
Thermal conductivity (λ)	W/(m K)	0.663
Specific heat	J/(kg K)	1000
Thermal diffusivity (α)	mm^2/s	0.3599

Thermo-physical properties of adobe

Parameter	Unit	Value with d = 30 cm	Value with d =35 cm	Value with d = 40 cm
Periodic thermal trasmittance (*Yie*)	W/(m^2 K)	0.347	0.210	0.127
Decrement factor (f_d)		0.216	0.146	0.098
Phase shift (φ)	h	11.0	12.9	14.8
Surface mass (Ms)	kg/m^2	553	645	737

Dynamic thermal characteristics of adobe-made walls, according to UNI EN ISO 13786:2007

South-west facade of casa Mancosu, Sardinia.
Ventana adobe texture by Sardinia.
(photos: S. Di Benedetto)



RAMMED EARTH ART STUDIO

ODEMIRA, ALENTEJO, PORTUGAL

Architect: Alexandre Bastos

authors
Célia Macedo, Filipa Gomes, Inês Costa Carrapiço

The case studies are established within Odemira, in the Alentejo coast of Portugal. According to the Koppen Climate Classification, the region holds a temperate climate with dry and/or hot summer (Csa) (AAVV, 2011).
The building consists in an art studio, designed by architect Alexandre Bastos. The performance of the buildings was analysed as part of the MSc Thesis of Macedo (2009). Its selection was based upon the uniformity of the rammed earth, and the climate conditions of the region. In order to assess its thermal performance and environmental impact, the methodology adopted combined a triangulation of methods, encompassing in situ measurements, occupancy surveys and simulation. The analysis of the results acknowledges the thermal inertia of earthen walls, most effective in providing comfortable indoor temperatures during the warmer periods of the year, and when combined with night cooling ventilation, conclusions which are supported by the occupancy surveys. During colder periods, the values recorded with no auxiliary heating system, revealed inferior to comfort levels (Macedo and Chandiwala, 2010).

This case study illustrates how different parameters and strategies combination can annul or enhance thermal inertia performance: the importance of the night ventilation is highlighted, as well as the combination of thermal mass with external thermal insulation, and so is the impact of poor insulation. The case also clearly depicts how thermal inertia in thermal mass walls meets the aims/ needs of the environmental and economical scopes of the VerSus project, mainly by virtue of its potential, to provide indoor thermal comfort without artificial aid and a low impact in the building's life cycle, through the reuse of earth in construction, and its low embodied energy.

ENVIRONMENTAL PRINCIPLES

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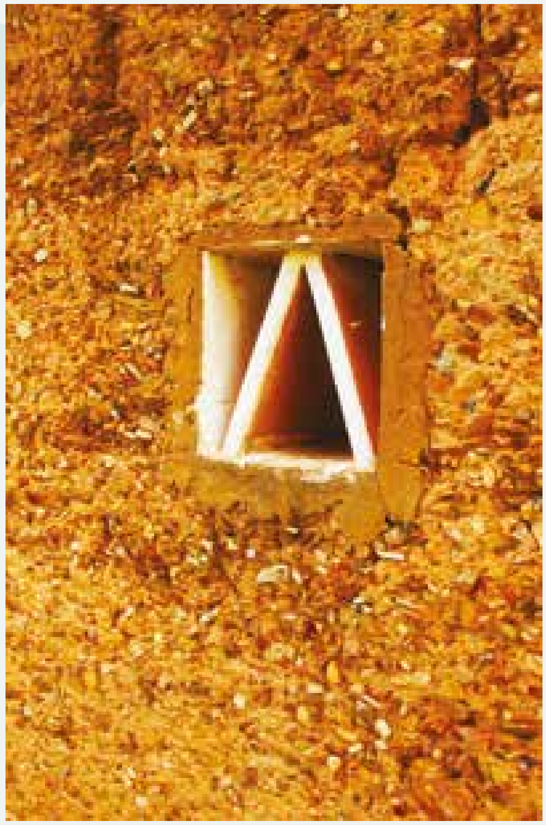
SOCIO-ECONOMIC PRINCIPLES

to support autonomy; to promote local activities; to optimise construction efforts; to extend building's lifetime; to save resources



Wall in rammed earth in Alentejo, Portugal (photo: F. Gomes).

The art studio by Alexandre Bastos in Alentejo, Portugal (photos: F. Gomes).

WINERY AT THE MONASTERY OF SOLAN, LA BASTIDE D'ENGRAS

LANGUEDOC-ROUSILLON, FRANCE

Architects: Perraudin Architects

authors
Nuria Sánchez, Enrique Sevillano

ENVIRONMENTAL PRINCIPLES

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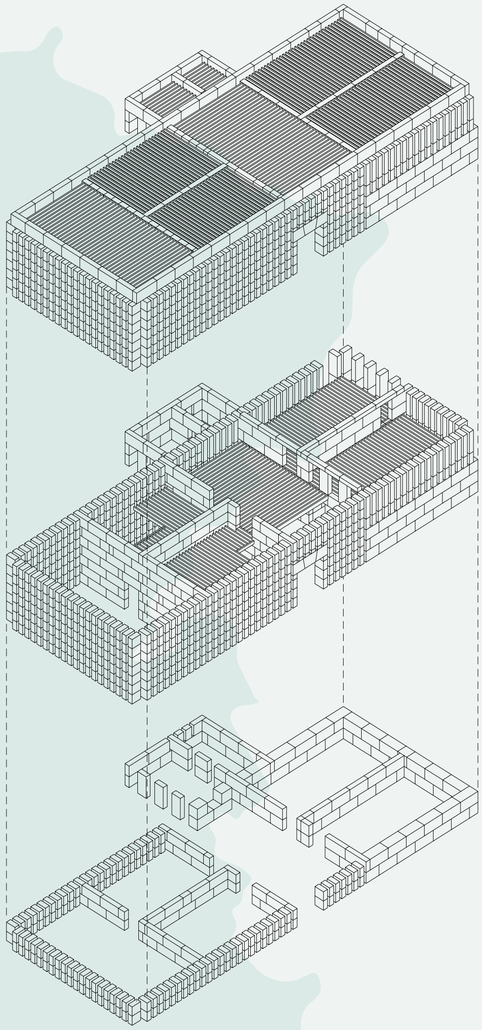
This winery is a production facility of 1, 000 m^2 completed in 2007 for the Greek Orthodox Solan Monastery, in La Bastide d'Engras, Languedoc-Rousillon. It was important to be in harmony with the historical architecture and culture, to respect nature and the ecological systems of the area and to preserve the spiritual life and austerity of the residents.
The medieval community already produced their own natural wines from the vineyards of this region. This building enhances the local production and processing sector, helping the promotion of local activities. It maintains the transfer of skill labour and the recognition of quality local products.
The stone module of the building follows the standard size produced in the nearby quarry, so blocks stack one on top of another with only a lime mortar to prevent the air from entering. Stone has a huge energy storing capacity and cools off as humidity evaporates, favoring natural air conditioning. This feature, as well as the thermal inertia gained from being half buried in the topography, reduces the energy consumption. All these facts, together with the use of natural materials (Douglas beams and floors), prevent the pollution of the wine and ensure its quality. Stone is a historical resource in this region. Its production releases almost no emissions, with little maintenance it is almost everlasting, and can be endlessly recycled. Moreover, its use here is proposing an updating of the construction system: a Lego-block working at once as structure, as a main part of the enclosure, and as a solar shading device.



➔ Axonometric view of the winery building.

↓ General view of the winery building.
Building process of the winery bilding.
Interior view of the winery building and the production process.
(photos: Perraudin Architects)

Philippines community helps to move an house to a new location (photo: Bonvallite, CC BY-SA 3.0).

Lightweight structures

Leonardo G. F. Cannas
University of Cagliari, Cagliari, Italy

'Lightweight structures' are understood to mean every architectural element that is characterized by a low self-weight in comparison with other building systems which guarantee the same performances (fig. 1).

Vernacular lightweight structures are present in the building cultures from all over the world. They include nearly the entire set of building elements. The materials used are varied, and among them could be cited timber, reed, bamboo, grass, palm, straw, some of them woven. An important feature of lightweight structures, which have numerous technical advantages, is the fact that they are made using by dry construction methods, which are based on assembling pieces with the use of mechanical fasteners, with no need of binders (concrete, lime, glue or similar). Specifically, it refers to jointing, lashing, weaving and similar methods (fig. 2). Timber and bamboo can be conformed in order to create joints, secured by wedges, such as the mortise and tenon system. More flexible and elastic materials, with a consistent length-to-width ratio, such as grass or reeds, can be easily interlaced between them or around a supporting structure.

Frame structures are understood to be vernacular lightweight structures with a load-bearing function. These are basically sets of linear elements, reciprocally connected at the ends to form three-dimensional networks (Oliver, 1997). The structural functioning is based on the transmission of loads to the vertical elements, by the bending stress of the other elements (Oliver, 1997). These structures were used because of their high strength-to-weight ratio, hence they were able to sustain high loads, or to provide support in order to envelope large areas, with a reduced use of material (Oliver, 1997). To build them it is necessary to use materials that have a good strength-to-weight ratio, regarding bending stress, and easy to work in order to get linear forms and effective linkages (Oliver, 1997). Timber was widely used in vernacular architecture to build framed skeletons. Bamboo was also widely used in this sense (Oliver, 2003) (fig. 3). Frame structures were also used to put into practice the building on piles, which responded to defensive reasons, elevation over water or swamp, cooling and ventilation and protection from insects and rodents (fig. 4) (Lewis, 2014).

In vernacular architecture spanning systems were lightweight. By spanning systems we mean roofs and suspended floors. Benefits in lightweight spanning systems are obvious: low commitment for structural supports, saving of building material, construction practicality, and the possibility of wider spanning.

These building elements were composed by both a structural and a finishing component. The former had the task of supporting the loads and to transmit them to the support structure. The latter met other requirements, such as protection from atmospheric agents, thermal/acoustic insulation, and providing a continuous horizontal surface.

In the case of suspended floors, the structural component consisted in regularly spaced beams which span the shortest distance of the related space (Torricelli et al., 2001). Beams were bend-stressed, and made of timber or bamboo. The continuous surface finish was obtained with the same lightweight materials, to which sometimes more layers were added, such as earth screed and tiles, which guaranteed a better performance in terms of sound insulation, durability, and ease of cleaning (fig. 5) (Oliver, 1997).

In the case of gable roofs and hipped roofs, vernacular structural components can be classified according to their main structural element in: rafter type, purlin type and truss type (Tavares et al., 2014).

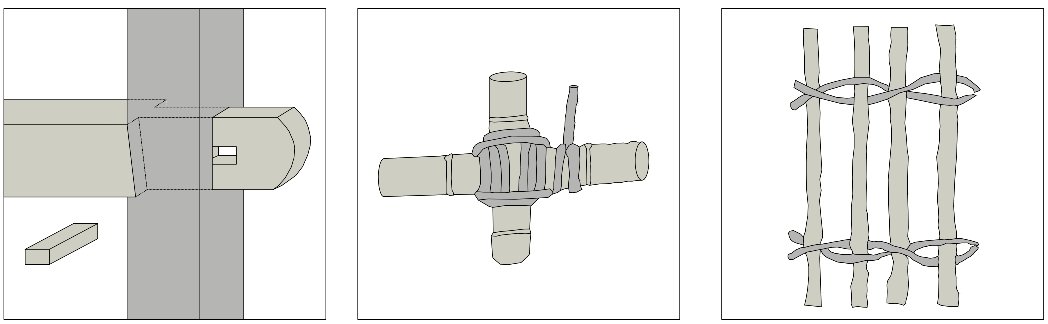


Fig. 2 Mechanical fasteners, respectively jointing, lashing, weaving (drawing: L. G.F. Cannas).

M. Correia, L. Dipasquale, S. Mecca (edited by), *VERSUS: Heritage for Tomorrow. Vernacular Knowledge for Sustainable Architecture*, ISBN (online) 978-88-6655-742-5, ISBN (print) 978-88-6655-741-8, CC BY-SA 4.0, 2014 Firenze University Press

Fig. 3 Timber framework house in Normandy, France (photo: L. G.F. Cannas).

Fig. 4 House in Luang Prabang, Laos (photo: Anguskirk).

The rafter type consisted in regularly spaced rafters connected to another rafter at the ridge level and to the load-bearing walls, which support the out-of-plane impulses of this system (Tavares et al., 2014). The purlin type was based on load beams, such as the ridge beam, which supports secondary rafters elements and transfers loads to load-bearing walls: in this case there were no out-of-plane impulses, but just compression impulses (Tavares et al., 2014). The most stable system was the truss type, which was based on the closed triangle principle (Oliver, 1997). This geometric configuration is a way to optimize load bearing by distributing it among several elements that are geometrically organized in order for them to eliminate stress mutually (Torricelli et al., 2001). In particular truss, in the simplest form, consisted of a pair of converting rafters, joined at the base by a tie beam. This configuration allowed to cancel the horizontal stress of rafters on supporting structures (fig. 6) (Torricelli et al., 2001).

The minimum requirement for roof finishing is to be waterproof. In vernacular architecture there were ingenious solutions based on superimposed lightweight materials, in a way that prevented the presence of interstices through which water could penetrate. Among

Fig. 5 Suspended floor in Samassi, Sardinia, Italy (photo: Associazione Nazionale Città della Terra Cruda).

Fig. 6 Traditional truss in Samassi, Sardinia, Italy (photo: Associazione Nazionale Città della Terra Cruda).

Fig. 7 Tiles in Ussana, Sardinia, Italy (photo: L. G.F. Cannas).

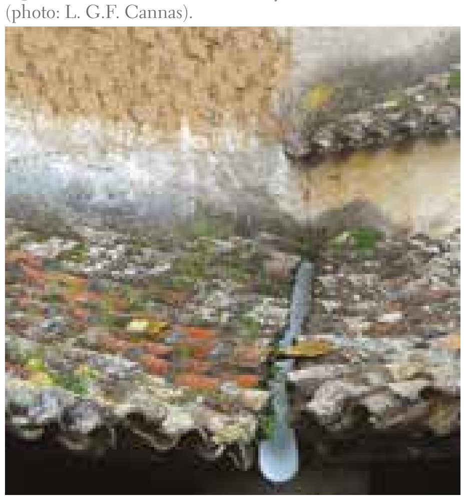


Fig. 8 Conical roof in Cuile, Sardinia, Italy (photo: A. Caddeo).

Fig.9 Wattle and daub house in Raduil, Bulgaria (photo: A. Wilson).

them it is worth to cite tiles, wood shingles, half-section bamboo stems, canes or the thatching tradition (fig. 7) (Oliver, 1997). The latter also offered good thermal insulation (Oliver, 1997).

Another kind of vernacular lightweight roofing is conical roofs. They were constructed by radial poles, raised on cylindrical walls, supplemented by a water-resistant sheath of reeds, straw, litter, twigs or stubble (fig. 8) (Oliver, 1997). The assembly technique that was most commonly used was the lashing of rings of vines or thin and flexible branches in order to restrain undue buckling or deformation of poles and to secure the finishing layer (Baldacci, 1952; Oliver, 1997). Often the waterproof layer thinned at the top, to leave gaps which allowed smoke a way out (Baldacci, 1952).

It could be stated that the modern concept of curtain walls has been developed in vernacular architecture. For example elements such as "opaque elevation, non-supporting structures, specifically destined to act as closure and separation buffers [...]" (Oliver, 1997). Regarding sedentary building cultures, this kind of building envelope was used as necessary filling of the framework skeleton. Bamboo curtain walls were made by interlacing bamboo strips on a frame (Oliver, 2003, 1997). In Europe a similar technique is usually known as *wattle* and *daub*: wattles were interlaced around slender poles or inserted into cut grooves and then mud was used to fill in the interstices in order to provide waterproofing, as well as air tight and thermal proprieties (fig. 9) (Oliver, 2003).

Lightweight structures were used as temporary dwellings because of their versatility. Nomadic shelters were made of lightweight structures due to their lightness, which resulted in easy transportability (fig. 10) (Oliver, 1997). Lightweight structures were also used in situations where a short duration of the construction was foreseen, such as seasonal residences (Baldacci, 1952) or areas prone to natural disasters (Oliver, 1997). The manufacturing technologies were not different from those used for covering: vegetable elements (leaves, straw, reeds, etc.) were fixed on a supporting structure of variously arranged poles (converging at the top, bent like arches) (Oliver, 1997). Great care was dedicated to the overlap of the finishing elements, so as to ensure a good weather seal (Oliver, 1997). Among lightweight building envelopes it is worth to cite fabric curtains. The most famous examples are the tents of nomadic desert tribes, which are made of woollen strips stitched together longitudinally, which provide shade in desert climates by functioning according to the principle of cable traction (Oliver, 1997).

Further elements made with lightweight technologies were partition walls, which were made of a timber framework, spanning from floor to ceiling, that supported the wall surfaces which, in turn, consisted of timber strips or reeds with lime finish (Guallart Ramos, 2006; Sanna and Cuboni, 2009). These solutions allowed to rationalize the use of space, without subjecting the suspended floors to great stress. Furthermore they were easy to construct and disassemble, so they permitted flexibility in spatial organization.

Doors and windows were made of timber (Oliver, 1997), since they

needed to be easily conformable to the shape of the opening, not to weigh excessively on supporting structures and, most importantly, had to be easily manoeuvrable.

The same needs are shared by shading systems and wind protective shields. In particular, they have to be operable, in order to be used only in seasonal times of need. This is particularly the case of variable climates such the Mediterranean one (Coch, 1998). For example, in Andalusia, during summer time, curtains have been used to protect circulating roads from the sun (fig. 11).

Regarding the bioclimatic point of view, lightweight structures are particularly favourable for building in hot humid climates. As matter of fact, lightweight structures have the characteristic of offering at the same time shade and natural ventilation (fig. 12). These, according to scientific literature (Coch, 1998; Szokolay, 2006), are the two most efficient passive strategies in places with constant high temperatures and humidity. Vernacular buildings in such areas were constructed using frame supporting skeletons, finished with a breathable envelope which protected from the sun and the rain and, allowing at the same time the presence of a continuous air flow (Coch, 1998; Oliver, 1997).

Principles of sustainability in leightweight structures

The sustainability of vernacular lightweight structures lies mainly in their principal feature, which is that of having a relatively low weight and, indirectly, in the materials and techniques used to assemble them. From the environmental point of view, the lightweight framework ensures indoor environmental quality by controlling climatic effect. Framework supporting structures allow buildings to have very large openings as well as floors raised from the ground. These features are particularly useful to provide ventilation in the aforementioned hot wet climate (Coch, 1998). Envelope elements were made by superimposing plant elements, which were more or less woven, depending on the climate. In cold climates, the internal environment was protected by insulating layers, such as English and French thatched roofs. In warm climates, plant meshes were larger, with the purpose of guaranteeing both shade and ventilation at the same time. Using local available materials, of both vegetable and animal origins, combined with the use of dry construction methods, minimized hazard impacts in the building life cycle. As for building materials, they were easily accessible, their supply was regenerated in a short time, and they were perishable and recyclable, due to which

Fig. 10 Nomad tent, Ouarzazate Province, Morocco (photo: J. Hope).

Fig. 11 Lightweight shading system in Andalusia, Spain (photo: L. G.F. Cannas).

they did not produce any kind of pollution. The construction techniques were low-rate processing, and therefore low-energy consuming. Lightweight structures were also easy to demolish if necessary. This means that buildings could be easily maintained and modified, prolonging their useful life.

Lightweight structures met socio-cultural needs because their ephemeral nature supported a particular lifestyle. They represented a rational solution for needs determined by economic activities, or by the natural dynamics of the places. Breeding animals leads to a nomadic lifestyle. In order to follow animals in seasonal movements, lightweight shelters can be made.

The duration of lightweight may be seasonal or longer, in any case the commitment of resources involved in them was optimized for the required use. This consideration could be made also for building in areas prone to natural hazards, as lightweight structures could be built also in order to resist to them, such as in the case of flooding (building on piles) or earthquakes (thanks to the elasticity of both bamboo and timber).

The same considerations applies to the environmental sustainability of lightweight structures. Reduced environmental impact is convertible into economic terms. As matter of fact, saving material, energy and time resources also implies an economic effort content. As mentioned previously, the materials used were local materials, easy available, workable and manoeuvrable. The construction techniques were quick and easy to assemble and, above all, allowed disassembly in an equally simple way. This meant quick and easy maintenance and modification of the building.

Weakness and lacks in the vernacular strategy

The defects of these vernacular lightweight structures are related to the organic origin of its materials. The consequence of this is a lack of uniformity and a tendency to rapid decay (Oliver, 1997). Weathering brings decay and fosters the proliferation of fungi and insects (Oliver, 1997). Fire is also a problem (Oliver, 1997). As Oliver stated "Vernacular builders address these weakness through careful selection and arrangement of the elements". (Oliver, 1997). This means that to realize thin kind of buildings it is necessary to know well the related building culture. For instance, It is necessary to collect the building material only at certain times of the year, which are related to the biological cycles. Today most of this building *know-how* has been lost. In certain respects it can be considered as a time-consuming manufacturing process, that is inoperable in our time-cost concept society (Zupancic, 2009).

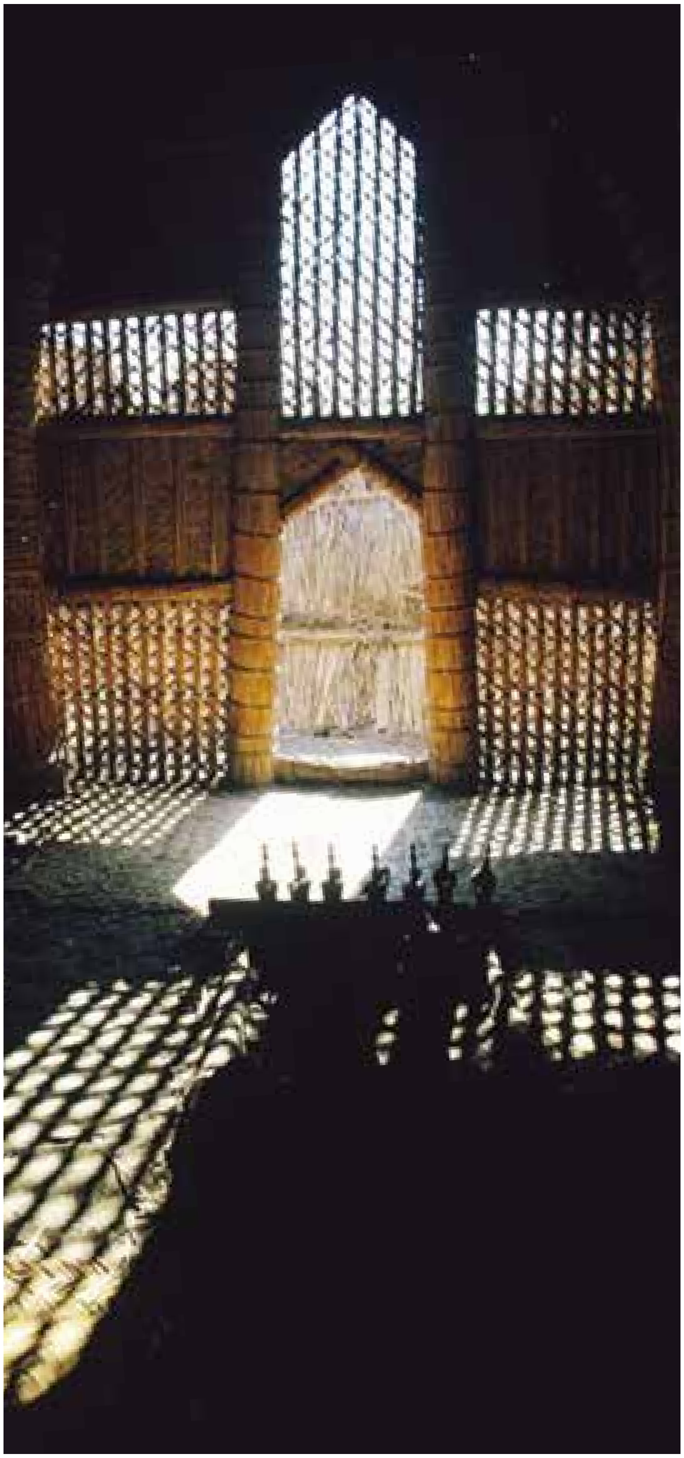
Lessons and contributions for contemporary architecture

The lessons we can learn from vernacular lightweight structures, for contemporary sustainable architecture, are strategic design principles. As it has already been said, due to their weakness, vernacular lightweight technologies can not be simply copied and proposed today as building solutions. However, as Zupancic has also stated (Zupancic, 2009), the needs that have determined their development are still present today, so it is worth to explore the possibilities offered by their design principles, using contemporary materials that go beyond vernacular material technical limits.

The benefits of using lightweight structures will be illustrated bellow, regarding both intrinsic technical characteristics and building technologies.

Vernacular lightweight structures are a source of inspiration for designing optimized bearing structures. By this we understand sup-

Fig. 12 Mudhif traditional reed community structure in the swamps of southern Iraq, Al Kuthra, Iraq (photo: J. Gordon).



porting structures which have a self-weight-to-bearing capacity ratio (Torricelli et al., 2001). Through spatial configurations that make the most of the mechanical strength of materials, lightweight structures are capable of spanning wider than it is technically possible with other technologies, or cover equal lengths or carry equal loads with a great saving of material. This last consideration especially is valid regarding environmental respect, through the judicious use of resources.

Lightweight structures are suitable for meeting bioclimatic needs in particular conditions. Due to their lightness and their lack of thermal inertia, they are appropriate in every climate in which the use of solar radiation and temperature variation by envelope thermal inertia is not convenient (Coch, 1998). It is the case of the already mentioned hot wet climate as well as of cold climates (Coch, 1998), as long as the envelope has low thermal transmittance.

By combining vernacular dry constructive techniques with contemporary prefabricated materials, It is possible to have sensible benefits in terms of speed and certainty of execution. This could have significance in economic terms, or regarding post-disaster management. These technologies could also encourage a return to self-construction.

Finally, vernacular lightweight structures could exemplify how to manage some fundamental phases of the building life-cycle, such as maintenance, demolition and recycling. Those phases have been neglected for a long time, however now it is clear that they are a crucial aspect of building sustainability.

In fact, building elements that can be easily disassembled allow for the programming of maintenance, thus minimizing costs and improving the durability of the building. They also allow building in fragile contexts, in which impermanent and reversible solutions are mandatory, such as in the case of protected landscapes and buildings (Biagi, 2009).

Lightewight structures are suitable in areas with strong seismicity, due to the correlation between structural mass and inertial force. Timber structures are ductile and therefore able to move with the force of the earthquake and dissipate its impact.

SARDINIAN *BARACCAS*

SARDINIA, ITALY

author
Leonardo G. F. Cannas

ENVIRONMENTAL PRINCIPLES

to respect environmental context and landscape · to benefit of natural and climatic resources · to reduce pollution and waste materials · to contribute to human health and welfare · to reduce natural hazards effects

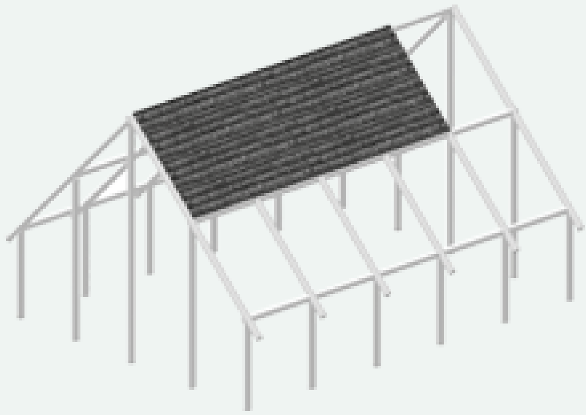
SOCIO-CULTURAL PRINCIPLES

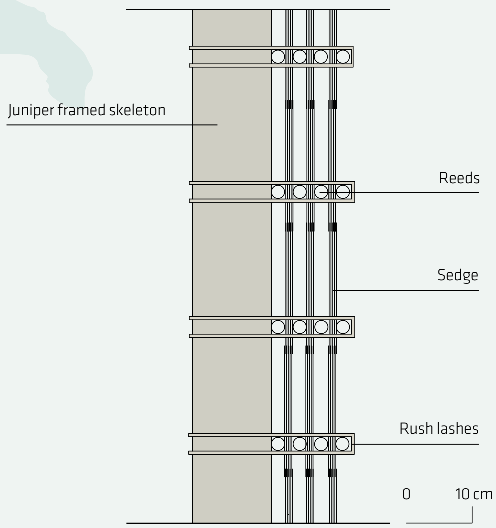
to protect the cultural landscape · to transfer construction cultures · to enhance innovative and creative solutions · to recognise intangible values · to encourage social cohesion

SOCIO-ECONOMIC PRINCIPLES

to support autonomy · to promote local activities · to optimise construction efforts · to extend building's lifetime · to save resources

Baraccas were makeshift habitations used by fishermen, that were built on the shores of lagoons, or the sea, in the Sinis Peninsula (Manca Cossu et al., 2005). The Sinis Peninsula is situated in the middle of the west coast of Sardinia. This geographic area is a flat territory, characterized by the presence of many wetlands, for example the estuary of the river Tirso, the pond of Cabras, and the Mistras Lagoon (Area Marina Protetta 'Penisola del Sinis-Isola di Mal di Ventre' n.d.; Manca Cossu et al., 2005). This area, which includes a fifty kilometer-long coast, the main economic activity was fishing. As for locally available building resources, there is an abundance of materials of plant origin, such as juniper wood, reeds, rush and sedge. *Baraccas* are rectangular huts with double pitch roofs (Mossa, 1992). The load-bearing building element was a juniper framed skeleton (Manca Cossu et al., 2005; Mossa, 1992), while the building envelope, both roof and walls, was made out of overlapping layers of sedge, fastened with reeds that were placed horizontally and tied to the framed skeleton with rush lashes (Manca Cossu et al., 2005; Mossa, 1992). The building effort was reasonable for the temporary use of these buildings. *Baraccas* were built in two months by the owner himself with the help of two or three labourers, using an entirely manual building process (Manca Cossu et al., 2005). *Baraccas* guaranteed good micro-climatic conditions, thanks to the properties of sedge, which dilates in winter, due to the high humidity, and contracts in summer, due to the high temperatures, thus allowing ventilation when necessary (Sardegna Digital Library, 2014). The envelopes required maintenance every four to five years. At the end of their life cycle, *baraccas* could be easily disassembled or simply left to be dismantled by the natural elements.





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Baraccas axonometric scheme (drawings: L. G. F. Cannas. Based on *Architecture Naturale: Cabras* 2002>04).
Baraccas cross section (drawings: L. G. F. Cannas).

↓

Baracca, San Giovanni del Sinis, Sardinia (photos: L. G.F. Cannas).

TABICCU
SARDINIA, ITALY

author
Leonardo G. F. Cannas

ENVIRONMENTAL PRINCIPLES

to respect environmental context and landscape · to benefit of natural and climatic resources · to reduce pollution and waste materials · to contribute to human health and welfare · to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

to protect the cultural landscape · to transfer construction cultures · to enhance innovative and creative solutions · to recognise intangible values · to encourage social cohesion

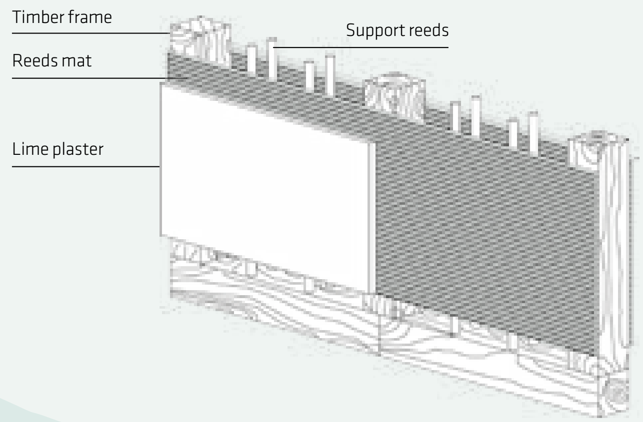
SOCIO-ECONOMIC PRINCIPLES

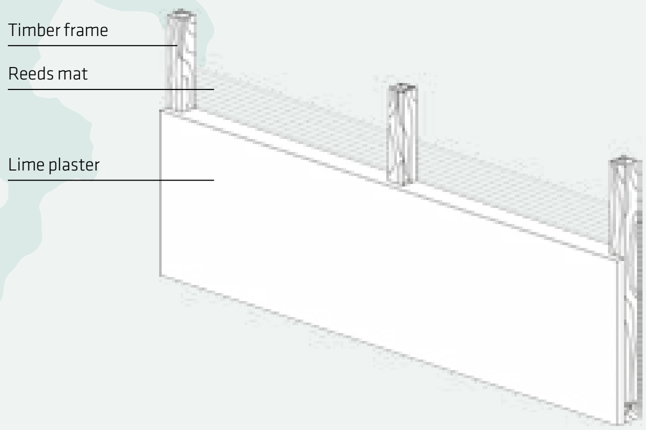
to support autonomy · to promote local activities · to optimise construction efforts · to extend building's lifetime · to save resources

Tabiccus are the vernacular partition walls used in Sardinia from 1800 until 1950. *Tabiccus* have been realized in very different contexts: they belonged to the earthen heritage with an agricultural vocation, as well as to the stone buildings of mountainous people involved in sheep farming activities.

According to scientific literature (Sanna and Cuboni, 2009), they were made using a framework of timber, spanning from floor to ceiling, that supported the wall surfaces. Depending on the material availability, the wall surface was made of reed mats or reed mats and mud infill. A lime finishing was also present. Where reeds were not available the wall surface was made using only painted timber planks, without lime finishing. Horizontal timber beams were placed on the ceiling, the floor and as lintels at openings.

Lightness was a mandatory characteristic for these building elements, in particular when they were realized on suspended floors. First they were used to envelope the stair-case, then to create bedrooms and finally to create toilets in the residual spaces (Sanna and Cuboni, 2009). Their application allowed a better utilization of the interiors, providing divisions between the different functions, eliminating sources of mutual disturbance, and offering greater privacy. *Tabiccus* were also prone to be easily modified, thus providing flexibility for the building.





→ Axonometric view of a traditional Sardinian partition wall; axonometric view of a traditional Sardinian partition wall, single reed mat version (drawings: L. G.F. Cannas. Based on *Manuali del Recupero dei Centri Storici della Sardegna*).

↓ Sardinian vernacular partition wall or *tabiccu* (photo: M. Achenza).
Tabiccu underway (photo: M. Serra).
Sardinian vernacular partition wall or *tabiccu* (photo: Associazione Nazionale Città della Terra Cruda).

PAPER LOG HOUSES

KOBE, JAPAN

Architect: Shigeru Ban

author

Leonardo G. F. Cannas

ENVIRONMENTAL PRINCIPLES

■ to respect environmental context and landscape ■ to benefit of natural and climatic resources ■ to reduce pollution and waste materials ■ to contribute to human health and welfare ■ to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

■ to protect the cultural landscape ■ to transfer construction cultures ■ to enhance innovative and creative solutions ■ to recognise intangible values ■ to encourage social cohesion

SOCIO-ECONOMIC PRINCIPLES

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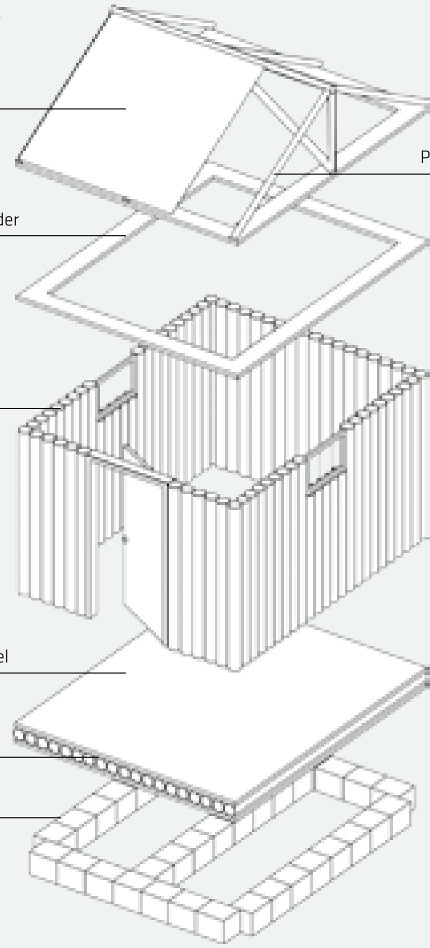
Paper Log Houses are temporary shelters for victims of disasters. They are based on the project of the Japanese architect Shigeru Ban. They were realized for the first time in 1995, in occasion of the Kobe earthquake, in Japan. They were used for the earthquakes in Turkey, 2000, in India, 2001, and for the typhoon in Philippines, 2013 (Shigeru Ban Architects, *n. d.*). The general constructive logic involves the use of lightweight prefabricated inexpensive materials which are essentially either locally available or recycled and which can be dry-assembled without the aid of skilled manpower. The name derives from the material used for the load-bearing elements: 106 mm diameter, 4 mm thick paper tubes, made with recycled paper. The first version of the house was made in this way: a basement made from beer crates loaded with sandbags, two plywood panels, separated by paper tubes, as floor, load-bearing walls made by placing vertical paper tubes, and a paper tube framework to support the roof envelope made by tenting material (Shigeru Ban Architects, *n.d.*). In time, this configuration was adapted to different contexts. For instance, in the Philippines, which is characterized by hot wet climate, paper tubes were used as a framework skeleton that supports a building envelope made with vernacular woven bamboo sheets (Shigeru Ban Architects, *n.d.*). Paper Tube Houses are based on a building technology that is originated by combining vernacular principles (local adaptation, dry assemblage, using recycled materials, and so on) with contemporary industrial materials. The result is a shelter of reasonable quality, in terms of appearance and thermal control, very inexpensive, very rapid to be built and also easy to be disposed of, recycled or re-used.



Axonometric scheme of the Kobe paper log house.
(drawing: L. G.F. Cannas. Based on www.shigerubanarchitects.com)

Paper log house in Japan; paper log house in India; interior of paper log house in India.
(photos: Forgemind ArchiMedia. CC BY 2.0)


10

Wooden frame building in Kastaneri, Greece (photo: S.Mecca).

Earthquake resistant systems

Letizia Dipasquale, Dalia Omar Sidik, Saverio Mecca
University of Florence, Florence, Italy

Seismic culture and vernacular earthquake resistant techniques

In regions affected by frequent and high intensity earthquakes, local communities have developed vernacular strategies to protect themselves from the risk, such as building systems or specific devices, designed to reduce the vulnerability of their building habitats. Seismic vernacular reinforcements are numerous, and in a lot of instances, depend on available materials, local building cultures and the skills of the builders. The entirety of knowledge, both pragmatic and theoretical, that has built up in a community exposed to seismic risks through time can be described as a seismic culture (Homan et al., 2001). The local seismic cultures include the earthquake-resistant regulations which have not been formally laid out in written code but which are still visible in the building characteristics, in the choice of the site and in the general layout of the territory (Ferrigni, 2007). The origins and persistence of a local seismic culture can be determinate both by the scale of intensity and the frequency with which the earthquakes occur, and the economic and social conditions, including resource availability and the cultural traditions (Ferrigni et al, 2005). The ancient builders used all the well-known constructive criteria and devices to build houses able to resist earthquakes; perfecting them with time and experience, and comparing the performance of these systems with respect to the effects caused by earthquakes. In this way a process of technical evolution by experimental testing has been developed, that is based on the direct observation of the real behaviour, following telluric forces.

Buildings seismic response and requirements for earthquake resistance

Most of the buildings in Mediterranean area are made of bearing masonry walls. Masonry buildings are vulnerable to seismic event, since they are constituted by the assembly of heterogeneous elements and materials (as stones, earth or clay bricks), whose characteristic is the not tensile strength. The seismic forces are transmitted through the soil at the base of the building as horizontal actions. These forces give rise to a rotation out of lane at the base of the wall perpendicular to the direction of the earthquake, which tent to an overturning (first way of damage) and a consequent partial or general collapse of the masonry building. If the bonds between the orthogonal walls are effective, the building shows a box-like behaviour: the overturn is avoided and the horizontal actions are transferred on the walls in the direction of the earthquake, as shear actions that produce diagonal cracks primarily distributed along the mortar joints (second way of damage).

The observation of the damages on the buildings affected by the earthquake and the identification of the main mechanisms of damage enable the identification of elements that affect the seismic behaviour of masonry buildings. Under seismic action, in order to avoid the first way of damage, the structure has to guarantee a box-like behavior that can be achieved through good connections in the corners between perpendicular walls and effective horizontal tying elements. The openings represent a discontinuity on the wall surface and a proper distribution and dimensioning is a fundamental anti-seismic rule. The wall is the base element of the masonry buildings and under horizontal forces it has to behave as a monolithic structural element. From the good workmanship depend the mechanical properties of the wall and the ability to perform small oscillations under seismic actions maintaining the integrity of the thickness. In general, the experience shows that masonry building, if properly designed and build according the rules of the art, have high chances to respond satisfactory to the earthquake.

Vernacular earthquake resistant strategies

Living under seismic risk, local builder had introduced technical solutions and technological devices, whose choice is a natural selection dictated by the climatic context and locally available materials. As safeguarding measures, in various historical and geographical contexts, can be found the adoption of geometrical and typological solutions, as the use of massive walls and buttresses or the disposition of the walls in dense orthogonal meshes, or through a technological and constructive approach by the introduction of wooden devices within the masonry structure.

The combination of materials with different characteristics between them, allow to give rise to a system responding against the damages produced by the horizontal actions: the excellent elastic properties of wood, the characteristics of flexibility and deformability without reaching break, allow the mitigation of the effects of the earthquakes on the buildings.

M. Correia, L. Dipasquale, S. Mecca (edited by), *VERSUS: Heritage for Tomorrow. Vernacular Knowledge for Sustainable Architecture*, ISBN (online) 978-88-6655-742-5, ISBN (print) 978-88-6655-741-8,

Fig. 1 Rows of bricks used for wall reinforcement, Lamezia, Calabria, Italy (photo: L. Dipasquale).

Fig. 2 Reinforcing all the ground floor at Civita di Bagnoregio, Lazio, Italy (photo: S. Onnis).

Fig. 3 Butress in a masonry building, Naples, Italy (photo: L. Dipasquale).

Historical earthquake resistant strategies in Mediterranean area

Amongst the ancient cultures the Cretan (2000-1200 BC) and Mycenaean (in the fourteenth century BC) had developed a great sensitivity towards earthquakes. Archaeological excavations have revealed some strategies for earthquake proof buildings used in the ancient buildings. Amongst the remains there exists masonry composed of limestone and gypsum stones, where some of stone elements are placed systematically in the direction perpendicular to the wall. The walls intersect each other tightly and, always crossing at right angles, form dense rectangular mesh networks. This planimetric configuration allows the creation of patterns capable of withstanding strict regimes of dynamic stress. In addition, the work of archaeologists have unveiled inside the large stone blocks, the housings of large pins crossing the rocks to accommodate wooden connecting elements, with the purpose to keep the various blocks connected and to give a strong plasticity to the whole structure.

In ancient Roman building traditions, rows of bricks were set down horizontally through the conglomerate wall section, functioning not only to connect and reinforce, but at the same time serving to interrupt the possible spreading of cracks. This technique is still visible in many stone walls of the Italian historic cities (fig. 1).

Masonry reinforcement measures

In seismic regions where stone, earth or bricks masonry is the prevalent building technique, the most frequent prevention and/or reinforcement measures consist of adopting the mechanism of mutual contrast between (or part of) the buildings to counteract horizontal forces. Following are described the most common traditional devices used to the scope of contrast and seismic reinforcement in vernacular masonry buildings.

- *Buttress*, or *counterfort*, with a rectangular or trapezoidal cross-section, are made of strong materials, such as brick or stone. They are placed against and embedded to the wall in more stressed areas, to resist the side thrust created by the load on an

Fig. 4 Anchor plates in a stone building in Florence, Italy (photo: L. Dipasquale).

Fig. 5 Anchor plates in a rammed earth building, Mertola, Portugal (photo: M. Correia).



Fig. 6, 7, 8 Reinforcement and discharging counter arches in Anghiari (Tuscany), Ostuni (Apulia) and Palermo (Sicily), Italy (photos: L. Dipasquale).

arch or a roof. Buttress can be added to existing walls or they can be built at the same time as the building, with the purpose to reinforce corners or walls with wide openings (fig. 1-3). In Southern Italy and in southern France, the traditional *loggia* can be seen as an evolution of the buttress system (Ferrigni et al., 2005). It is used as reinforcement at the base of the building and at the same time it provides a shading space at the entrance of the house.

- *Anchor plate* (or *wall washer)* is an iron plate, connected to a tie rod or bolt, used to assembly the braces the masonry wall against lateral bowing. Iron-rods are stretched across the building from wall to wall, creating a horizontal clamping between the outer walls of the building. Anchor plates are made of cast iron, sometimes wrought iron or steel and can be also fixed at the ends of the wooden floor beams. This technique is used on brick, stone, or other masonry-based buildings (Bucher, 1996, p.576) (fig. 4, 5).
- *Reinforcement or discharging arches* are stone or bricks masonry arches set between two opposed buildings separated by a small street or a narrow passage. They allow the transmission of horizontal constraints to the opposite building at the level of the floor. In this way buildings behave as an ensemble of dynamics block, not as isolated elements (fig. 6-8).
- *Lowering the centre of gravity.* Several techniques were used to increase buildings stability by concentrating their mass closer to the ground**.** The most common solution is the use of increasingly lighter materials. In the ground floor walls are heavier, being made by strong and compact stone (responding also at the need to resist to water pounding the base of the building), and present higher depth than in the upper floors. In the South of Italy vaulted spaces at the ground floor are very common. After the earthquake of 1793 in South-East of Sicily, for example, almost all the ground levels of reconstructed building are covered by a masonry vaulted structure, while the intermediate floor structure is made of wood. Also buttress and staircases at the base of the walls contribute to lower the centre of gravity of the building (fig. 9, 10).

Fig. 9 Stone masonry vaults increase the mass of the building at the ground floor and create a solid connection between opposed walls. Lunigiana, Tuscany, Italy (photo: L. Dipasquale).

Fig. 10 External staircases lower the centre of gravity of the building and reinforce its base Ragusa, Sicily, Italy (photo: L. Dipasquale).

Fig. 11 Masonry building with timber hooping in Albania (photo: I. Hasa).

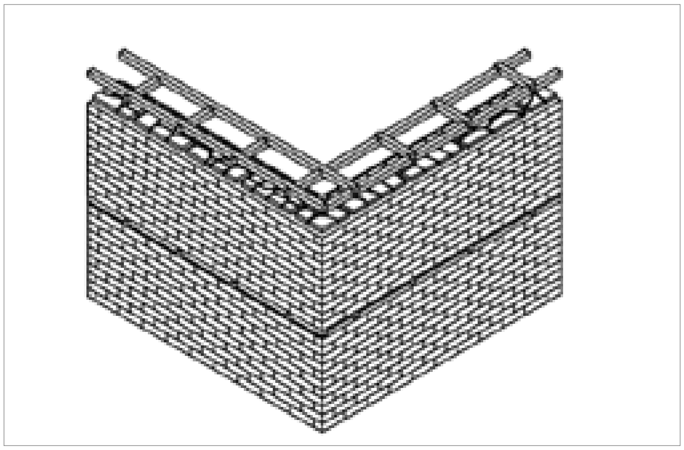


Fig. 12 Building system scheme of timber hooping (drawing: D. Omar Sidik).

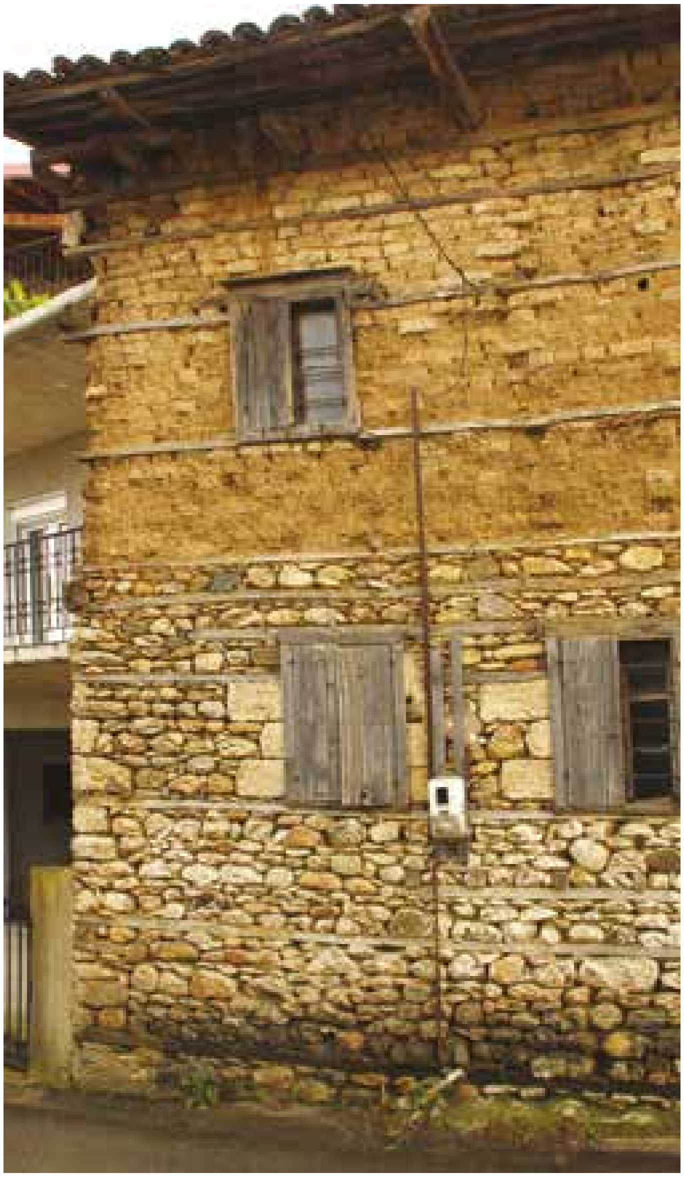


Fig. 13 Stone and adobe building with hooping reinforcement in Kastaneri, Greece (photo: S. Mecca).

Timber frame earthquake resistant reinforcement

In areas where earthquakes are endemic, a recurring strategy is the use of wooden elements as devices to improve the earthquake-resistant performance of the building, and also to increase the structural behaviour of the stone, adobe or bricks masonries.

The great elastic properties of wood, its characteristics of flexibility, lightness and deformability without reaching the breaking point, offers good resistance capacity against horizontal loads, and enables the dissipation of substantial amounts of energy. Moreover, timber elements divide the structure into sections, which prevent the spread of cracks occurring in portions of the masonry. By creating horizontal and vertical connections, wooden devices applied to structures with good compression behaviour (such as stone, adobe or brick masonry) can improve the resistance to shearing, bending and torsion forces.

There can be various uses of wood as earthquake-proof reinforcement material, but two main categories can be indentified: the *hooping* and the *frame systems*.

The first provides the arrangement of the circular or square section wooden beams, horizontally disposed within the load-bearing masonry during the construction phase (fig. 11-13). In many cases two beams are used, one to the inner side of the wall and the other to the outer, connected by transverse wooden pieces. The empty spaces between the beams are filled with fragments of brick or stone. Interlocking systems of nailing's are used for the connections between perpendicular elements. The ring beams can be inserted at the height of the floors, in correspondence to the openings and lintels or regularly distributed along the height of the construction.

This system can be found elsewhere in seismic regions of Mediterranean areas: from Balkans, to Turkey, Maghreb Greece (it is systematically used in houses in Akrotiri on the island of Santorini) and Italy.

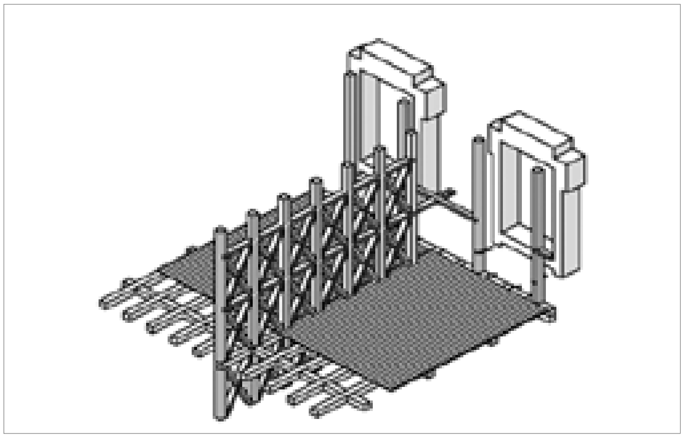


Fig. 14 Gaiola building system in the downtown of Lisbon center, Portugal (drawing: D. Omar Sidik).

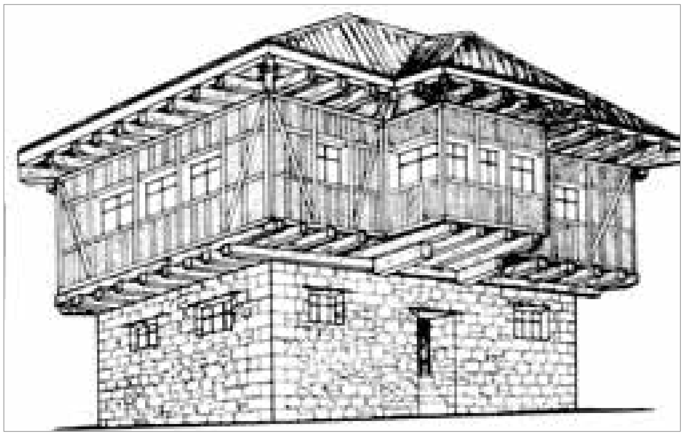


Fig. 15 Wooden frame uilging system of traditional ooden frame system on the upper floor is Adapazari, Turkey (drawing: M. Ciampa).

The second category include wooden frame systems, which are articulated in round or square section beams and pillars, and frequently, diagonal bracing elements. The empty spaces defined by the frame are filled with locally available materials (earth, stone or brick). If the beams are not as long as the entire wall, timbers are connected together through elaborate interlocking systems. In some cases the longitudinal beams are held together in the thickness of the wall by transverse elements that are wedged or nailed, and the corners present additional reinforcement.

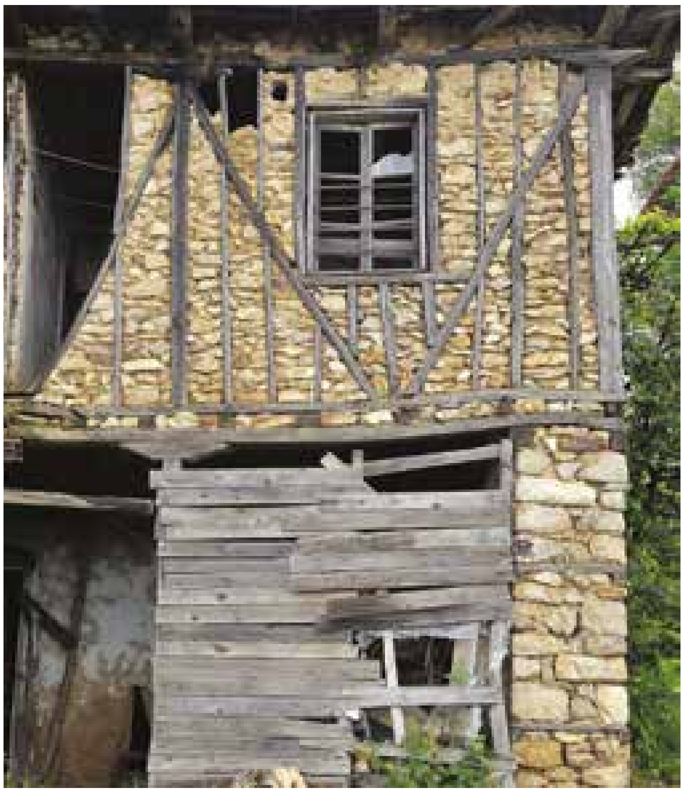
One of the most ancient examples in Italy of timber-frame buildings techniques is the *opus craticium* by Vitruvius, today visible in some of the surviving houses of the archaeological sites of Herculaneum and Pompei. The *opus craticium*, was largely diffused in the Roman Provinces, and later developed in different ways in a large number of Mediterranean and European areas.

In the Mediterranean area relevant traditional examples of timber frame structures together with masonry can be found in Turkey[1], in Greece and parts of Eastern Europe. In these countries common traditional buildings techniques are based on the use of masonry laced bearing wall constructions on the ground floor level, and lighter infill-frames for the upper stories. The ground floor masonry walls are often laced with horizontal timbers; these elements can be thin timber boards laid into the wall placed so that they overlap at the corners or squared wooden beams.

[1] In northern Anatolia, traditional wooden frame type building type, called *Duzce*, consist of a massive foundation walls constructed with stone (sometimes built up to the first floor), while upper floors have timber framed structures with stone or brick infill. *hımış* buildings are composed by a timber frame filled with stone, adobe or brick. In the building constructive system called *Bagdadí*, the voids between the timber frame structural elements are filled with lighter construction elements such as lime mortar or plaster applied on timber laths.

A very significant example of the use of timber framed structures for masonry anti-seismic reinforcement is the so-called *gaiola* system, diffused in Lisbon after the earthquake of 1755. The technique of *gaiola* includes the use of the 'Pombalino' wall (fig. 14). This system consists of a set of timber members, embedded along the inner face of the main stone masonry façade wall. The timber elements are made of oak or holm oak squared beams, with a section of 9-12 cm^2. The wooden elements of the structure are framed form-

Fig. 16 House with a stone-built ground floor and a wooden frame structures with stones infill in the region of Gotse Delchev , Bulgaria (photo: S. Mecca).



ing a pair of crossing braces, called in Italy *St. Andrews Cross* and are connected with both the walls and the floors timber beams, forming a cage (*gaiola*) (Ruggeri et al, 1998, Gulkan, 2004, Paula et al, 2006). The frame is filled with brick, whole and broken pieces, and stone rubble. The interior walls are covered with plaster, hiding the infill and the timber frame. The building is no more than four storeys high, with masonry arcades at the ground floor level, external structural masonry walls (*gaiolas*), internal timber-masonry walls (*frontais*), and internal partition walls (*tabiques*) (fig. 5). All these structural elements combined have very good anti-seismic performances, as many experimental studies have shown.

Wooden frame structure are used in many earthquake vulnerable areas in Latin America, Eastern Europe, Middle East, and Asia. The constructive system is always based on a grid of wooden poles making the main structure, while infill techniques vary depending on materials locally available (stones, bricks, adobe, cob, daub or mixed materials). Many studies, proving the seismic resistance of wooden structure, are developed in Turkey, Bangadlesh, India, Pakistan, Haiti[2], Chile, Italy and other countries recently affected by earthquakes.

Timber frame system – using traditional timber housing system, light timber frame systems or platform systems, and new type of techniques such as crossed laminated timber – begins to be extensively used across northern Europe countries and European seismic zones, because of its many positive factors besides the good seismic inertia, such as the low environmental impact of the material, the higher level of industrialization and prefabrication, and the short time of assembly in the building process.

Sustainability of vernacular earthquake resistant strategies

Nowadays advanced technologic systems – such as base isolation and vibration control, or new materials as large space membranes, etc. – allow to build structures with the highest level of seismic inertia. However, the elevate earthquake resistance is not ever corresponding to a good level of sustainability of the building. Vernacular architecture has proven to be resilient in disaster prone areas due to its evolution over time and ability to adapt to nature. Using vernacular systems and adapting them to properly evolve, can reconnect inhabitants to their history and their cultural heritage, and provide environments that can respond to future disaster with even greater resilience (Audefroy, 2011).

Underling the characteristic of sustainability of vernacular seismic resistant techniques we would demonstrate the value of local knowledge, skills and capacity to find new appropriate solutions and to make societies increasingly resilient to natural hazards.

Environmental sustainability

The knowledge contained in vernacular constructive systems can help improve project implementation by providing valuable information about the local context. Starting from the analysis and understanding of local constructive systems help to find appropriate solutions for improving the seismic resistance of buildings, which are connected with the place and its characteristics. The benefits of employing local materials and low-tech solution inspired by vernacular constructive systems are numerous: arousing wider ecological benefits, enhancing local resources, saving energy, reducing transports and pollution, and definitely favours a deeper respect the environment.

Sociocultural sustainability

The incorporation of local knowledge in reconstruction policies encourages the participation of the affected community and empowers its members to take the leading role in all disaster risk reduction activities (Shaw et al., 2008; Mulligan and Nadarajah, 2011). The scope of local knowledge, skills and capacity is very wide and it encompasses technical, social, cultural and other forms of knowledge. The building culture, as already seen, performs an important role as a vehicle to express values and identity, and have a powerful influence on people's choices, behaviours and wellbeing. The acknowledgment and conservation of the vernacular cultural heritage, fair access to it and equitable sharing of the benefits deriving from its use enhance the feeling of place and belonging, mutual respect and sense of collective purpose, and ability to maintain a common good, which has the potential to contribute to the social cohesion of a community and strengthening the social relations and a collective maintenance culture (Shaw et al., 2008). Local communities can be empowered to reduce the risk from and vulnerability to the natural haz-

[2]An analysis on local building practices conducted by CRAterre, in collaboration with Haitian association, between 2012 and 2012 demonstrated that the damages on traditional wooden frame housing (Clissage were very limited and concerned mostly the plaster (Caimi et al. 2013).

ards they face through better and more accurate engagement and participation. Moreover, community participation in this process can help to define more suitable and efficient techniques and buildings can receive adequate maintenance and undergo compatible modifications when people is familiar with the constructive techniques.

Socio-economic sustainability

The socio-economic environment needs to be taken into account in a profound way in the seismic design. A properly seismic resistant structure does not necessarily have to be extremely strong or expensive. It has to be properly designed to withstand the seismic effects while sustaining an acceptable level of damage.

Traditional structures proving a good behaviour against the impact of natural hazard, can be an affordable start point to build improved resilient buildings. Indeed, in case of earthquakes, damage mostly affected the secondary structures of traditional seismic resistant buildings, while the main structure were preserved, making them easily repairable, both financially and technically (Caimi, 2013; Jigyasu, 2008; Audefroy, 2011; Mulligan and Nadarajah, 2011). Therefore, in post-disaster phase the use of local materials, technique and skills can optimize construction efforts, enhance local activity and reinforce the community self-sufficiency.

Using local knowledge and systems to built future seismic resistant constructions

It is widely demonstrated that local wisdom can offer useful input to find even new earthquake resistant solution, since traditional construction and technologies have been tested over generations and are best suited to local environment and cultures.

Building knowledge and know-how learned over the years in seismic areas have for centuries formed the unwritten earthquakes resistant building codes; these were codified in recommendation and regulation only since the eighteenth century. Observing the traditional earthquakes resistant structures we have understood some common rules that can improve the seismic inertia of the buildings, such as: a good execution of the work, a good connection between the elements of the buildings (walls, floors, roof, façade elements..), a progressive reduction of materials weight from the bottom to the top of the building, devices capable of counteracting horizontal forces, and systems able to increase the ductility of the buildings.

Despite traditional building knowledge has potential for mitigation against earthquakes, when we look at the actual situation, vernacular communities are often most adversely affected from natural hazards.

This occurs because a culture of conservation and maintenance is not so diffused, and local knowledge, skills and capacities for disaster mitigation are often obscured by the impact of existing development models and last transformation processes. Houses constructed with traditional good quality materials performed poorly when built without proper and professional knowledge, such as, in absence of proper application of professional know-how, even reinforced concrete structures can became highly hazardous during severe shaking (Shaw et al., 2008).

Afterwards one of the missions of the scientific community is to better understand traditional knowledge while also recognizing how this knowledge can evolve and innovate to work with modern materials and techniques. Reducing the vulnerability of ancient buildings, as well as modern buildings, through the lessons of local seismic culture can achieve an appropriate and innovative response to emergencies. Therefore the appropriate use of modern techniques and materials, together with vernacular strategies and devices, can help to rehabilitate and improve traditional structures and thus combine safety with preservation of a rich architectural heritage.

Identifying and taking into account the local specificities of existing buildings and know-how can be the basis for improving construction methods and building skills, as well as a way to reduce the vulnerability of local communities in the long term.

The awareness of the extraordinary quality of many traditional solutions, and the interest in the preservation of this heritage and the building culture, represents essential achievements through which we can compose models for appropriate effective rehabilitations, future sustainable architectures and settlements. The recognition of local seismic cultures requires a systematic and homogeneous form of cataloguing and archive work, that can used to improve building codes, and to create protocols listing, which can aid technicians to identify suitable methods for protecting and reinforcing buildings against earthquakes, geared as closely as possible to the specific features of ancient buildings in the local area, respecting the original structural concept and, therefore, their authenticity.

THE *BARACCATA* HOUSE

CALABRIA, ITALY

author
Letizia Dipasquale, Dalia Omar Sidik

ENVIRONMENTAL PRINCIPLES

to respect environmental context and landscape · to benefit of natural and climatic resources · to reduce pollution and waste materials · to contribute to human health and welfare · to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

to protect the cultural landscape · to transfer construction cultures · to enhance innovative and creative solutions · to recognise intangible values · to encourage social cohesion

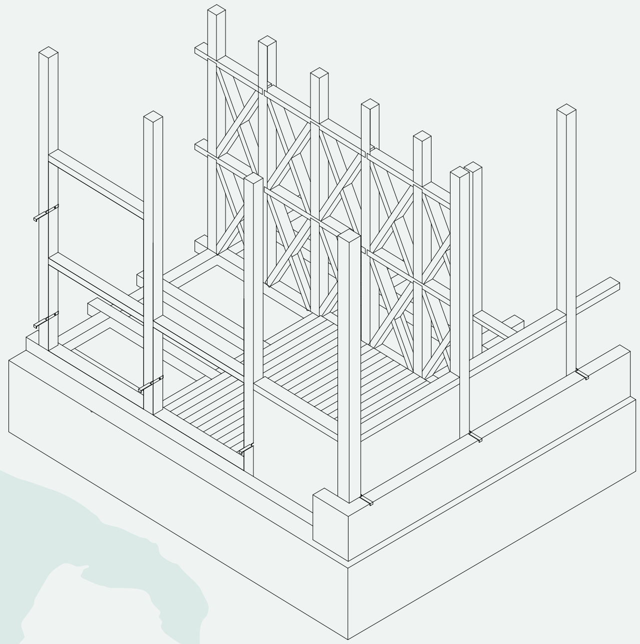
SOCIO-ECONOMIC PRINCIPLES

to support autonomy · to promote local activities · to optimise construction efforts · to extend building's lifetime · to save resources

The *baraccato* construction system has been widespread in Southern Italy from the fourteenth century and it was originally identified as temporary barracks used as shelter in the periods immediately after an earthquake. After the disastrous earthquake of 1783, the Bourbon government issued the guidelines for the construction of new earthquake resistant houses the technology of the *baraccata* house. The buildings are one or two stories high, with regular and symmetrical plant. The structural system consists in a masonry structure with a wooden frame integrate in its interior. The elements of the frame are not visible from the outside and are thus protected from the deterioration caused by insects and atmospheric agents. Beams and columns have a 10/12 cm wide square section and its are arranged in perimeter walls according to horizontal and vertical warpings, the partitions instead present St. Andrea cross ties. The masonry, consisting of stones or, in some cases, of raw earth bricks, collaborates with the inner wooden frame to provide a resistant behavior both against horizontal loads and horizontal seismic forces.

The good anti-seismic performance of this system was tested during the earthquakes that struck Calabria in 1905 and 1908, registering a magnitude of 9: the buildings suffered few significant damages and limited portions of masonry collapsed. In the following decades the *baraccata* system has not been implemented with the original rigor and often it present insecure timber connections; in the last decades it was definitely abandoned.

In 2013, a research conducted by the Italian National Research Council (CNR-Ivalsa) and the University of Calabria, scientifically demonstrated the validity of this building system as effective seismic resistant solution.

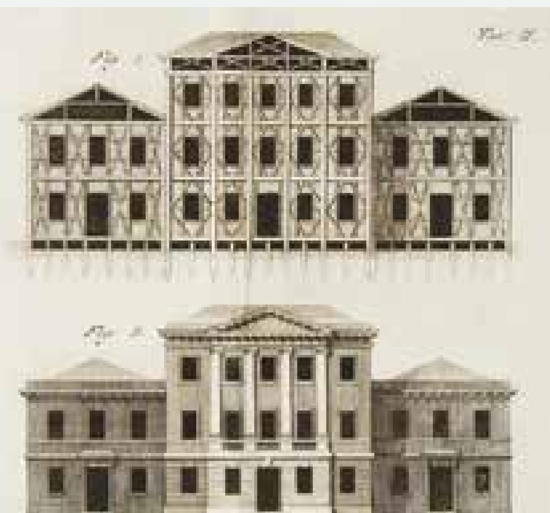


↑ The structural system of *Casa Baraccata* (drawing: D. Omar Sidik).

↓ *Casa baraccata* in the drawings of Giovanni Vivenzio.

Test in a vibrating table conductedz on a 1:1 scale portion of a wall of the bishop house of Mileto (Calabria), by the Italian National Research Council (CNR-Ivalsa) of San Michele (TN) and the Department of Earth Sciences, University of Calabria (UNICAL).

Old *baraccata* structure during restoration works site in Lamezia terme, Calabria, Italy (photo: E. Pelaia).



WOODEN FRAME FILL WITH *ADOBILLO* BLOCK

VALPARAÍSO, CHILE

Author
Natalia Jorquera

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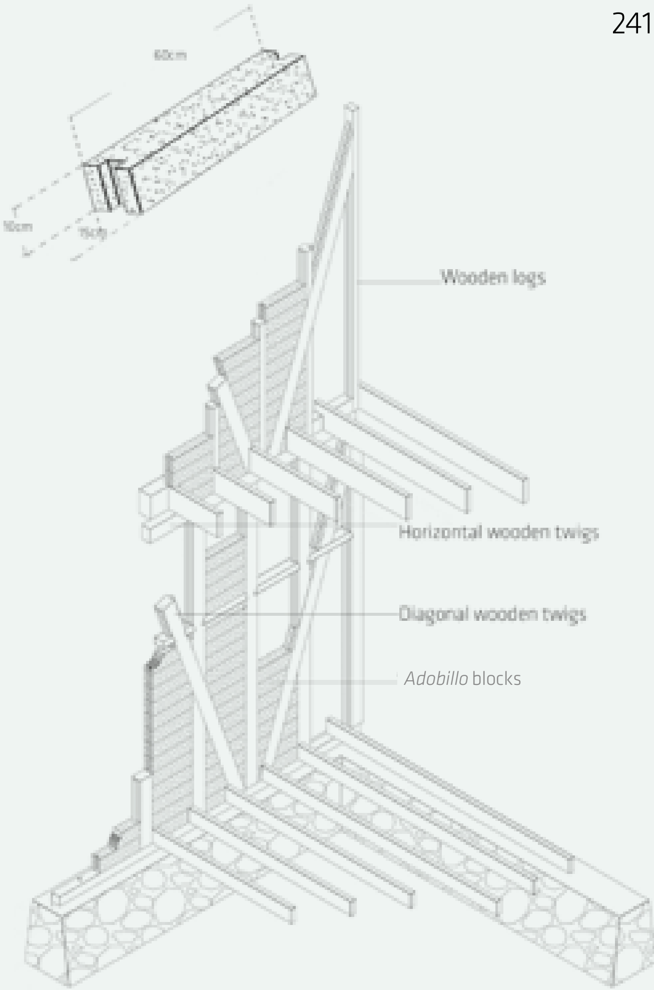
The *adobillo* is a daubed earth building system which originated in Valparaíso, Chile, in the middle of the 19th Century, when the city was the country's main harbour on the Pacific Ocean. At that time, hundreds of wooden logs used as ballast in ships arrived to the city, changing the old tradition of building with adobe masonry through a massive use of a mixed wood-earthen building system, which permitted an architecture that is able to adapt to the intricate topography of the hills of Valparaiso, as wood was the loadbearing structure.

The building system consists of a wooden frame composed by logs set systematically every 60cm, and horizontal twigs infilled with a special kind of earthen block of 60x15x10cm, which has the particularity of having two notches in every extreme of 1" in which a little piece of wood is introduced to fix the block into the wooden logs.

This very efficient mechanism of connection between wood structure and infill prevents the overturning of the blocks from the structure in the case of an earthquake and in fact, this technique became widely-spread after the earthquake of 1906 in Valparaiso, the biggest so far in the history of the city.

This technique is hidden under corrugated metal plates, which is why it is little-known, however much of the architecture of Valparaiso is built using it.

One last interesting aspect is that this technique represents a transition point between artisanal construction processes and modern standard ones, as a result of the incipient industrialization process experienced by the city in the 19th Century. It is interesting to notice how behind the variety of the vernacular architecture of Valparaiso, there exists this homogeneous and hidden building technique that has proven to be earthquake resistant until today.



The *adobillo* block and structural system (drawings: R. Cisternas).

Detail of *adobillo* technique. Corrugated plates that hide the technique
Valparaiso architecture built with *adobillo*.
(photos: R. Cisternas)

WOODEN FRAME STRUCTURE IN THE OTTOMAN HOUSE

TURKEY, GREECE, BALKAN AREA

authors

Dalia Omar Sidik, Letizia Dipasquale

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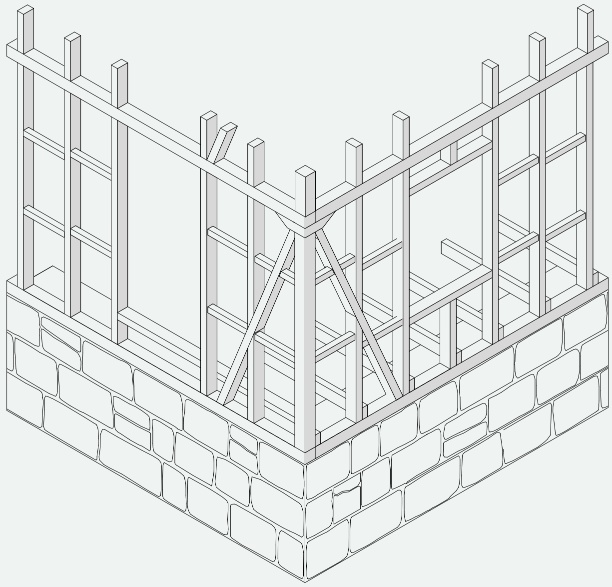
Wooden frame construction systems are widespread in Turkey and in the places that have been subjected to the influence the Ottoman empire, such as Greece and the Balkans. It consists of a wooden frame infilled with stones, bricks or adobe, held together by earthen mortar, and it takes many local variations depending on the materials available. The buildings realized with this technique can be isolated as rural housing, but also townhouses in the historic centers.

The structure usually consists of two or three floors above ground and a symmetrical plant. Foundations can reach great height and form a solid base of stone masonry. In many cases the whole ground floor in made by stone bearing masonry – often reinforced through the use of horizontal timbers embedded – while the timber framework is used for the upper floors.

The wooden frame is divided into a main structure of the timber elements, square section of about 15 cm to the side, horizontally and vertically arranged, and a secondary structure of sub-elements of smaller cross-section (10 cm side) placed in a horizontal, vertical and diagonal. The voids identified by the frame are generally filled with raw earth bricks, whole or portions of them, or stones and, in mountain environments, the filling is made with lightweight materials, such as wattle. The reduced thickness walls are coated with a layer of earthen plaster on the inner side and, in some regions, also on the external front. The wooden skeleton is usually visible. The roof is pitched and overhanging and it originally was made of straw and covered with earth.



↑ Ottoman wooden frame building system (drawing: D. Omar Sidik).

↓ Wooden frame building (locally called *hımış)* in Safranbolu, Karabük, Turkey (photo: Uğur Başak).

Wooden frame building in Albania (photo: I. Hasa).

Wooden frame building on the second floor of a building in Kastaneri, Greece (photo: S.Mecca).

CONTEMPORARY *QUINCHA*

VAL PARAISO, CHILE

author
Natalia Jorquera

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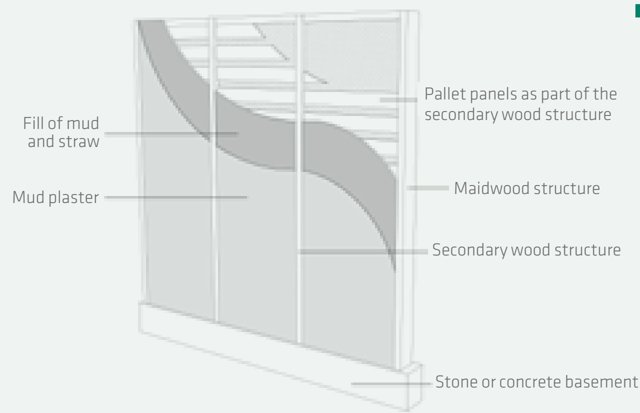
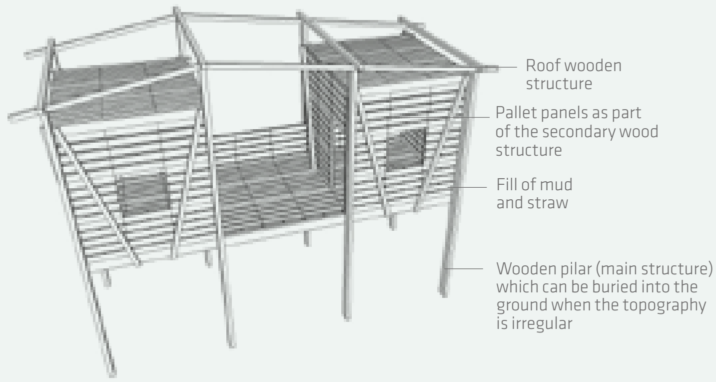
The *quincha* remains an alive constructive tradition in a seismic country like Chile, both in rural and urban areas, due to be an earthquake-resistant and very easy to build technique. In rural areas, especially in northern Chile, the technique is used in its traditional form, with a main half-timbered structure, a secondary reed structure and a fill of mud and straw. In urban areas the technique has been reinterpreted, where the main structure is made of industrial wooden or metal elements (in the latter case is called 'metal *quincha*'), the secondary structure is made of metallic mesh or waste components, while the fill is always made of a mixture of mud and straw.

Thanks to the ease and speed of construction of the *quincha*, is that it has been used in its contemporary version, in cases of emergency response. This is the case of the reconstruction of Valparaiso in central Chile after the big fire that hit the city in April 2014, where a group of inhabitants and volunteers spontaneously began to transform the huge amount of waste remained from the fire, in a *quincha*, to rebuild their homes. Thus, industrial wooden pillars have been used for the main structure, and rest of pieces of wood, wires or prefabricated wooden panels originated from packaging known as pallet, for the secondary structure. For filling, both the clayed soil and the recycled burnt adobe walls have been used.

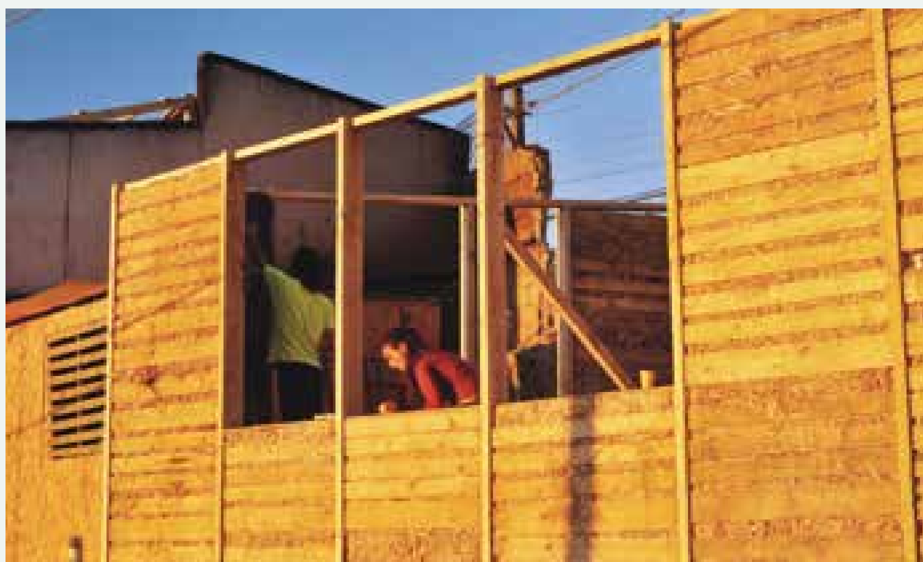
In this way, the disaster has become an opportunity, because many of the burnt houses have been replaced today by homes with better earthquake-resistant, fire-retardant and thermal conditions, thanks to the properties of the earth. The whole process can be considered sustainable in its three areas: environmental and economically because of re-using local materials, and socio-cultural because it has been led collectively and involving locally people.





↑ *Quincha* with pallet constructive system (credits: N. Jorquera).
3D scheme of the building system (credits: Moya, Alfaro et al.).

↓ *Quincha* House (photo: Sergio Levet).
Walls made of pallet panel (credits: Minga Valpo).



Window with sculpted stone lattice work to filter the sun in Pokaran (India) (photo: F. Vegas, C. Mileto).

Shading and cooling systems

Fernando Vegas, Camilla Mileto, Lidia García Soriano, Soledad García Sáez
Universitat Politècnica de València, Valencia, Spain

Shading and cooling systems are common in many parts of the world, but are clearly more profuse in sunny hot climates, where they have traditionally been absolutely necessary, if we take into account that air conditioning is a relatively recent invention. Many of these strategies are closely linked to the culture that created them but, since cultures have often come into being in a determined climatic environment, we might wonder whether cooling and shading systems depend on the climate or the culture where they were created or on a combination of both (Olgyay, 1963). Below there follows a short list of several shading and cooling systems in the urban and domestic sphere.

Street shading systems

The hot summer season typical of the Mediterranean area has traditionally required solutions (Rasulo 2003, pp. 177-188) that would allow people to walk along public streets protected from the sunshine, under generous eaves and cornices with a freely flowing breeze (fig. 1). The most immediate initial solution was the actual urban design of the past, with narrow, winding streets and possibly whitewashed houses that would partially avoid the absorption of heat (Vegas et al. 2013, pp. 104-105). In the same way, porticoes offered shelter both from the sun and the rain and other elements.

But apart from these strategies of architectural and urban design, there are many other ways of covering public space with parasols, like awnings or textiles stretching from one façade to the one opposite (fig. 2), trees with large crowns or the shade of palm trees or of grapevines and other climbing plants, and, especially in hot regions and countries of Islamic influence (fig. 3), wooden pergolas, trellised wooden roofs and canopies intermittently scattered over the streets of the souks. In Europe also, before covered markets became widespread at the end of the 19th Century, many fairs and street mark ets took place in the local squares under canvases and awnings that filtered the sunlight.

House shading systems

Sun and shade filters are very important architectural elements in buildings located in sunny climates. They are associated to the eaves (fig. 4), bays, balconies and terraces of a building. The history of these elements is undeniably linked to the history of the openings in the building and the way they are closed. Initially, when the lighting and ventilation of spaces depended inevitably upon the opening and closing of shutters, where they existed, these filters were more basic and rudimentary. The generalisation of the use of balconies and, above all, the introduction and popularisation of the use of glass in the windows of ordinary buildings in the 19th Century generated a large amount of sun and shade filters in the fenestration of

Fig. 1 Eaves in a street of Palma de Mallorca preventing the sun from impacting on façades and streets. Spain (photo: F. Vegas, C. Mileto).

Fig. 2 Textiles stretching from one façade to the opposite to create shadow in Larios street, Málaga, Spain (photo: F. Vegas, C. Mileto).

Fig. 3 Decorated portico offering shadow in New Delhi, India (photo: F. Vegas, C. Mileto).

M. Correia, L. Dipasquale, S. Mecca (edited by), *VERSUS: Heritage for Tomorrow. Vernacular Knowledge for Sustainable Architecture*, ISBN (online) 978-88-6655-742-5, ISBN (print) 978-88-6655-741-8, CC BY-SA 4.0, 2014 Firenze University Press

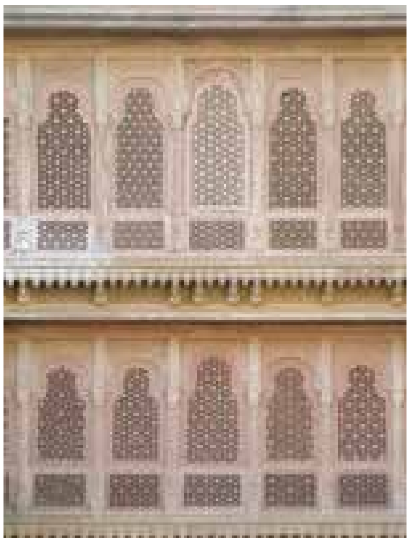
Fig. 4 The eaves in Japanese architecture prevent the sunrays from touching the house, that is simultaneously open in all fronts to catch the breeze and create a crossed ventilation inside the dwelling. Japan.

Fig. 5 Stone latticework sculpted in stone to filter the sun. Bikaner, India.
Fig. 6 Stone latticework. Fatehpur Sikri, India.
Fig. 7 Wooden latticework. Alhambra of Grenade, Spain.
(photos: F. Vegas, C. Mileto)

buildings that enriched and filled with nuances the relationship of the building and its inhabitants with the public thoroughfare underneath (Vegas et al. 2013, pp. 232-241).

Lattices: In olden times, especially in very hot places, wooden lattices were very common, as they let in light and air and protected the interior from being seen from outside at the same time as they let the people inside see what was happening outside (fig. 5-6-7).
Some of these lattices probably had shutters on the inside that could be closed, especially in the winter months. They are usually fixed, although there are also some that may be opened. In the Islamic world, these lattices can sometimes be three dimensional in the form of bay windows (fig. 8).

Curtains: These have probably existed since the very distant past to prevent the wind from blowing in, partially darken the room inside, keep people from seeing in and even as decoration. The advent of the balcony initially seems to have brought curtains to the exterior of the façade. These long curtains, sometimes longer than the window, were usually hung over the handrail of the balcony, providing a certain amount of visual protection from the front, that was deemed necessary in narrow streets, and at the same time letting the inhabitants see out from the sides, while providing some shade and allowing the air to circulate. In especially hot places, they were made of cloth or lightly woven esparto grass (fig. 9).
Some of them had a double cord system thanks to which they were easily rolled up and down. This type of curtains went out of fashion



in the late 19th Century when it was gradually replaced by roll blinds. On the other hand, other types of curtains in especially hot climates were made of strands of hemp, a solution to be found in several cultures from the Mediterranean basin to Japan at the entrance of street shops, to allow the wind inside but avoid sunshine, insects and views inside the house.

Roll blinds: Especially in the last quarter of the 19th Century, roll blinds made of rush and roll blinds with wooden or bamboo laths appeared, apparently to replace the outside curtains on buildings, perhaps because they were easier to maintain and because the use of wire had become popular. They are rolled up quickly and easily by means of a cord. They were also very popular in Japanese traditional architecture, where it is called *sudare* if regulated vertically or *yoshizu*, if regulated horizontally (Yagi 1992, p. 31). Originally the wooden lath on top of the opening on the façade was hung on the outside or placed inside de jambs, without interfering with the upper part of the window. The blinds were used exactly in the same way as the curtains described above, either hanging down vertically or sloping over the handrail of the balcony, for the same purpose of offering light, shade, breeze, side views and, at the same time, safeguarding privacy from the front (fig. 10).

Louvered shutters: These shutters have horizontal slats angled in a way to admit light and air but to keep out direct sunshine and rain. The angle of the slats may be fixed or operable, so that the light coming in and the views onto the street may be adjustable (fig. 11). Due to their complexity because of the insertion of slats, this system only became widespread from the 19th Century on in small formats. The bigger louvered shutters open and shut by folding them vertically like an accordion so as not to take up too much space and consequently are rather expensive, they are usually found in mansions and palaces, and placed on the outside of the windows for extra protection. In full-length louvered shutters, the lower part or apron of the shutters can also be opened or shut independently from the top, converting this architectural element, capable of enriching the nuances of the light inside the house, into a piece of craftwork that required special attention.

Fig. 8 Bay windows made of wooden latticework in Cairo, Egypt.
Fig. 9 Old system of lightly woven esparto curtains in Malaga, Spain.
Fig. 10 Roll blinds in Malaga, one of them hanging over the handrail of the balcony Spain.
Fig. 11 Operable and graduable louvered shutters vertically foldable not to take up too much space. Barcelona, Spain.
(photos: F. Vegas, C. Mileto)

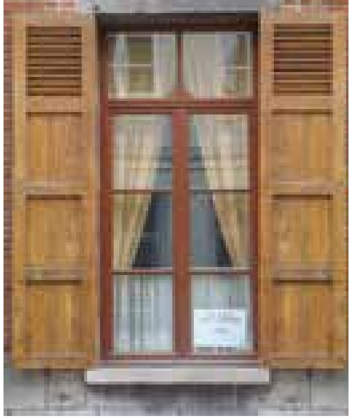


Fig. 12 Net curtain in a sash window in Castle Combe, England.
Fig. 13 Window with partial louvered shutters, net curtains and curtains in Mons, Belgium.
Fig. 14 Roman shades at Venice, Italy.
Fig. 15 External Venetian blinds at Valencia, Spain.
Fig. 16 Die-cut metal valance for external Venetian blinds in Valencia, Spain.
(photos: F. Vegas, C. Mileto)

Net curtains: Within the tradition of certain cultures of seeing out from the inside of a building without being seen, which led to the use of lattices, some fine fabric curtains, the chinks in wicker matting or the interstices in louvered shutters, sheer curtains appeared and became more widespread, however, when associated with glass, and came to be used commonly on windows in the city during the 19th Century. They can be hung like curtains or directly applied to the glass, always attached to or hung from a rod on the inside, adopting three positions: either covering the whole window, as short curtains at the bottom of the apron to avoid people seeing the legs of the inhabitants, or at the top to protect their privacy and allow the people inside to see outside without being seen. They are usually made from a sheer fabric, often with fine embroidery that makes them another element in the decoration of the building (fig. 12-13).

Roman blinds: Also called Roman shades, they are a type of window covering used to block out the sun, but also the breeze and the view from the outside to the inside. They stack up with the help of a cord mechanism that allows the inhabitant to adjust the height of the covered area. There are two main types: the looped Roman shade that folds cascading down and the classic Roman shade that has a pleated design (fig. 14).

Venetian blinds: These are blinds with thin slats hung from cords or strips of cloth called tapes that can be rolled op or folded to open them. It is a very functional and useful element which allows excellent control of the light inside. The slats are so fine that when they are placed perpendicular to the façade they hardly block the view at all but when they are closed they can prevent the sunlight from entering completely. The concept of this extraordinary design is very like that of the modern Venetian blinds used in offices and houses in the 21st Century (fig. 15).

Valances for Venetian blinds: On the inside of the dwelling, Venetian blinds were simply hung like net curtains or ordinary curtains. On the other hand, external Venetian blinds popular at the end of the 19th Century called for the need for a valance on each window to permit them to be hidden when rolled up and, in exterior blinds, to protect them from the wind and the elements.

Fig. 17 External board and batten shutters in an old half-timber house at Albi, France.
Fig. 18 Internal panelled shutters in the Alhambra of Granada, Spain.
(photos: F. Vegas, C. Mileto)

In existing architecture valances of openwork wood were added to the existing windows either by fitting them into the bay if there was enough room or making them stick out from the façade if not. In new architecture at the end of the 19th Century, far from being a problem, the presence of this new architectural element was an excuse for generating new decorative solutions for the building which was very much to the liking of the architects of the time. The materials used were wood and metal and, very exceptionally, in the early 20th Century, wrought iron, die-cut metal and artificial stone were also used. The valance was usually made of decorated fretwork to let in some light, creating a beautiful effect in the space inside (fig. 15).

Shutters: Both board-and-batten, as well as panelled shutters, are relics of a time when there was no glass and so they were the only way of shutting the openings of the façade. Lighting and ventilation took place simultaneously, with the problem this caused in cold weather. Although this is not a fixed rule, in the coldest climates, shutters were usually placed on the outside of the window, whereas in warmer climes they were usually located inside (fig. 17-18). Shutters were widely used throughout the second half of the 19th Century and the beginning of the 20th, and began to disappear from dwellings in the Nineteen-twenties when roller blinds became more and more popular, whether inside or outside of the windows, as they also afforded total darkness.

Awnings: Awnings are secondary coverings composed of some kind of cloth or canvas over a wooden or metal structure attached to the exterior wall of a window, door or a building over the sidewalk. It provides shade for the inhabitants, but also breaks strong winds and protects from rain or snow and allows fresh air circulation and views onto the street while avoiding direct sunlight. The first awnings were used by the ancient Egyptian and Syrian civilizations in the shape of woven mats which were later inherited by the Romans, who used them in a domestic scale in shops and dwellings, but also on a large scale covering theatres and amphitheatres with the use of *velaria*, a massive complex of retractable shade structures that could be deployed above the seating areas. Awnings became popular, widespread and economically available from the first half of the 19th Century on (fig. 19).

Fig. 19 A group of elegant awnings in Medioeval windows at Venice, Italy.
Fig. 20 Fresh tunnel-like pergola made of vegetation at the Alhambra of Granada, Spain.
(photos: F. Vegas, C. Mileto)

Fig. 21 The breathable vegetal mass of thatched roofs helps to create a cooling system for the internal comfort of the dwelling. Ainu house in Sapporo island, Japan.
(photo: F. Vegas, C. Mileto)

Roll shutters: Roll shutters, held in a box at the flashing of the window and similar to those still used today, seem to have been introduced in Paris at the end of the 19th Century, and spread from there to the rest of the world. They were wooden shutters joined by metal clamps. They became enormously popular thanks to their cheap price. The fact that they could be hidden from view and were versatile, since they allowed the amount of light to be graduated or completely darkened the room, led to the disappearance of many of the historic solutions described above. The most sophisticated roll shutters incorporate a structure to allow the shutter tilting to let the breeze inside and watch the street.

Street cooling systems

In street cooling systems we can include the street shading systems mentioned above, since the generation of shade always results in a decrease of temperature. Among the many strategies available, those involving air circulation, the presence of vegetation, the creation of shade and a suitable use of water deserve special mention.

Strategies involving air circulation: In this section it is worth underscoring as well a clever design of the streets that often favours the most pleasant breeze in the summer for the area in question, or a sea breeze, for example, to ensure the best possible urban ventilation and therefore the best possible ventilation for the dwellings that form the network of the city. This design is usually created in such a way that it also cuts off the harsh and bitter local winds (Ji, 2014).

Strategies involving the presence of vegetation: The existence of live vegetation, in general, with the ensuing creation of areas shaded from above (treetops, bowers, etc.), from the sides (treetops, climbing plants, etc.) and from below (grass, aromatic plants, flower beds, shrubland, etc.) not only affords shade but cools the atmosphere thanks to its capacity to evaporate and retain water in the foliage (fig. 20).

Strategies involving the creation of shade: The creation of pergolas, canopies, arbours, galleries, etc., often not too dense so as not to prevent the circulation of air in a vertical direction, but dense enough to provide plenty of shade, succeeds in refreshing those who walk or take shelter underneath.

Fig. 22 Vents on top of stairways and domes that generate the circulation and renewal of fresh air in the dwellings. Cairo, Egypt (photo: F. Vegas, C. Mileto).

Strategies involving a suitable use of water: Finally, some ancestral customs, almost forgotten nowadays, such as emptying a basin of water or wetting the area just around the entrance to the house, produce a fall in temperature from the effect of evaporation. Nowadays this task is often carried out by municipal services that in some hot areas wet the streets in summer in order to clean them and reduce the temperature at the same time.

House cooling systems

Inside the dwelling, some devices and strategies have traditionally helped keep the place cool in hot weather. There are three types of strategies that can be grouped according to the following factors: dimension, mass and wind.

Strategies involving dimension: The construction of spaces with high ceilings makes it possible to cool rooms in the summer thanks to the movement of air by convection and the possibility of opening windows and creating cross ventilation overhead, although this may have a negative effect in wintertime. That is why the custom is more frequent in hot climates. It is interesting to point out also that the use of vaults or domes to cover spaces produces more pleasant thermal conditions.

Strategies involving mass: The use of thick walls and thermal inertia in extremely hot or cold places provides greater comfort in winter and cooler places in summer. In this same line, it is worth mentioning the great thermal inertia of underground excavated architecture (Aranda, 1986; Aranda, 2003), which provides extraordinary thermal comfort both in winter and in summer, especially when combined with the ventilation chimneys for the back spaces. In thatched roofs, the combination of breathable vegetal mass with the exterior wind helps to create a cooling system for internal comfort (Kimura et al., 1982) (fig. 21).

Strategies involving water and vegetation: The presence of water in the form of a fountain or a pond, along with vegetation, provides greater thermal comfort inside the dwelling thanks to the coolness caused by the evaporation of water. It is the custom to wash the floor every day, not only to keep it clean but to keep the interior of the dwelling cool, also due to evaporation.

Strategies involving wind: This is fundamentally what is known as cross ventilation in dwellings which, when suitably combined with an adequate urban orientation of the layout and filters placed on the windows, allows the breeze to circulate around the darkened inside, making it cooler for the inhabitants. The creation of hot-cold ther-

Fig. 23 Millowner's Association building by Le Corbusier, with its characteristics brise-soleils to prevent the hard sun from entering inside. Ahmedabad, India (photo: F. Vegas, C. Mileto).

mal gradients between façades with different orientation or zones on different levels enhances this cross ventilation. The chilling effect will be accentuated if this circulation of the breeze is combined with the presence of vegetation, water in the form of fountains, or subterranean spaces with greater humidity.

The wind also serves to chill auxiliary spaces that act as a thermal insulation for the house, such as attics, which, when closed in winter, provide thermal insulation and, when open, serve to dissipate whatever heat may have accumulated under the roof. In the event of possessing half-basements or underground devices initially intended for heating, such as Spanish, Chinese or Korean *glorias*, the circulation of air in summer makes them mechanisms that lessen the heat. The same occurs with chimneys, built to heat the house but equally useful in the summer season to ventilate and cool it (Ji, 2014).

An extraordinary refrigerating system is wind-catchers (Rudofsky, 1973; Rudofsky, 1977), found mainly in Iran, Egypt, Bahrain, Dubai and Saudi Arabia, which are devices for ventilating, humidifying and refrigerating the interior of a dwelling by means of the circulation of air forced by a solar-produced temperature gradient through canals with water or subterranean spaces (fig. 22). In a similar way, staircases in blocks of flats in Mediterranean climates built between the late 19th and early 20th Century, with a glass ceiling with perimeter ventilation, refrigerate the building almost unnoticed through the stairwell, to the advantage of the dwellings, which used to open their doors, windows and clerestories on to the stairs to take advantage of the cool air circulating there.

Another extraordinary case is the systems of air conditioning used by termites, which generate a temperature gradient with the fermentation of their fungi crops and their own body heat, producing cross ventilation in their apparently monolithic nests, where renewed air enters through little pores on the surface, cools when passing through perimeter canals, receives humidity from wells excavated up to 40 m deep to the groundwater table level and spreads to all the cells (Von Frisch 1974, pp. 139-144; Korb et al. 1999, pp. 312-316). These intelligent systems are being studied in order to apply them to modern architecture (Doan, 2012)[1].

Shading and cooling systems in modern architecture

The architecture of the Modern Movement, which originated in a Central European climate with an obsession for hygiene, illumination and ventilation, tended to use large panes of glass as a sort of

[1] See also http://biomimicryinstitute.org/case-studies/case-studies/termite-inspired-air-conditioning.html

declaration of principles (Woodbridge 1988, pp. 82-83)[2]. This diaphanousness made sense above all in especially salubrious buildings, conceived for curing and convalescing in sunshine, like the Zonnenstraal tuberculosis sanatorium (Meurs et al., 2010) (Hilversum, Holland) by Jan Duiker and Bernard Bijvoet (1928) and the one in Paimio (Schildt, 1996) (Finland) by Alvar Aalto (1932). Very shortly afterwards, Aalto himself shifted course in the Viipuri Library (1935) by designing skylights in such a way that the sunlight did not shine in directly and by planting creeperson the glass over the stairs with the double intention of filtering the strength of the sun and moderating the aggressiveness of the technology to achieve a more human atmosphere.

Le Corbusier also partook of this initial trend to build smooth walls and a lot of glass on the façade, as we can see in the Swiss Pavilion he designed for the City University or the Salvation Army building in Paris. But he was also one of the first to change this trend (Aicher 1996, pp. 125-130) by inventing the *brise-soleil* (Editor 1993, pp. 71-74), which he incorporated in his projects from 1935 onwards, both in Europe, India (fig. 23) and in the United States, after his visit to Brazil to design the Ministry of Health and Education in Rio de Janeiro (1935), and even restored the bombed façade of his Salvation Army building after the war, incorporating new *brise-soleils* (Boesiger et al., 1987).

Another architect of the same generation who used *brise-soleils* from an early stage, perhaps spontaneously, was the Czech Antonin Raymond for his design of the Golconde Dormitory in Pondicherry (India, 1935-42) (Helfrich et al., 2006).

Other Western architects commissioned to work in tropical climates were also obliged to design shading systems, like Louis Kahn's porticoes (Mc Carter 2009, pp. 75-84) in his works in India and Bangladesh, or all of Henry Klumb's oeuvre on the island of Puerto Rico (Vivoni, 2006).

And the fact is that climatic requirements, at least in extremely hot conditions, have generally taken precedence over any architectural language, as we have seen from the work in the past of architects born in the desert, like Hassan Fathy (Fathy, 1973; Fathy, 1986), Abdel-Wahed El-Wakil, among others, or in the tropics, like Charles Correa, Balkrishna Doshi, Geoffrey Bawa (Robson, 2002), Oscar Niemeyer (Araújo 2013, pp. 68-93), and, today, architects like Rahul Mehrotra (Rossato 2013, pp. 16-29) or Bijoy Jain of Studio Mumbai (El Croquis, 2011), and others.

Some current architects have skilfully reinterpreted the tradition of the local louvered shutters and the cooling presence of water in works made on the Mediterranean basin, as is the case of the Fundación Pilar y Joan Miró in Palma de Mallorca (1992) by Rafael Moneo (El Croquis, 2004). Finally, it is worth highlighting the current trend to dematerialise or even atomise the skin of the building (Cortés, 2003), breaking it up into myriad elements, converting the whole façade into a filter or shading system, often regardless of the climate. Among many others, we can mention the work of Herzog and De Meuron[3], Kengo Kuma (Kuma, 1999), the Li Xiaoduong Atelier (Wilson 2010, pp. 108-117), the Zhanglei Atelier (Le Berre 2012, pp. 116-125), etc.

[2] Curiously enough, the first 'curtain wall' façade built entirely in glass was erected even before the arrival of the Modernist style. It is the Andrew S. Hallidie Building (1917) in San Francisco (California, USA), named after the inventor of the cable car, designed and built by the architect Willis Polk. See Woodbridge, Sally B. 1988, *California Architecture*, Chronicle Books, San Francisco, pp. 82-83.

[3] AAVV. 'Herzog and De Meuron'. *El Croquis* ns. 60 (1983-1993), 84 (1993-1997), 109/110 (1998-2002), 129/130 (2002-2006), 152/153 (2005-2010)

EXTERNAL VENETIAN BLINDS

VALENCIA, SPAIN

authors
Fernando Vegas, Camilla Mileto

ENVIRONMENTAL PRINCIPLES

■ to respect environmental context and landscape ■ to benefit of natural and climatic resources ■ to reduce pollution and waste materials ■ to contribute to human health and welfare ■ to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

■ to protect the cultural landscape ■ to transfer construction cultures ■ to enhance innovative and creative solutions ■ to recognise intangible values ■ to encourage social cohesion

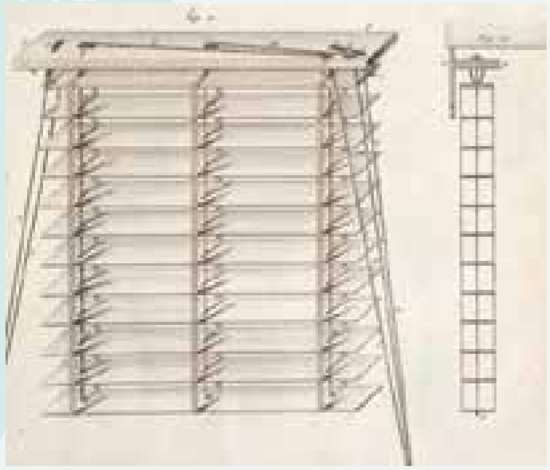
SOCIO-ECONOMIC PRINCIPLES

■ to support autonomy ■ to promote local activities ■ to optimise construction efforts ■ to extend building's lifetime ■ to save resources

This is a system of controlling sunlight that was probably exported from Venice to France (Roubo, 1769) and England in the early 18th Century in the version located inside the window with strips of cloth. Patents of the system were taken out by Gowin Knight (1760) and Edward Beran (1769) in England, but they were well known in France before. Indeed, the French carpenter M. Roubo (1769) wrote about them and drew them in his treatise of carpentry, as a somehow recently incorporated element since the system was still not so widely spread. The system had been exported to the East Coast of the United States as early as 1745 for the use of patrician houses. We know as well that St. Peter's Church in Philadelphia incorporated Venetian blinds in 1761 (French, 1941). Venetian blinds became extraordinarily popular by the end of the 19th Century in the external corded version, especially in some Mediterranean cities, like Valencia, for example.

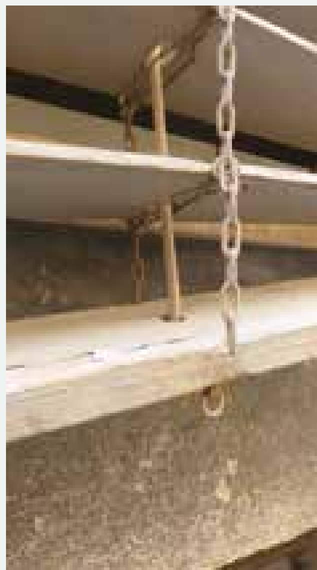
In the version placed in individual cells made of strips of cloth, the slats can be rolled up or down as well as oriented as one wishes. In the version with cords, as well as the thin slats placed all down the blind, there are two thicker slats at the top and at the bottom, two little chains of links that hold them and allow the slats to be oriented and one cord that allows the blind to be rolled up in a small space.

The popularity of external Venetian blinds called for the need of a valance on each window to permit them to be hidden when rolled up and, in exterior blinds, to protect them from the wind and the elements, creating a decorative element that soon was to characterise some cities in the Mediterranean.



Internal venetian blinds as drawn by M.Roubon in *L'Art du Menuisier* (1769).

External Venetian blinds in Valencia, opened and closed; detail of a Venetian blind with wooden valance; detail of external venetian blinds. (photos: F. Vegas, C. Mileto).



LOUVERED SHUTTERS
MEDITERRANEAN COAST

authors
Fernando Vegas, Camilla Mileto

ENVIRONMENTAL PRINCIPLES

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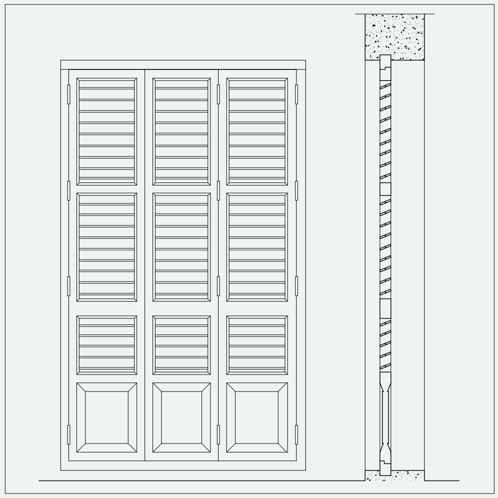
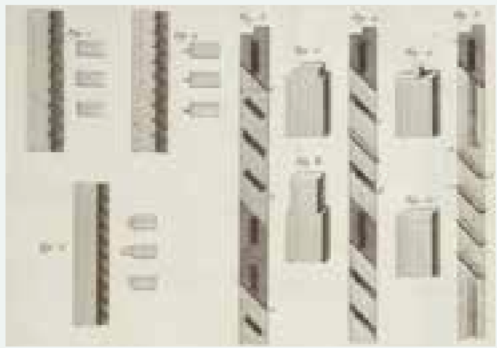
It seems that the first known antecedent of louvered shutters, created to provide shade while letting air in, was made of marble in Ancient Greece. The use of slats on windows spread throughout the Mediterranean region. In any case, as we know them today, wooden fixed louvered shutters were not widely used until the end of the 18th Century, when they became popular all over the Mediterranean and in the hottest tropical parts of the American Continent, where they were known as plantation shutters, colonial shutters, Bahama shutters, etc. Around the Gulf of Mexico, these shutters were also named hurricane shutters, as they afforded extra protection from tropical storms. The French carpenter M. Roubo (1769) names and draws it in his treatise of carpentry as an already common element among the richest houses.

The more sophisticated operable louvered shutters, regulated by a tilt rod and capable of graduating the amount of light inside in many ways, began to be manufactured around 1830-40. The fact that these operable louvered shutters could be graduated, which is also the case of the extraordinary Venetian blinds, is usually an indication of the intensity of the light in the places where they appeared and reflects the local skill and interest in controlling it at will. Besides, in large windows, the necessary subdivision of the sheets of louvered shutters with rails created several separate sections of laths which could be raised or lowered freely, thereby multiplying even more the possibilities of graduating the light. On the other side, the non-operable louvered shutters sometimes incorporate a hinge to allow at least part of the shutter to tilt outwards, offering in this way views onto the street.





Details of louvered shutters (drawings: F. Vegas, C. Mileto).
Louvered shutters as drawn by M. Roubon in *L'Art du Menuisier* (1769).

from left to right: Larache, Morocco; Plaza de la Merced, Málaga, Spain; Mallorca, Spain; Menorca, Spain (photos: F. Vegas, C. Mileto).

FUNDACIÓN PILAR AND JOAN MIRÓ

PALMA DE MALLORCA, SPAIN

Architect: Rafael Moneo

authors

Fernando Vegas, Camilla Mileto

ENVIRONMENTAL PRINCIPLES

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This building, designed and built by the renowned Spanish architect Rafael Moneo, is a masterly interpretation of the local louvered shutters which are so popular and widely used that their Spanish name (*mallorquina*) is a reference to the island of Mallorca itself. In fact, the outer walls of the building are designed using large sloping slats of local Marés stone, resulting in a *mallorquina* in stone that prevents the direct entry of solar radiation.

The inner windows behind these stone slats use alabaster instead of glass, harking back to a time-honoured tradition found particularly in churches, by which these stone sheets provided an additional filter against the intense daylight. There are also several pools at the foot of the building and on its flat roof, where the light is reflected on the water and enters the building through the alabaster slats and sheets, creating beautiful aquatic-movement effects inside, a constant reminder of the building's Mediterranean island setting.

The museum also includes some apertures which selectively and adroitly use their orientation and inclination to filter light and to create additional effects inside. The garden around the museum has palm trees and other perennials which contribute to the filtering of the light and, in conjunction with the building's various pools, provide cooler air (El Croquis, 2004).

External view of Fundación Miró, Mallorca.

General and internal views of Fundación Miró, Mallorca.
On the right: Traditional louvered shutter from Mallorca.
(photos: F. Vegas, C. Mileto).

Passive heating through underground inertia, France (photo: S. Moriset).

Low energy heating systems

Hubert Guillaud
CRAterre-ENSAG, Grenoble, France

Vernacular heating: from the simplest to the most sophisticated systems

Archaeological research throughout the world has brought to light, from antiquity when settlements first took place alongside the development of agriculture and the domestication of animals, the evidence of the permanent presence of fireplaces at the heart of living spaces. Fireplaces, besides being used for cult practices and making offerings to pantheons of idols and gods, were essentially used for the four fundamental conditions of life: cooking food, providing heat, lighting living spaces, and ensuring protection against invading animals. Those primitive heating and lighting devices were initially dug into the earth or bordered by stones, and were generally placed in the centre of built-up spaces. In Greco-Roman Antiquity, mobile *braseros* were used to transport hot embers. Later, fireplaces were progressively raised on earthen or stone platforms; those early fireplaces evolved very slowly towards hearths, which originated in Western Europe in the Gallo-Roman period. With the evolution of roofing to the gabled version came the opportunity to build flues against gable walls or interior cross-walls, connecting them to chimney stacks jutting up from the roof. The principle of a chimney flue replacing an opening at the top of a roof to evacuate smoke did away with the constant smoky, suffocating atmosphere in a main living space known as the 'fire chamber or room' (Fréal 1977, pp. 330-347)[1] (fig. 1). Those high-hooded fireplaces, open to living spaces, not only provided heat and light but were also used to smoke food in order to preserve it. However for a long time they were draughty and uncomfortable, as the evacuation of smoke requires an intake of cold air and necessitates leaving a window or door open; this intake would generally have been located opposite the fireplace; however, the subsequent fire hazard implied constant vigilance. Medieval fireplaces were often large in size. In many regional dwelling traditions, benches were installed under the hoods and in some cases closed beds were fitted on the insides so that the inhabitants could benefit from the warmth of the dying embers as they fell asleep. This type of fireplace paved the way to a social space where storytelling evenings or the sharing of domestic chores such as repairing household items, preparing meals, mending, sewing or embroidery, took place. These 'fire rooms' were the heart of a house; indeed, the 'fireplace' or 'foyer' was also used as a basis for the first population censuses carried out in the Middle Ages. However, the heat efficiency of these old fireplaces was low if not mediocre. As Cléa Rossi and Hervé Fillipetti (2007, p. 155) point out: "Fire architectures in rural settings (…) can only be appreciated at their true value in a long-term context of rural lifestyle and economy based on modest technical means, limiting the degree of comfort that implied inventing solutions, the archaism and ingenuity of which still surprise us today".

Their performance was improved much more recently and they were gradually extended to most of the other living spaces in houses, but their high consumption of wood made them a luxury available only to those with the appropriate wood resources and the right to cut wood. In the 19th Century, the advent of coal mining and the replacement of wood with coal or mixed combustibles (wood and coal) saw the development of *potagers* (large cooking stoves) and fired clay ovens, as well as ceramic and later cast iron stoves[2], contributing to the decline of open fireplaces. Their performance was much more effective. This evolution preceded the advent of boilers and central heating systems that were developed in the 20th Century.

Vernacular underfloor heating systems

The same astonishing ingenuity also brought about highly effective heating methods in vernacular dwellings that had been developed by several civilizations since ancient times. The principles of the *hypocaust* (fig. 2), already known to the Greeks and developed by the Romans, the Chinese *Kang-Bed* or the Korean *Ondol* were some of the most developed examples. The *hypocaust*, commonly implemented in a large number of Roman villas and other public buildings (the *caldarium* in Roman Baths), and perpetuated in the Gallo-Roman period in the western regions of the Empire, was a highly sophisticated yet simple heating process. Depending on the size of the

[1] One example of the best thriving traditions of these large 'fire room' chimneys is the large *sarrasin* chimney that can be found in half-timbered farms in the Bresse region of France, to the north of the Lyon region and east of the River Saone. The unusual oriental or Gothic inspired conic cowl shapes, or Roman-style square cowl or other baroque shapes of their brick roof stacks are among the gems of their genre in the French vernacular architectural heritage (Ibid, Fréal 1977, p. 334; Fréal, 1978; Dulier, 1990).

[2] In Alsace, France, the heavy, imposing earthenware 'mass stove heaters' or *kachelöfen*, are some of the best examples of their kind. Similar examples can also be found in Austria and Sweden.

M. Correia, L. Dipasquale, S. Mecca (edited by), *VERSUS: Heritage for Tomorrow. Vernacular Knowledge for Sustainable Architecture*, ISBN (online) 978-88-6655-742-5, ISBN (print) 978-88-6655-741-8,

Fig. 1 Fire chamber' or 'fire main room' with a closed bed, barn of Les Planons, Eco museum of Bresse, Saône-et-Loire, France (photo: H. Guillaud).

Fig. 2 Roman hypocaust. Villa La Olmeida at Pedroso de la Vega, Spain, II°-IV° centuries A.C. (photo: H. Guillaud).

buildings, heat was transmitted by means of natural convection under hanging floors (*suspensura*) on small brick blocks, from one or several fireplaces external to the spaces being heated. These were located in utility spaces also used for storing wood. The solid floors, comprised of superimposed slabs and screeds, accumulated the heat that was given back by radiation. The Chinese *Kang-bed*, which was developed in the cold regions of northern China, is also highly ingenious. It comprises a sleeping platform placed against, and heated by, a stove also used for cooking food. The principle uses a system of heat radiating from the mass, and the inertia of the sleeping platform. The Korean *Ondol* (fig. 3) – or *gudeul* – is an intermediate system between the hypocaust and the *kang* and also comprises a system of underfloor heating. In traditional Korean houses, the floors are raised above the ground, leaving a space for the air to be heated. The ground is shaped into cavities forming throats which accelerate the draught, thus enabling the heat generated in a fireplace located against one of the shorter sides of the dwelling to circulate by underfloor convection. Large stones are also used as accumulators and the stored heat is emitted by radiation during the night. Smoke is evacuated via an outside chimney built on one side of the dwelling at the other end of the heated air's path (fig. 4). A similar low energy underfloor heating system is known in the northern region of Spain, in the territory of Tierra de Campos, Castille and León, where a precious tradition of earthen architecture in adobe and *tapia* (rammed earth) was also developed. This heating system is called *gloria* and can be traced back to the Roman times, and is undoubtedly derived from the *hypocaust* system. Here, the combustible material is not wood but straw which is cultivated in abundance in the region, which was then, as it is now, an important producer of wheat. The peculiarity of this system consists in building the rooms of the houses and their floors in tiles over adobe or brick vaulting. The straw is placed in the passages or galleries under the vaults and slowly burnt. When the fire is lit, the smoke is evacuated with a system of opposite flues (placed at the base of the two opposite walls of the house) that are closed at the entry and opened at the exit. The heat that is delivered from this slow combustion is stored in the mass of the adobe or brick vaultings and gradually returned to the living spaces of the house (Ruth Gibson 1996, pp. 29-38).

These systems, albeit high-performance, consume large amounts of heating materials, notably wood, even if the residue from woodcutting or trimming (branches, twigs and bark) or stems of cereals, or chestnut or walnut husks were frequently burned in fireplaces, stoves and ovens. Thus the heating issues of vernacular houses were not resolved just by heating devices – hearths, stoves, fireplac-

Fig.3 Typical house in the village of Hahoe, South Korea ; with *Ondol* heating system.
Fig.4 Outdoor chimney of *Ondol* heating system, house (19th Century) in Damyang Changpyeong, South Korea (photos: H. Guillaud).

es and other solutions mentioned. A recent study report by Arene Ile-de-France (2012, p. 86)[3], entitled *Bâti vernaculaire et développement durable*, (Vernacular Building and Sustainable Development) concludes as follows: "(...) cultures (constructive or otherwise) evolve with time and are fed both through encounters and influences from elsewhere, and by the rediscovery of past knowledge. Although globalization is now accused of simplistic standardisation in building, it could very well serve a future renewal in the connection between nature, history and living space. The 'switching over' to sustainable town planning and economy implies a renewed relationship with history, whereas the modern architectural movement is based notably on a *tabula rasa* notion".

It could indeed be conceived that an undeniable part of history and rediscovered vernacular cultures holds a mine of inspiration for the future. This is what we have endeavoured to broach in above, not only by presenting of a short synthesis of the evolution of traditional heating systems, but also by providing an opening to a global inter-cultural dimension.

[3] A study carried out for Arene by Nomadéis, an environmental and sustainable development consulting and research agency. www.nomadeis.com

Some lessons on vernacular bioclimatic for low energy heating

The issue of the heat balance in vernacular houses should also be looked at in correlation with the design of the house itself, as it plays an essential role. In colder regions, thick stone or earthen walls with high inertia, small openings in many cases, direct capture of sunshine through south and west-facing walls, solid walls exposed to the elements, part of the living volumes enclosed in dips in the land, 'buffer spaces' for storing harvests or ploughs and other tools, all contributed to traditional heating methods. Alternate positioning of barn spaces and living spaces provided insulation by means of accumulated fodder, and the proximity of the stables contributed animal heat. This was a deciding factor for more effective global heat balance in houses.

Such global intelligence should call for inspiring and innovative reappraisal, but not only with a view to reducing the amount of fuels and heating energies, despite the importance in current prescriptive trends in terms of reduction in fossil and non renewable resources (fuel, gas) or the relatively high price and potential safety hazards related to electricity derived from nuclear sources.

Two successive fossil energy crises took place in the seventies (1973 and 1979). Thirty years later, researchers from all backgrounds and

Fig. 5 Compact and grouped buildings; Serres in Upper-Alps department, France (photo: N. Sánchez).

members of the building profession, considering the 'Hubbert Peak'[4] and the potential scarcity of 'black gold', suddenly became aware of the energy-guzzling nature of buildings, and began to look for alternative solutions with a view to reducing energy consumption. During that period which followed 'the glorious thirty' (fifties, sixties and seventies), increased criticism was made with regard to the modern 'international style architecture' (all concrete, glass and steel) that consumed high amounts of energy; it was observed that interest returned to traditional architecture giving rise to 'regionalism' otherwise known as 'vernacularism'. *Architecture without Architects* (Rudofski, 1964-1977) and *Making the Place* (Norberg-Schülz, 1981) anthropological approaches to houses (Rapoport, 1972) brought back to light autonomous building processes, local building cultures and the logic of adapting to a site having a direct impact on the design of vernacular housing and their forms of intelligence located in their distinct settings (fig. 5). Further studies developed within numerous contexts in vernacular architectural heritage were particularly inspiring in the emergence of a movement in favour of bioclimatics and 'passive' solar architecture with the objective of making the most of the physical and climatic conditions of their sites. They gave rise to achievements benefiting from lessons learnt from local building cultures, cultural diversity in building responses and integrated alternative solar energy, giving abundant free energy and reverting to natural ventilation devices to heat and air-condition houses.

What can be retained from vernacular bioclimatics in regions along the Mediterranean coastline that could contribute to low energy heating solutions for future housing? Account should be taken of the 'west-side temperate', 'hot' or 'subtropical' Mediterranean cli-

[4] The geophysicist Marion King Hubbert (1903-1989), suggested in the 1940's that the production curve for a raw material, notably oil, makes a bell-shaped curve that reaches a maximum level then inevitably decreases. The maximum point is known as the 'Hubbert Peak'.

mate zone, which is simply characterized by hot, dry summers and mild, damp winters. Rainfall is rare in summer but can be stormy and violent, and sometimes devastating. Summer aridity can be a source of water shortages and a fire hazard in areas of scrubland and forest. Rainfall occurs during the intermediate seasons (spring and autumn) notably on land under maritime influence. In regions to the north of the basin, violent and dry winds – Mistral, Tramontane (south of France and the Balearic isles) and Bora (Adriatic) – contribute to cold spells in winter, but also bring frequent blue skies. In the south, warm winds – Sirocco and Khamsin –, blow from Africa to the sea and dry the air. Understandably, heating in winter and ventilation in summer are two aspects of comfort in Mediterranean basin houses of particular interest to vernacular builders, and which influence the action taken by users in relation to their own comfort.

Some of the main principles of vernacular bioclimatics have been synthesised by Plemenka Supic (1993)[5], who points out that man's 'technical know-how' as a 'builder and user of his environment' in terms of a vernacular bioclimatic response depends on three interacting milieux: human, natural and material. This holistic approach to the milieu would appear necessary to avoid an overly technical positioning on the issue of low energy heating. The architectural responses are determined by the 'economic', 'social' and 'cultural' data of the human milieu, via a capacity to 'channel the environmental characteristics – physical, climatic, morphological and geologic of the natural milieu – whether to use them or protect from them by the implementation of materials and the principles (….) that reveal the forms and (….) means of expression of the geometry of a building'. Furthermore, Olivier Sidler (2003, pp. 3-5)[6] points out the need to rehabilitate the inertia of buildings (fig. 6-7). Continuous inhabiting of houses contributes to the amortization of brutal variations in temperature (day/night and inter-seasonal), the avoidance of overheating and limiting of heat loss, and also constitutes a source of comfort both in summer and winter. Over and above these essential considerations underlined by Supic and Sidler, it should be specified that the heat balance is dependent on heating systems, but also on the design of a house and the habits of its users – three interactive elements. Thus, with regard to the climatic factors and responses already provided by vernacular housing in the Mediterranean milieu, and to ensure comfortable low energy heating and cooling, the following main design elements should be retained:

- privilege north/south facing; preference for north-facing built-up volumes to be sunk to give shelter from cold, drying winds, or for the creation of 'buffer spaces' for that direction;
- compact and grouped built-up volumes;
- walls with high inertia (stone, earth), preferably closed on the north and east faces but with small openings enabling cool air to enter for cross ventilation in summer;

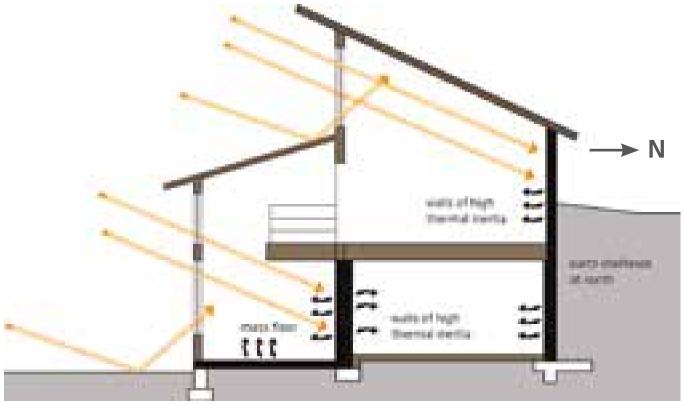


Fig.6 Capturing thermal energy with the walls of high inertia (redrawn by B. Özel).
Fig. 7 Mountain dwellings leaning their nord facades against the terrain. Trentino Alto Adige, Italy (photo: M. Masera).

[5] Plemenka Supic is a professor and researcher at the Department of Architecture of the Federal Polytechnic School of Lausanne (EPFL) in Switzerland and he is an expert in vernacular architecture.
[6] Olivier Sidler is the director of the Enertech consulting agency and a founder member of Négawatt.

Fig. 8-9 Rammed earth stove, developed by Martin Rauch (© Lehmo).

- solar capture on south and west walls by accumulation in the mass of walls in winter but with a limited window surface that can be blacked out in summer (sun screens, louvered shutters) or protected by awnings, pergolas or vegetated galleries, or plantations of trees forming a screen;
- in the hottest, driest regions, a central internal courtyard or patio forming a well of light and ventilation by convective air exchange; the presence of floral and tree vegetation (summer humidity);
- a 'wind-adapted' roof shape as low as possible, notably on the north side;
- mainly inert roofs, either flat and vegetated (with enough of a slope to evacuate heavy rain), or with two or several slopes with reinforced inertia (notably south facing but which could insulate more effectively if north facing); the installation of ventilation chimneys or hot air extractors for summer.
- systems that take advantage of the underground thermal inertia.

The usefulness of mixed solutions for low energy heating, both vernacular and current

In heating systems, it is considered useful to envisage a mix of solutions that both ascribe value to current technology and take inspiration from older methods having proven their worth. A scenario can give rise to creative inspiration. A proposal by Martial Château (2012)[7] has been retained, whereby he aims to combine the rehabilitation of an inert hypocaust type heating floor, the heat source of which could be a traditional wood pellet stove together with a hot air recuperator/pulser (air/air heat pump), or coupled with air solar captors (less expensive than thermal water captors or other heat transfer liquid, and requiring less maintenance) associated with a simple ventilator that can be turned off in summer. The *hypocaust*, with its high accumulation capacity, radiates a relatively uniform temperature throughout the rooms. Other thermal captors or air/water exchanger systems provide hot water, with the photovoltaic ones providing electricity.

In the last years, we can also observe a tendency towards an increasing use of local resources for developing low energy heating systems that are inspired from traditional principles. Thermal engineers and contractors in thermal design fittings, but also of builders and self-builders, favour the development of ecological passive systems that are exploiting the local available natural energy as underfloor or geothermal heating, biomass stoves or storage heaters (with thermal mass in stones or burnt bricks, and even stoves or hearths in rammed earth[8]) (fig. 8-9). These devices coupled with greenhouses oriented to the south, including Trombe walls or other heat storage in thermal mass are proving very efficient in energy saving. Facing the necessary and tangible implementation of a sustainable development, our age is becoming very creative and imagines a wider range of mixed solutions that are reaping the benefits from the lessons of vernacular architecture.

[7] Martial Château is the administrator of the French Sortir du nucléaire (Leaving Nuclear) network. Jesús Castellanos was the first to update the principle of hypocaust, known as hypocaust XXI.0, which designates the 21st Century version of the principle.

[8] Martin Rauch, an Austrian rammed earth builder, has developed this device of stove using rammed earth.

RADIANT HEATING UNDERFLOOR SYSTEMS: *GLORIAS* AND *TRÉBEDES*

INNER SPAIN

authors
Fernando Vegas, Camilla Mileto

ENVIRONMENTAL PRINCIPLES

to respect environmental context and landscape · to benefit of natural and climatic resources · to reduce pollution and waste materials · to contribute to human health and welfare · to reduce natural hazards effects

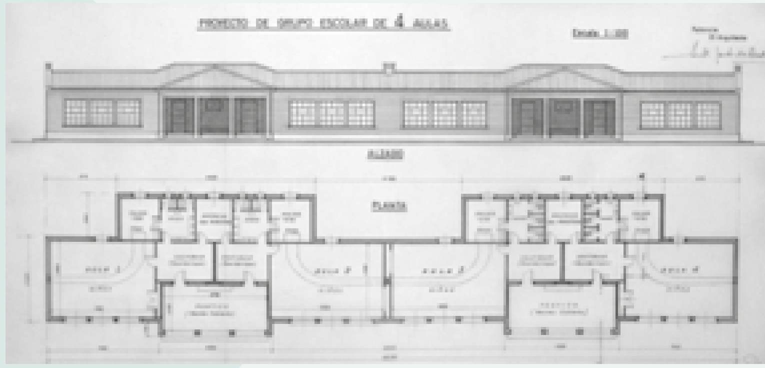
SOCIO-CULTURAL PRINCIPLES

to protect the cultural landscape · to transfer construction cultures · to enhance innovative and creative solutions · to recognise intangible values · to encourage social cohesion

SOCIO-ECONOMIC PRINCIPLES

to support autonomy · to promote local activities · to optimise construction efforts · to extend building's lifetime · to save resources

The Spanish *gloria* is a central heating system built under the whole floor of a room that is typical of cold climates in inner Spain. When the heating system only covers a platform in the room it is called *trébede*. *Gloria* stands for 'glory', due to the happiness of getting warmness from the system (Jovellanos, 1859) and *trébede* derives from the Latin word for 'tripod'. They consist of a firebox, either inside the room, where it is used also for cooking, or more commonly located outside the heated room, where one or several ducts where the smoke runs under the floor or the platform until it arrives to a vertical flue for exhaustion. Both systems have a slow rate of combustion that allows people to use little amounts of fuel like hay with very good heating results. A modern equivalent of the *gloria* would be underfloor heating, either with piped hot water or with electrical resistances. Both related systems seem to derive from the Arab bath system and, further back, from the Roman hypocaust (Torres Balbás, 1934), apparently invented or improved by the Roman engineer Caius Sergius Aurata in the 1st Century BC. However, central heating systems similar to *trébede* are to be found in China (*kang*, literally 'to dry') (Ji, 2002; Nishimura et al., 1994; Noguchi et al., 2002) and Korea (*ondol* or *gudeul*, literally 'heated stone') (Bean et al., 2010), and systems similar to *gloria* in China (*dikang*, literally 'ground kang'). Apparently, systems similar to *trébede* also exists in some parts of Russia and Alaska (Font, 2013). The oldest Chinese *kang* found to this date belongs to the 1st Century AD, and the word already appears in the Chinese dictionary in AD 121. Chinese heated walls with a double flue system where also found in an ancient palace of the Jilin Province, dating as far back as the 4th Century.



Plan and facade design of Village School, by arch. Antonio Font de Bedoya (Credits: J. Font).

Ondol heating system from Korea (drawn by Vegas and Mileto after Bean et al. 2010).

Trebéde at Amayuelas Abajo, Spain; traditional Spanish *trébede* (photos: J. Font).

ECOCENTRE PIERRE ET TERRE

MIDI-PYRÉNÉES, FRANCE

Architect: Jean Marc Jourdain

authors
Nuria Sánchez, Enrique Sevillano

ENVIRONMENTAL PRINCIPLES

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SOCIO-CULTURAL PRINCIPLES

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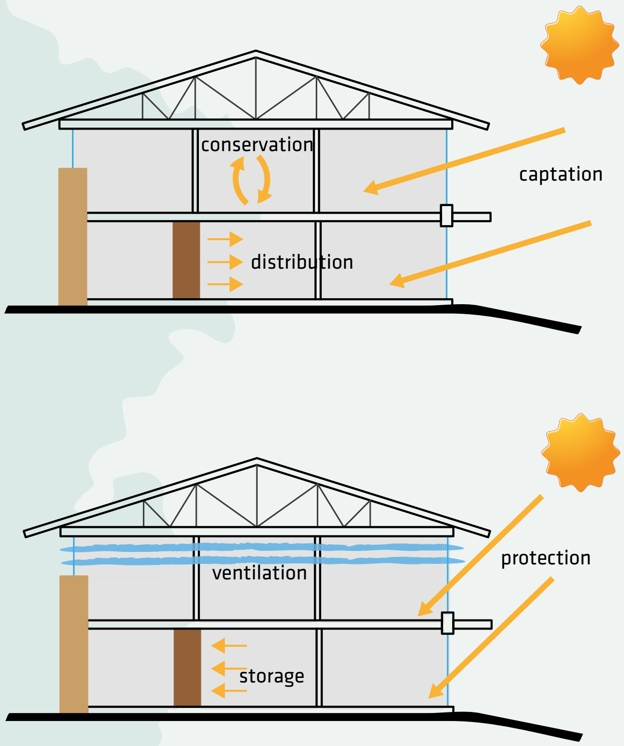
The eco-centre Pierre et terre is located in the village of Riscle, in the Gers department. This centre is managed by an association whose targets are to give support and training to people interested in sustainable construction and the rational use of buildings, as well as to promote awareness-raising in these fields.

This eco-centre is a two-floor rectangular prism. This compactness aims to reduce the contact surfaces with the outside in order not to lose energy. The main façade of this building is oriented to the South and its design is adapted both to summer and winter conditions. In winter time sun's energy is collected through large openings in the south side, and potential energy losses in the north one are controlled thanks to small triple glazing windows. Meanwhile, in summer, protection from sunlight is achieved thanks to the roof overhang and a plant shading. The presence of windows in both main facades allows natural ventilation is possible in summer time.

This construction is almost autonomous in terms of heating not only thanks to this bioclimatic design, but also to the solar panels that heat water circulating inside a storage rammed-earth wall. There is a pellet stove as a supplementary heating system for the coldest days. The building associates high thermal inertia elements, such as the rammed-earth wall, with a very efficient thermal insulation: straw bales for walls, wool and cotton cellulose for the roof and hemp for the floor.



Scheme of passive heating, thermal storage and natural ventilation of the building in different seasons. (drawings: Eco-Centre 'Pierre et Terre').

Internal view of the Eco-centre (photo: E. Sevillano).
Heat storage inside a rammed-earth wall (photo: E. Sevillano).
South oriented facade with large openings. (photo: N. Sánchez).

RENOVATION AND EXTENSION OF A WORKSHOP AT THE UNIVERSITY OF RENNES

BRITTANY, FRANCE.

Catherine Proux, Yves Marie Maurer Atelier d'Architecture

authors
Nuria Sánchez, Enrique Sevillano

ENVIRONMENTAL PRINCIPLES

■ to respect environmental context and landscape ■ to benefit of natural and climatic resources ■ to reduce pollution and waste materials ■ to contribute to human health and welfare ■ to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

■ to protect the cultural landscape ■ to transfer construction cultures ■ to enhance innovative and creative solutions ■ to recognise intangible values ■ to encourage social cohesion

SOCIO-ECONOMIC PRINCIPLES

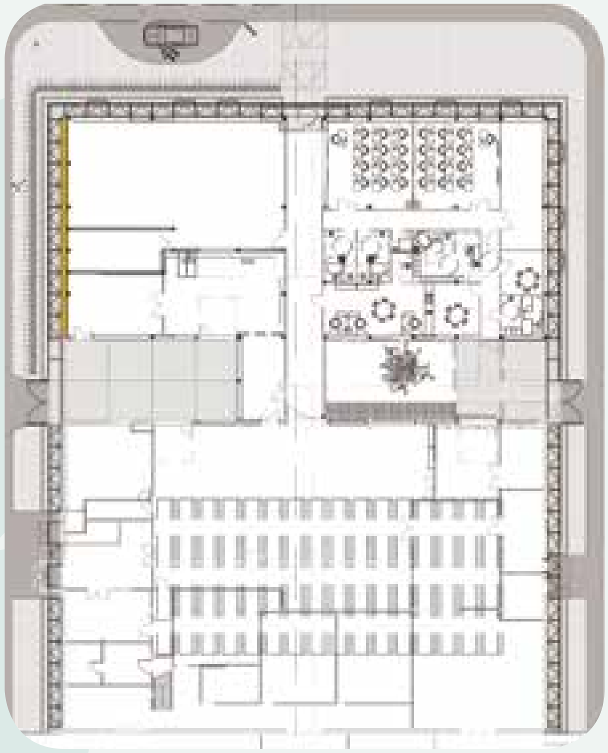
■ to support autonomy ■ to promote local activities ■ to optimise construction efforts ■ to extend building's lifetime ■ to save resources

This recently renovated building is situated in the Campus of Beaulieu, which belongs to the University of Rennes. The campus was conceived in the sixties as a rigorous orthogonal urban fabric. This mechanical workshop is representative of the original constructions built in the campus. That is the reason why its renovation intended to preserve the original appearance while improving energetic and acoustic performances.

The building is thermally protected thanks to a double skin. The inner skin corresponds to the original wall except for the extension. It is composed of high thermal inertia bricks and double glazing windows equipped with thermal breaks. In the south façade of the extension this first skin is a cob Trombe wall. The second skin is placed 90 cm apart from the first one. It is a façade made of tempered glass with galvanised steel studs. Blinds are installed between both skins.

In wintertime, when there is sunshine, this double skin causes a greenhouse effect allowing the walls to store calories and gradually warm the building. Earth is a good material to achieve this heating effect. In summertime, the blinds are lowered during the periods of sunlight and the air gap between the two skins is naturally ventilated thanks to a lower entrance of air and the opening of the upper part of the windows.

In the original building the outer façade has been extended in order to improve its thermal and acoustic performance while maintaining the original architecture readable.



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Plan scheme of the workshop building (photo: E. Camarasaltas).

South facade with tempered glass and galvanised steel studs; particular of the double skin facade; view of the south facade (photo: E. Camarasaltas).

Winery on the slopes of Etna, Catania, Italy (photo: Gaetano Gulino, Santi Albanese).

Earthen building in Marrakech, Morocco
(photo: L. Lupi).

Toward future projects

Mariana Correia, Saverio Mecca, Letizia Dipasquale, Hubert Guillaud, Camilla Mileto, Fernando Vegas, Maddalena Achenza, Alexis Castro, Gilberto D. Carlos

The positive outcomes that resulted from the VerSus project entailed the need for a continuity of the approach. Therefore, a new project was planned to continue the operative approach. VerSus 2 intends to outreach society, not only through the dissemination of the accomplished lessons, principles and indicators, but also by showing the sustainable qualities of the identified examples. This would be possible through the establishment of an operative approach that could be adjusted to different contexts and undertaken by local communities of designers, builders and stakeholders.

The second project aims to raise public awareness regarding the contribution of vernacular architecture to the development of new design strategies for sustainable living, reaching new audiences and strengthening international networks through different strategies. Master classes, seminars, exhibitions, innovative communication through the web, a Web Atlas of vernacular and contemporary solutions following vernacular architecture principles, and participative actions in urban and open spaces involving citizens will be developed by the 11 partner institutions, with a long term experience in the field of research and education on the conservation and innovation of cultural heritage, to improve knowledge and creative approaches to new sustainable architecture based on the cultural diversity of vernacular heritage.

The VerSus project is complementary to the enhancing actions of cultural heritage, as it strengthens the common awareness that vernacular architecture throughout the world is alive and can still play an active role in contemporary society. This is possible not only as a resource for tourism, but also as a benchmark to generate a more sustainable development based on local resources and knowledge.

Nowadays, the debate on the lessons that can be learned from the vernacular heritage to create sustainable architecture should involve not only scholars and designers, but also a wider public, composed by the builders and the community itself.

To achieve sustainable architecture and construction processes, both for the conservation and rehabilitation of vernacular buildings, as well as for the construction of contemporary architecture, there is a need to improve and enhance a common awareness on the existent connection between heritage and sustainability, which covers environmental issues, but also socio-cultural and socio-economic questions.

As citizens, professionals, teachers and parents of the next generation, it is relevant to mention our common responsibility towards a critical reflection, and a responsible engagement for each of us, to be more active towards the sustainable development of our society.

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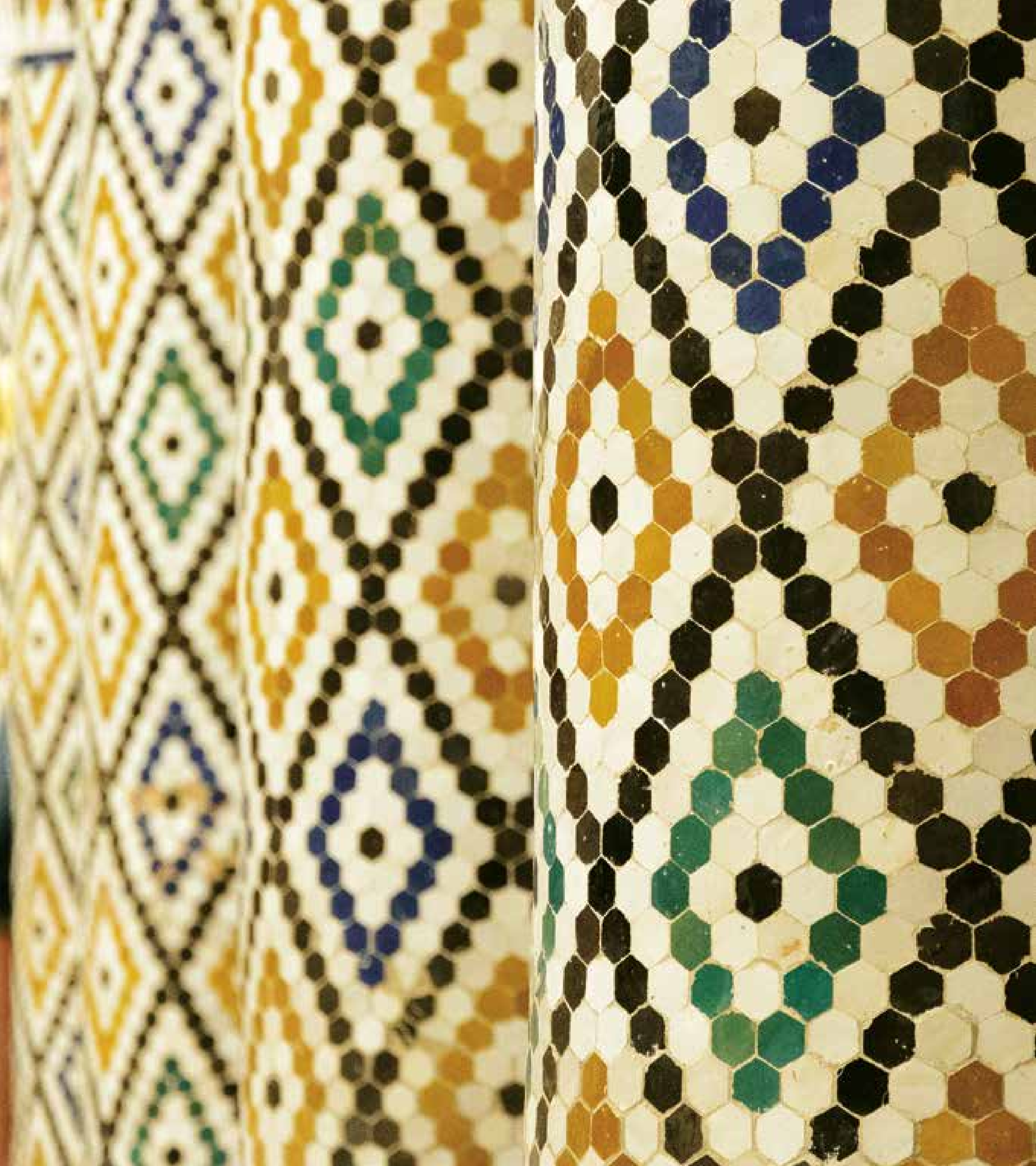

Decorative tiles in Marrakech,
Morocco (photo: L. Lupi).

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Vernacular architecture represents a great resource that has considerable potential to define principles for sustainable design and contemporary architecture. This publication is the result of an overall aim to produce a valuable tool for analysis regarding vernacular heritage through different assessments, in order to define principles to consider for sustainable development. This was possible through a comprehensive reflection on the principles established and the strategies to recognise in different world contexts.

The present publication was the result of an in-depth approach by 47 authors from 12 countries, concerned with the analysis and critical assessment of vernacular heritage and its sustainable perspective. The book presents 8 chapters addressing operational definitions and synopses advances, regarding the main areas of vernacular heritage contribution to sustainable architecture. It also presents 15 chapters and 53 case studies of vernacular and contemporary approaches in all the 5 continents, regarding urban, architectural, technical and constructive strategies and solutions.

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