



*International Conference on Ancient Water Systems
in the Mediterranean Region*

Piran, October 10th – 11th 2024

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RIPAM - Rencontre Internationale sur le Patrimoine Architectural Méditerranéen

**International Conference
on Ancient Water Systems
in the Mediterranean Region**

RIPAM 10.5 / 16th EMUNI Conference

Piran, October 10th – 11th 2024

Book of abstracts

by

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Conference organized by

Euro-Mediterranean University EMUNI

in collaboration with

Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS
(National Institute of Oceanography and Applied Geophysics)

Union pour la Méditerranée (UpM)

Table of contents

CONFERENCE ORGANIZATION.....	7
Conference Reasons (English)	7
Les raisons de la conference (Français)	8
أسباب المؤتمر (باللغة العربية).....	9
Organization Committee	11
Scientific Committee	12
SESSION 1 - WATER AND ITS SOCIAL IMPLICATIONS	13
Jurisdictional conflicts as a form of sharing-practice: water and conduits between Cerdanya and Sierra Nevada (18th-21st c.).....	14
Water Diplomacy in the South Mediterranean: Mitigating Conflicts and Promoting Cooperation..	15
Accès informel à l’AEP dans les quartiers à habitat spontané. Cas de Berbessa en Algérie	16
Alger moderne. La question des réservoirs publics et des citernes domestiques	17
Evolving Water Management Practices in Oasis Regions with Balancing Tradition and Modernity for Socio-Economic Stability: Narrative Review	18
Traditional irrigation system in Milan as a resource for a sustainable city.....	19
Ancestral innovation and sustainability: Exploring traditional irrigation and storage systems in Morocco	20
Techniques et systèmes d’irrigation et de partage de l’eau au Sahara Algérien	21
The Khettaras System, the social management of water and the scarcity of water resources in the era of climatic variability in the Moroccan Oases.....	22
Triora et le système d’eau de la République de Gênes (1261 - 1797)	23
SESSION 2 - FROM THE SACRED VISION OF WATER TO A CAREFUL MANAGEMENT OF THIS RESOURCE.....	24
Knowledge and enhancement of heritage at risk: ice-houses in mountain territories	26
Sacred Wells: pagan survivals and Christian worship	27
La Foggara, un savoir-faire et un ordre socio-spatial.....	28
From open courtyards to enclosed sanctuaries: Techniques for the assessment of ablution spaces in Marrakech's historic mosques	29
“Venice is in the water, but has no water”. From historical knowledge an example of sustainability and resilience	30
Gestion de l'eau et adaptation au contexte territorial : les structures du passé en Ligurie lues avec les outils de l' «archéologie des ressources naturelles» (Italie).....	31
Gestion durable des ressources en eau souterraines: le cas du système des ghouts dans la région du Souf	32
The forms of water in the history and transformation of the Sicilian Landscape.....	33
Hydrogeological and hydrochemical study of the Foggaras of the Touat region (Fenoughil), South West Algeria	34
POSTER SESSION	35
Harnessing Traditional Khettara Systems for Modern Thermal Regulation in Marrakech	36
Khettara: Traditional System of Transporting Groundwater in Morocco	37
Water management and land defense: Roman artificial lake emissaries.....	38
Sustaining Heritage: Geospatial analysis and enhancement of Morocco's Khettaras	39

Assessing the Impact of Climate Change on the Water-Energy-Food Nexus in Southeastern Morocco: A Case Study of the Wadi Guir Watershed 40

SESSION 3 - WATER AND THE LANDSCAPE: CHANGES AND POSSIBILITIES FOR CONSERVATION 41

Water supply and management of Lake Garda lemon houses: A close connection between irrigation and the landscape 43

Water, mills and channels: between rural archaeology and history. Case studies from western Ligurian Apennines (17th- 21st c.) 45

Water supply in military coastal systems in XIX e XX century in Sardinia (Italy). Knowledge and musealization 46

Water supply system in Ottoman Damascus and Constantine: Comparative study 48

Le développement enviromental et technologique - Valorisation du patrimoine méditerranéen, « El Hnaya et La Foggara » 49

Historical Evolution of Water Management in Liguria: From Agricultural Landscapes to Coastal Gardens 50

Historical water drainage systems in Palermo (Sicily) in medieval and modern examples. Qanat, water towers, cisterns 51

Palermo, historic center between water and greenery: a possible future? 52

L’aqueduc de la rive droite de la Soummam, un essai de restitution 53

The water and marble of the Apuan (Italy) 54

SESSION 4 - WATER IN REUSE AND MEMORY RECOVERY PROJECTS. FROM ANALYSIS TO PROJECT 55

The "memory" of the presence of water in restoration projects. Some cases in Arab-Norman architecture in Sicily 57

The fulling mills in Remole, Bagno a Ripoli (Florence) 59

De la restitution du réseau hydraulique de Muslubium, l’antique port disparu 60

Scan to GIS methodologies for the multi-scalar representation of water landscapes 61

Irrigation systems in oases: case of khettarat 62

Sahrij Labgar : un ouvrage hydraulique millénaire à Marrakech (Maroc). Interrogations et comparaisons 63

Built City and Dug City. An opportunity for reconnection 64

The Aqueduct of Ain Zeboudja: Last Witness of Hydraulic Works from the Regency of Algiers during the Ottoman Period, Between Influences and Constructive Innovations 65

Les Foggaras système hydraulique à sud Algerian: patrimoine ou un système durable? 66

SESSION 5 - CLIMATE CHANGE AND NEW PERSPECTIVES IN LANDSCAPE AND HERITGE MANAGEMENT 67

Hassi Labiad khetgara, Morocco 69

Rivers, Lakes, and Seas: Reflections on the Significance of Water in Egyptian Children’s Literature 70

Blue Centuriation: The Hydraulic Heritage of Roman Centuriation of Padua for Climate Change Adaptation 71

Water management and climate change adaptation: insights from traditional water systems in the Palermo countryside (Sicily, IT) 72

Historic fresh-water sources in the coastal Mediterranean Town of Piran 74

Assessment of Flood Mitigation Strategies: A Case Study of the Ait Athmane Center in the Errachidia Region 75

L’aqueduc d’Hippone : Témoin du temps passé 76

SESSION 6 - CLIMATE CHANGE AND NEW PERSPECTIVES FOR COMPATIBLE WATER

MANAGEMENT	77
New Era in Solving Water Scarcity for Agriculture-Food Systems Using Green Technology: From Theory to Application in MENA Region	79
Hydrological modeling to support the co-design of water management strategies revitalizes traditional water uses.....	80
Offshore groundwater aquifers: a promising resource? Insights from the RESCUE project.....	81
The role of geophysics in identifying, characterising and protecting groundwater	82
LTA, history of an Italian aqueduct.....	83
AUTHORS INDEX	84
ACKNOWLEDGMENTS	86

Conference organization

Conference Reasons (English)

The International Conference on Ancient Water Systems in the Mediterranean Region invites researchers, scholars, archaeologists, historians, engineers, and enthusiasts to contribute their insights and findings to a multidisciplinary exploration of these vital lifelines of ancient civilizations. This conference aims to foster dialogue, exchange knowledge, and advance our understanding of ancient water management practices across the Mediterranean basin.

The Euro-mediterranean University EMUNI, located in Piran, ancient coastal mediterranean city, has the honour of hosting joint event of the sixteenth EMUNI Conference and Ripam 10.5 intermediate conference “International Meeting on Mediterranean Architectural Heritage” from October 10 to 11, 2024.

The main objective of this international event is to exchange between national and international experts and to deepen discussions on issues of preservation of ancient Mediterranean water systems in general, and learn a valuable lessons in water conservation, management in particular.

The conference is co-organised by Istituto Nazionale di Oceanografia e di Geofisica Sperimentale – OGS (i.e. National Institute of Oceanography and Applied Geophysics) and the Union for the Mediterranean – UfM.

The RIPAM, Rencontre Internationale sur le Patrimoine Architectural Méditerranéen (International Meetings on Mediterranean Architectural Heritage) are scientific events organized since 2005 by a group of researchers, academics, historians, architects, heritage scientists, experts, curators and professionals from different countries and institutions of two shores of Mediterranean basin. The last two conferences were in Lisbon (Portugal) in 2022 and in Errachidia (Maroc) in 2023 (website: www.ripam.org).

Emuni University is a higher education institution that focuses on promoting collaboration and dialogue between countries in the Euro-Mediterranean region. Emuni University was established in 2008 in Slovenia, with the aim of fostering academic and cultural exchange, as well as promoting economic development and cooperation among Mediterranean countries and European Union member states. Emuni University also conducts research and organizes annual conferences, workshops, and other academic activities to address challenges and opportunities facing the Euro-Mediterranean region. Through its educational programs and research initiatives, Emuni University contributes to the promotion of peace, stability, and prosperity in the Euro-Mediterranean region (website: www.emuni.si).

In the Mediterranean region, ancient water systems are an integral part of its cultural heritage. cisterns, wells, khetarras, aqueducts, qanats and fog collection represent the knowledge, skills, and values of ancient societies and have been used for millennia as a reliable source to ensure

water. They played a crucial role in sustaining life and enabling the development of thriving civilizations around the Mediterranean basin.

Many of these systems demonstrate remarkable feats of engineering and continue to be studied and admired for their ingenuity, effectiveness, and strong cultural, historical, technological, socio-economic, and environmental impact.

In a period where (clean) water scarcity is a significant global challenge that affects millions of people worldwide, understanding ancient water systems can teach to our modern societies valuable lessons for sustainable water management and environmental stewardship, helps us to foster a sense of pride, connection, and continuity within mediterranean communities.

The conference official languages are English and French, and all abstracts in this book are in one of these two languages. However, some authors have provided a copy of their abstract in a second Mediterranean language of their choice. This book main language is English, but short translation of the main concepts in French and Arabic are given below, as those three are the official languages of the RIPAM community.

Les raisons de la conference (Français)

La « Conférence internationale sur les systèmes hydrauliques anciens dans la région méditerranéenne » invite les chercheurs, les universitaires, les archéologues, les historiens, les ingénieurs et les passionnés à apporter leurs idées et leurs découvertes à une exploration multidisciplinaire de ces lignes de vie vitales des civilisations anciennes. Cette conférence vise à favoriser le dialogue, à échanger des connaissances et à faire progresser notre compréhension des pratiques anciennes de gestion de l'eau dans le bassin méditerranéen.

L'Université euro-méditerranéenne EMUNI, située à Piran, ancienne ville côtière méditerranéenne, a l'honneur d'accueillir l'événement conjoint de la seizième conférence EMUNI et de la conférence intermédiaire Ripam 10.5 « Rencontre internationale sur le patrimoine architectural méditerranéen » du 10 au 11 octobre 2024.

L'objectif principal de cet événement international est d'échanger entre experts nationaux et internationaux et d'approfondir les discussions sur les questions de préservation des systèmes hydrauliques anciens méditerranéens en général, et d'apprendre de précieuses leçons sur la conservation et la gestion de l'eau en particulier.

La conférence est co-organisée par l'Istituto Nazionale di Oceanografia e di Geofisica Sperimentale – OGS (Institut national d'océanographie et de géophysique appliquée) et l'Union pour la Méditerranée – UpM.

Les RIPAM, Rencontre Internationale sur le Patrimoine Architectural Méditerranéen sont des événements scientifiques organisés depuis 2005 par un groupe de chercheurs, universitaires, historiens, architectes, scientifiques du patrimoine, experts, conservateurs et professionnels de différents pays et institutions des deux rives du bassin méditerranéen. Les deux dernières

conférences ont eu lieu à Lisbonne (Portugal) en 2022 et à Errachidia (Maroc) en 2023 (site web : www.ripam.org).

L'Université Emuni est un établissement d'enseignement supérieur qui se concentre sur la promotion de la collaboration et du dialogue entre les pays de la région euro-méditerranéenne. L'Université Emuni a été créée en 2008 en Slovénie, dans le but de favoriser les échanges universitaires et culturels, ainsi que de promouvoir le développement économique et la coopération entre les pays méditerranéens et les États membres de l'Union européenne. L'Université Emuni mène également des recherches et organise des conférences annuelles, des ateliers et d'autres activités académiques pour relever les défis et les opportunités auxquels est confrontée la région euro-méditerranéenne. Grâce à ses programmes éducatifs et à ses initiatives de recherche, l'Université Emuni contribue à la promotion de la paix, de la stabilité et de la prospérité dans la région euro-méditerranéenne (site Web : www.emuni.si).

Dans la région méditerranéenne, les anciens systèmes d'eau font partie intégrante de son patrimoine culturel. Les citernes, les puits, les khattaras, les aqueducs, les qanats et la collecte de brouillard représentent les connaissances, les compétences et les valeurs des sociétés anciennes et ont été utilisés pendant des millénaires comme une source fiable pour assurer l'approvisionnement en eau. Ils ont joué un rôle crucial dans le maintien de la vie et le développement de civilisations prospères autour du bassin méditerranéen.

Beaucoup de ces systèmes démontrent des prouesses d'ingénierie remarquables et continuent d'être étudiés et admirés pour leur ingéniosité, leur efficacité et leur fort impact culturel, historique, technologique, socio-économique et environnemental.

À une époque où la pénurie d'eau (propre) est un défi mondial important qui affecte des millions de personnes dans le monde, la compréhension des systèmes hydriques anciens peut enseigner à nos sociétés modernes de précieuses leçons pour une gestion durable de l'eau et une gestion de l'environnement, nous aide à favoriser un sentiment de fierté, de connexion et de continuité au sein des communautés méditerranéennes.

Les langues officielles de la conférence sont l'anglais et le français, et tous les résumés de ce livre sont rédigés dans l'une de ces deux langues. Cependant, certains auteurs ont fourni une copie de leur résumé dans une deuxième langue méditerranéenne de leur choix. La langue principale de ce livre est l'anglais, mais une petite traduction des principaux concepts en français et en arabe est donnée ici, car ces trois langues sont les langues officielles de la communauté RIPAM.

أسباب المؤتمر (باللغة العربية)

يدعو المؤتمر الدولي حول أنظمة المياه القديمة في منطقة البحر الأبيض المتوسط الباحثين والعلماء وعلماء الآثار والمؤرخين والمهندسين والمتحمسين للمساهمة بأفكارهم ونتائجهم في استكشاف التخصصات المتعددة لهذه الخطوط

الحيوية للحضارات القديمة. يهدف هذا المؤتمر إلى تعزيز الحوار وتبادل المعرفة وتعزيز فهمنا لممارسات إدارة المياه القديمة في جميع أنحاء حوض البحر الأبيض المتوسط.

الأوروبية المتوسطية، الواقعة في بيران، المدينة الساحلية المتوسطية القديمة، باستضافة حدث EMUNI تتشرف جامعة الوسيط "الاجتماع الدولي حول التراث Ripam 10.5 ومؤتمر EMUNI مشترك للمؤتمر السادس عشر لجامعة المعماري المتوسطي" من 10 إلى 11 أكتوبر 2024

الهدف الرئيسي من هذا الحدث الدولي هو تبادل الخبرات بين الخبراء الوطنيين والدوليين وتعميق المناقشات حول قضايا الحفاظ على أنظمة المياه القديمة في البحر الأبيض المتوسط بشكل عام، وتعلم دروس قيمة في الحفاظ على المياه وإدارتها بشكل خاص

والاتحاد من أجل المتوسط (OGS) يتم تنظيم المؤتمر بالتعاون بين المعهد الوطني لعلوم المحيطات والجيوفيزياء التجريبية (UfM).

(اللقاءات Rencontre Internationale sur le Patrimoine Architectural Méditerranéen، RIPAM يعتبر الدولية حول التراث المعماري المتوسطي) حدثاً علمياً نظم منذ عام 2005 من طرف مجموعة من الباحثين والأكاديميين والمؤرخين والمهندسين المعماريين وعلماء التراث والخبراء وأمناء المتاحف والمهنيين من بلدان ومؤسسات مختلفة على ضفتي حوض البحر الأبيض المتوسط. حيث نظم المؤتمران الأخيران في لشبونة (البرتغال) في عام 2022 وفي الرشيدية (www.ripam.org) (المغرب) في عام 2023 الموقع الإلكتروني

هي مؤسسة للتعليم العالي تركز على تعزيز التعاون والحوار بين البلدان في منطقة الأورو متوسطية. EMUNI جامعة في عام 2008 في سلوفينيا، بهدف تعزيز التبادل الأكاديمي والثقافي، فضلاً عن تعزيز التنمية EMUNI تأسست جامعة الاقتصادية والتعاون بين بلدان البحر الأبيض المتوسط ودول الاتحاد الأوروبي الأعضاء. كما تجري جامعة إيموني أبحاثاً وتنظم مؤتمرات سنوية وأورش عمل وأنشطة أكاديمية أخرى لمعالجة التحديات والفرص التي تواجه منطقة اليورو- في تعزيز السلام والاستقرار EMUNI المتوسط. ومن خلال برامجها التعليمية ومبادراتها البحثية، تساهم جامعة (www.emuni.si)، والازدهار في منطقة اليورو- المتوسط الموقع الإلكتروني

في منطقة البحر الأبيض المتوسط، تشكل أنظمة المياه القديمة جزءاً لا يتجزأ من تراثها الثقافي. حيث تمثل الصهاريج والآبار والخطارات والقنوات المائية وتجميع الضباب المعرفة والمهارات والقيم التي اكتسبتها المجتمعات القديمة، وقد استُخدمت لآلاف السنين كمصدر موثوق به لضمان المياه. ولعبت دوراً حاسماً في دعم الحياة وتمكين تنمية الحضارات المزدهرة في جميع أنحاء حوض البحر الأبيض المتوسط

تُظهر العديد من هذه الأنظمة مآثر هندسية رائعة وتستمر في تشجيع الدراسة والإعجاب ببراعتها وفعاليتها وتأثيرها الثقافي والتاريخي والتكنولوجي والاجتماعي والاقتصادي والبيئي القوي

في فترة حيث يشكل ندرة المياه (النظيفة) تحدياً عالمياً كبيراً يؤثر على ملايين الأشخاص في جميع أنحاء العالم، فإن فهم أنظمة المياه القديمة يمكن أن يعلم مجتمعاتنا الحديثة دروساً قيمة للإدارة المستدامة للمياه والرعاية البيئية، ويساعدنا على تعزيز الشعور بالفخر والاتصال والاستمرارية داخل المجتمعات المتوسطية

اللغات الرسمية للمؤتمر هي الإنجليزية والفرنسية، وجميع الملخصات في هذا الكتاب مرتبة في إحدى اللغتين. وقد يقدم بعض المؤلفين نسخة من ملخصاتهم بلغة البحر الأبيض المتوسط الثانية التي يختارونها. اللغة الأساسية في هذا الكتاب هي اللغة الإنجليزية، مع ترجمة صغيرة للمبادئ والمفاهيم باللغة الفرنسية، وباللغة العربية، لأن هذه اللغات الثلاث هي اللغات الرسمية لمجتمع RIPAM

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Session 1 - Water and its social implications

Chairman: Mounir Ghribi

Director of the Jean Monnet Centre of Excellence on Sustainable Blue Economy

Today, as in the past, water is a precious resource. Especially in some regions of the Mediterranean area, water supply has been, and still is, problematic. In this section, we look at the different contexts, especially trying to grasp the social aspects that may be behind the search, collection, storage and use of water. Sometimes these aspects, especially for the past, can be deduced from written sources and archive research therefore becomes essential. For the contemporary context, looking at water as a resource can in some cases be a source of conflict; also in this case, thinking about what happened in the past can, in some cases, help in resolving disputes. This part of the research, therefore, can be seen as a further, and perhaps different, aspect of sustainability

Session 1 - L'eau et ses implications sociales

Aujourd'hui comme par le passé, l'eau est une ressource précieuse. Dans certaines régions de la région méditerranéenne en particulier, l'approvisionnement en eau a été et est toujours problématique. Dans cette section, nous examinons les différents contextes, en essayant notamment de saisir les aspects sociaux qui peuvent être à l'origine de la recherche, de la collecte, du stockage et de l'utilisation de l'eau. Parfois, ces aspects, en particulier pour le passé, peuvent être déduits de sources écrites et la recherche d'archives devient donc essentielle. Dans le contexte contemporain, considérer l'eau comme une ressource peut dans certains cas être une source de conflit ; dans ce cas également, réfléchir à ce qui s'est passé dans le passé peut, dans certains cas, aider à résoudre les conflits. Cette partie de la recherche peut donc être considérée comme un aspect supplémentaire, et peut-être différent, de la durabilité

الجلسة 1 - المياه وتداعياتها الاجتماعية

اليوم كما في الماضي، تعتبر المياه مورداً ثميناً، وخاصة في بعض مناطق البحر الأبيض المتوسط، حيث كانت إمدادات المياه ولا تزال تمثل مشكلة. في هذا القسم، ننظر إلى السياقات المختلفة، وخاصة في محاولة لفهم الجوانب الاجتماعية التي قد تكون وراء البحث عن المياه وجمعها وتخزينها واستخدامها. في بعض الأحيان، يمكن استنتاج هذه الجوانب، وخاصة في الماضي، من المصادر المكتوبة، وبالتالي يصبح البحث في الأرشيف أمراً ضرورياً بالنسبة للسياق المعاصر، يمكن أن يكون النظر إلى المياه كمورد في بعض الحالات مصدراً للصراع؛ وفي هذه الحالة أيضاً، يمكن أن يساعد التفكير فيما حدث في الماضي، في حل النزاعات. وبالتالي، يمكن اعتبار هذا الجزء من البحث جانباً آخر وربما مختلفاً من جوانب الاستدامة

Jurisdictional conflicts as a form of sharing-practice: water and conduits between Cerdanya and Sierra Nevada (18th-21st c.)

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Abstract. For the centrality that water resource management has played in the social construction of space, both in its material dimension and its jurisdictional dimension, Cerdanya and Sierra Nevada can be defined as true irrigation societies. In both cases, the sharing of the resource, in terms of artifacts, practices, and specific actions, appears as a central element for understanding the continuity of its use despite the discontinuities that historical documentation regarding jurisdictional conflicts may suggest. By revisiting the debate on collective resources, this contribution will attempt to explicitly discuss the positive value of conflict as a mechanism for regulating forms of access to resources and to examine the role of objects in contributing to the continuity and discontinuity of their use. Objects, in fact, are the material devices through which resources are used, activated, shared, and distributed through specific practices, and so activate social relationships also due to their specific characteristics and the constant need for maintenance. In particular, the essay will seek to shed light on how the practices related to the maintenance and use of water conduits have contributed to shaping the social life of the social groups involved in the use of water resources. Secondly, it will seek to understand how these practices are linked to and reflected in the negotiation mechanisms that the documentary production related to disputes over access rights to resources allows us to grasp. Through the discussion of two case studies (Barranco de la Poqueira in Sierra Nevada and Ribeira d'Eyne in Cerdanya), carried out by the Laboratory of Environmental Archaeology and History, the contribution aims to explore the connections between the material articulation of water conduits, the forms of resource sharing and the social morphology of local communities. Finally, it aims to establish whether and to which extent the longevity of such management forms (and therefore their sustainability) depends on the mechanisms of conflict and solidarity that water channels constantly activate precisely due to their continuous need for shared and collective maintenance.

Keywords: rural archaeology and history, topographic approach, conflicts and access rights , water perimeters, water societies

Water Diplomacy in the South Mediterranean: Mitigating Conflicts and Promoting Cooperation

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Abstract. Water resources in the South Mediterranean region are under increasing strain due to growing populations, the impacts of climate change, and competing socio-economic demands. Effective water diplomacy has emerged as a critical approach for mitigating conflicts and fostering cooperation among riparian states facing shared water challenges. This paper examines the theoretical foundations and practical applications of water diplomacy in the South Mediterranean context. Drawing on a comprehensive literature review, it explores key issues such as transboundary water management, sustainable development goals, and the role of international law in promoting equitable water allocation. The study highlights successful case studies of collaborative water projects and initiatives that have enhanced regional stability and resilience. Moreover, the paper identifies persistent barriers to effective water diplomacy, including political tensions, institutional constraints, and socio-economic disparities. It proposes policy recommendations aimed at enhancing cooperation through strengthened governance frameworks, stakeholder engagement, and technical capacity building. By synthesizing insights from diverse stakeholders, including governmental and non-governmental actors, and international organizations, this paper contributes to the evolving discourse on sustainable water governance in the South Mediterranean. It underscores the urgent need for integrated approaches that ensure, and environmental sustainability in managing shared water resources.

Keywords: Water diplomacy, Transboundary water management, Sustainable development goals, International law, Collaborative water projects

Accès informel à l'AEP dans les quartiers à habitat spontané. Cas de Berbessa en Algérie

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Résumé. Ce travail est une contribution à la compréhension de la gestion de l'alimentation en eau potable (AEP) dans les quartiers à habitat spontané à Berbessa (Algérie).

De cette étude, il ressort que sur les 100 ménages enquêtés de manière aléatoire, seuls 30% ont un branchement réglementaire et sont à jour de leurs redevances à la société de gestion des eaux (SEAAL), le reste recourt à des branchements illégaux sur conduit public ou carrément sur des forages destinés à l'agriculture (Berbessa est une zone de captage des eaux dont Alger la capitale est alimentée).

En 2010, la SEAAL a procédé à un grand assainissement de ces branchements illégaux avec l'aide de la police des eaux. La « police des eaux », instituée dans le cadre de la loi n°05-12 août 2005 relative à l'eau en Algérie, contrôlera donc les champs d'utilisation des ressources d'eau dans tous les domaines d'activités, notamment l'agriculture qui consomme près de 70% des ressources disponibles afin d'inciter les contrevenants à régulariser leurs branchements en plaçant des compteurs réglementaires.

Or ces pratiques résistent toujours face à la multiplication des quartiers spontanés ces cinq dernières années.

A cet effet, notre communication s'orientera vers ces pratiques et leurs limites.

Mots clés : Berbessa-habitat spontané –potabilisation de l'eau-branchement illicite-police des eaux .

Alger moderne. La question des réservoirs publics et des citernes domestiques

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Résumé. Les dernières recherches sur l'alimentation en eau de la médina d'Alger (16e-19e siècles) ont permis de mieux connaître la nature des réalisations, le transfert de techniques hydrauliques anciennes, telle les souterazi, et son évolution sur sa longue diachronie.

Un aspect important de la gestion de la cité consiste en l'établissement de réservoirs de stockage des eaux des aqueducs en des points stratégiques de la ville ; ce fait est relaté essentiellement par des sources écrites. Le réservoir le plus cité reste celui du fort El Fanar au bout du môle. Toutes les eaux y finissent leur course ; « (...) les vaisseaux et les galères viennent y faire leur aiguades », selon l'expression d'Emmanuel d'Aranda. Cet ouvrage sera toujours en usage au cours des premières décennies du 20e siècle.

A l'instar de bien des villes côtières du bassin méditerranéen, des citernes sont établies sous les patios pour la récupération des eaux pluviales. Obligation est faite aux propriétaires des maisons de canaliser ses eaux ; car les aqueducs peuvent être endommagés en cas de bombardement ou de séisme. Ce fluide couvre l'essentiel des besoins pour l'hygiène domestique. Tout un savoir-faire, des coutumes d'entretien et de chaulage se sont développés. L'architecture de ces citernes, contrairement à celles de Constantinople ou encore celles d'Alexandrie, n'a pas suscité beaucoup d'intérêt. Des travaux de terrain commencent toutefois à lever le voile sur ces ouvrages hydrauliques enterrés. L'histoire de l'eau raconte la société. Seuls quelques privilégiés pouvaient bénéficier d'un branchement sur la conduite de l'aqueduc, moyennant une forte contrepartie au Service des Eaux du beylik, comme le mentionnent différents actes habous. C'est ainsi que les habitants doivent se contenter de l'eau de leur citerne et de leur puits.

Mots clés: djeb ; Casbah d'Alger ; maison à patio ; alimentation en eau ; récupération des eaux pluviales

Modern Algiers. The question of public reservoirs and domestic cisterns

Abstract. The latest research on watersupply of the medina of Algiers (16th-19th centuries) has made it possible to understand the nature of the achievements, the transfer of ancient hydraulic techniques, such as souterazi, and its evolution over its long diachrony.

An important aspect of the city management consists to built water storage tanks at strategic points in the city ; this fact is reported mainly by written sources. The most cited reservoir remains that of Fort El Fanarat the end of the mole. All the waters end their course there ; « (...) the ships and galleys come to do their docking their », according to the expression of Emmanuel d'Aranda. This work of art will still be in use during during de firt decades of the 20th century. Like many coastal towns in the Mediterranean basin, cisterns are established under patios to collect rainwater. The owners of the houses are required to channel their water because the aqueducts can be damaged in the event of bombing or earthquake. This fluid covers most of the needs for domestic hygiene. A whole range of know-how, maintenance and liming customs have developed. The architecture of these cisterns, unlike those of Constantinople or those of Alexandria, has not aroused much interest. However, field work is beginning to lift the veil on these buried hydraulic structures.

The history of water tells about story of the society. Only privileged few could be benef from a connection to the aqueduct pipe, in return for a high compensation to the beylik water service, as mentioned in various habous acts. This is how the simple inhabitant have to make do with water from their cisterns and wells.

Keywords: djeb ; Casbah of Algiers ; patio house ; water supply ; rainwater harvesting

Evolving Water Management Practices in Oasis Regions with Balancing Tradition and Modernity for Socio-Economic Stability: Narrative Review

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Abstract. Water in oasis regions is a vital resource, fundamental to the socio-economic stability and historical continuity of these fragile areas. It serves as a key determinant of human activities and acts as a historical archive, documenting events, conflicts, and crises experienced by irrigation-dependent communities, especially in desert, arid, and semi-arid climates. Since ancient times, these communities have utilized simple, sustainable techniques to exploit available water resources, creating strategic social systems to manage scarcity within environmentally engineered water networks.

Historically, local tribes developed customary water management systems to harness river water, constructing facilities tailored to the climate of Ferkla, notably the "khetaras" – traditional underground irrigation channels. These systems have persisted under the harsh conditions of oasis environments, embodying principles of sustainability and effective resource management. However, with the advent of modern pumps and the decline of tribal control, these traditional methods have seen a significant reduction in use. The introduction of pumps has facilitated extensive groundwater exploitation, particularly in the lower parts of the oasis where water scarcity is most acute and persistent throughout the year.

The demographic pressures and increased land use have exacerbated water resource challenges, especially during successive drought years. The shift from traditional water management practice to modern techniques has led to significant socio-economic and environmental impacts, including the depletion of groundwater reserves and increased vulnerability of oasis communities to water scarcity.

This narrative review examines the evolution of water management practices in oasis regions, highlighting the transition from traditional to modern methods. It explores the socio-economic and environmental implications of this transition, emphasizing the need for sustainable water management strategies that integrate traditional knowledge with modern technology to ensure the long-term viability of water resources in these fragile ecosystems.

Keywords: Oasis Water Management, Socio-Economic Stability, Sustainable Techniques, Groundwater Exploitation, Traditional Irrigation Systems

Traditional irrigation system in Milan as a resource for a sustainable city

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Abstract. Historic irrigation systems are invaluable environmental and cultural resources for contemporary society, effectively addressing climate-related issues like droughts and floods in urban areas. Many peri-urban landscapes retain agricultural structures, including irrigation systems, which should be preserved and integrated into urban regeneration projects.

Milan's run-flow irrigation system, notably its water meadows developed by Cistercian monks, has been admired by scholars since the eighteenth century. These water meadows utilize year-round water availability and warmer subsoil water, flowing continuously from December to February through a network of carriers and drains.

Today, this traditional irrigation system is in decline. Regional parks around Milan now oversee its protection, employing both passive and proactive measures. Recent studies indicate that off-season winter flooding of cereal fields can recharge the water table when water availability is higher. High percolation rates have been observed in rice paddies during winter and summer, with lower crop yield damage during droughts linked to water meadow practices. Combining hydrological data with tangible and intangible heritage conservation can demonstrate how these ancient techniques provide resilience against drought and extreme rainfall.

Beyond environmental benefits, water meadows boost biodiversity, offering winter refuge to rare birds. The diverse fodder improves milk and cheese quality, enhancing their nutritional value with Omega-3 and healthy fats. Expanding these practices could benefit larger areas and promote sustainable peri-urban development.

Few territories actively enhance this landscape heritage, but dynamic entities like Ticino Park can lead change, inspiring other institutions to adopt collaborative and proactive policies. The results of 10 years proactive policies and collaboration between farmers, citizens, institutions and university will be presented as a base for expansion to other territories and landscapes.

Keywords: water meadows, agrarian landscape, heritage preservation, biodiversity, healthy food

Ancestral innovation and sustainability: Exploring traditional irrigation and storage systems in Morocco

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Abstract. In the Haouz region of Marrakech, traditional water management was ensured by systems such as the "Notfias" and the "Khetaras". Notfias, used in arid regions, are reservoirs that collect and store rainwater. They are made from local materials (stone, lime, clay, etc.) and are primarily used for domestic needs and animal watering. Khetaras, or qanats, are underground canals that capture water from aquifers for irrigation and domestic use in arid areas. This technique, over 2,500 years old, is of Persian origin and was adopted by the Almoravids (11th-12th century). It spread throughout the southern Mediterranean during the Islamic conquest.

These traditional systems reflect ancient knowledge passed down from generation to generation and are important to Morocco's cultural heritage. They symbolize sustainable harmony between human needs and the natural environment, preserving local ecosystems by maintaining soil moisture and supporting biodiversity. Their resilience in the face of climate change highlights their potential for integration into modern water management strategies. However, although some systems remain active, rapid urbanization and high maintenance costs are causing their decline. Projects involving researchers, local communities, and authorities aim to restore and revitalize these systems for sustainable water management in the face of arising challenges.

Integrating the study of these systems into educational programs can raise awareness among younger generations about sustainable water management, inspiring them to seek innovative solutions based on traditional practices. The revitalization of Notfias and Khetaras can create jobs benefiting locals, boost rural economies, and promote sustainable tourism, raising awareness among visitors of the importance of these water management practices.

Keywords: water management, traditional systems, sustainability, cultural heritage, climate resilience

Innovation ancestrale et durabilité : Exploration des systèmes traditionnels d'irrigation et de stockage au Maroc

Résumé. Dans la région de Haouz à Marrakech, la gestion traditionnelle de l'eau était assurée par des systèmes tels les "Notfias" et les "Khetaras". Les Notfias, utilisées dans les régions arides, sont des réservoirs qui collectent et stockent l'eau de pluie. Elles sont fabriquées à partir de matériaux locaux (pierre, chaux, argile, etc.), principalement pour les besoins domestiques et l'abreuvement des animaux. Les Khetaras, ou qanats, sont des canaux souterrains qui captent l'eau des aquifères pour l'irrigation et les besoins domestiques dans les zones arides. Cette technique, vieille de plus de 2 500 ans est d'origine perse et a été adoptée par les Almoravides (XIème-XIIème siècle). Elle s'est répandue dans tout le sud de la Méditerranée pendant la conquête islamique.

Ces systèmes traditionnels reflètent un savoir ancien transmis de génération en génération et sont importants pour le patrimoine culturel du Maroc. Ils symbolisent une harmonie durable entre les besoins humains et l'environnement naturel et préservent les écosystèmes locaux en maintenant l'humidité du sol et en soutenant la biodiversité. Leur résilience face aux changements climatiques met en évidence leur potentiel d'intégration dans les stratégies modernes de gestion de l'eau. Cependant, bien que certains systèmes restent actifs, l'urbanisation rapide et les coûts élevés de leur maintenance sont à l'origine de leur déclin. Des projets impliquant les chercheurs, les communautés locales et les autorités visent à restaurer ces systèmes et à les revitaliser, pour une gestion durable de l'eau face aux défis suscités.

L'intégration de l'étude de ces systèmes dans les programmes éducatifs peut sensibiliser les jeunes générations à la gestion durable de l'eau, en les inspirant à rechercher des solutions innovantes basées sur des pratiques traditionnelles. La revitalisation des Notfias et des Khetaras peut créer des emplois profitant aux locaux, stimuler les économies rurales et promouvoir un tourisme durable, sensibilisant les visiteurs à l'importance de ces pratiques de gestion de l'eau.

Mots clés : Gestion de l'eau ; systèmes traditionnels ; durabilité ; patrimoine culturel ; résilience climatique

Techniques et systèmes d'irrigation et de partage de l'eau au Sahara Algérien

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Résumé. Depuis que la vie existe sur la planète Terre, l'Eau a toujours constitué l'essentiel, un élément Vital, une source de Vie incontestée et autour naissent des civilisations florissantes.

Dans mon pays l'Algérie ou la superficie du Sahara se présente comme un espace géographique énorme, et où la vie reste rude puisque le pluviométrie reste faible, les populations des Ksours cultivent une agriculture dans les Oasis en s'appuyant sur les eaux souterraines et puisant dans les nappes avec un système d'irrigation qui remonte historiquement à des ères lointaines ancrées dans le temps, avec des techniques et savoirs ancestraux en matière de captage, de partage d'eau d'arrosage et d'irrigation que l'on retrouve particulièrement dans certaines vastes régions du désert Algérien parmi lesquelles nous citerons : Adrar la ville saharienne des monts, Le Gourara, Le Tidekelt, dans les belles Oasis de Beni Ounif à Béchar et aussi dans les petites villes autour de l'historique Ghardaia à Six cent kilomètres au sud d'Alger, cette technique en question est désignée sous le nom de FOGGARA, elle se présente comme un exemple extraordinaire d'une belle et équitable organisation à caractère social qui repose sur la notion de l'effort et le travail collectif qui réunit les populations sahariennes dont l'objectif a été depuis des siècles le génie de la bonne répartition de l'eau et de systèmes d'irrigation juste et incontesté.

Mon intervention met en exergue cette pratique ancestrale qui persiste à ce jour appelée je rappelle en Algérie : Foggara, en Tunisie : Kriga, au Maroc : Khattara, en me focalisant sur les systèmes d'approvisionnement, de captage traditionnel et d'irrigation des Oasis et des palmeraies.

Mots clés : Sahara Algérien, systèmes d'irrigation, Oasis, Ksours, Foggaras

Techniques and systems of irrigation and water partition in the Algerian sahara

Abstract. Water has been a source of life since the beginning of human's on earth, and a vital element in the emergence of human civilization.

In my country Algeria, where the area of the Sahara is vast, and where life is rude and rainfall is very low, have made the inhabitants of El ksours and Oasis in the big desert use irrigation to cultivate their oases.

This system of irrigation is traced back to very old eras with techniques and ancestral knowledge of both capture and irrigation found in certain regions of the Algerian desert: Adrar, Gourara, Tidekelt, in the oases of Beniounif in Bechar and Ghardaia.

The technique is called Fougara which preserved a typical Sahara region tradition based on the notion of collective effort to share water fairly.

My work tries to highlight this ancestral practice known in Algeria as foggara, in Tunisia as kriga, and in Morocco as khattara, with a focus on supply systems, traditional capture and irrigation of oases and palm groves.

Keywords: Algerian sahara, Ksours, Irrigation systems, Oasis, Foggaras.

The Khettaras System, the social management of water and the scarcity of water resources in the era of climatic variability in the Moroccan Oases

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Abstract. Water resources constitute, over time, a necessary condition for life. So, without them, we cannot speak of development work. This observation becomes very valid when it comes to arid environments which are characterized by the scarcity of this resource.

Our article addresses the problem of the scarcity of water resources in the oasis areas of Morocco through a diagnosis of the state of the oasis ecosystems, the pressures exerted on natural resources by human activity and climate changes, particularly on water resources. It looks at the forms of resilience developed by oasis humans to adapt to severe climatic conditions and the scarcity of water resources. These forms are found in the social management of resources (soil, water, rangeland, etc.), the establishment of khettaras, the diversification of crops, the development of know-how for the valorization of rare resources.

The pressures exerted on oasis ecosystems have accelerated over the last three decades because of the socio-economic transformations that oases are experiencing. So, it is pressing to see how oases will be affected by climate change? and how are these traditional ecosystems adapting to these global changes?

Despite the hostile climatic conditions, farmers have developed agro-systems in the oases which have allowed them to adapt to the harmful impacts of climate change. This three-story system (date palm, fruit trees and underlying crops) combined with social management of water resources means that oases today are models of resilience to climate change, ramparts against the advance of deserts, an example of the rational use of resources (water and soil), enjoy a wealth of biodiversity which has constituted a genetic reserve adapted to changing climatic conditions.

Keywords: Khettaras system - social management of water - climatic variabilities - Oases - Water scarcity

Triora et le système d'eau de la République de Gênes (1261 - 1797)

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Résumé. Triora, à l'extrême ouest de la Ligurie, dans la haute vallée de l'Argentine, perché sur le Monte Trono, dans le massif du Monte Saccarello, le plus haut de la région, est un village établi au Moyen Âge. Les premières fréquentations sont attestées à l'âge du bronze antique.

Le territoire est traversé par le ruisseau Argentina, le Tanarello, la source du fleuve Tanaro, le principal affluent du Pô, et le Negrone. Le nom de Triora est attribué à la présence des trois cours d'eau. Cette richesse en eau a favorisé la collecte des nombreuses sources aux fontaines et citernes du village, qui les conserve encore aujourd'hui.

Le système d'eau fournissait et prévoit encore en partie l'écoulement de l'eau des fontaines et des citernes par des canaux en pierre, bordés d'ardoise ciappe (sur le territoire de Triora, il y a des carrières d'ardoise), qui passent près des murs des maisons, descendant le long des virages en épingle à cheveux du village et déversant les eaux vers les bandes en contrebas. Ce système a été construit au cours des siècles où Triora, de 1261 à 1797, était un important Podesteria à la frontière nord-ouest de la République de Gênes.

Les principales fontaines, encore visibles, sont les fontaines soprana et sottana, cette dernière a été réalisée en 1480, comme le montre l'inscription qui y est apposée. La citerne centrale, située entre la place et la rue en contrebas, est située dans une partie semi-obscure entre un enchevêtrement d'arcs et de voûtes ; Elle est surmontée de deux dauphins artistiques, symbolisant l'eau.

Un grand puits a été creusé dans la place de l'Eglise pour recueillir l'eau de sources lointaines, dont une à environ trois kilomètres de la ville. La citerne centrale s'est avérée d'une importance vitale en cas de siège et de sécheresse. D'autres fontaines étaient celles du Château, du Poggio, du Manè, du Spianate et de San Dalmazzo, où se dresse encore l'ancienne citerne.

Mots clés : ruisseaux, sources, ardoise, fontaine, citerne

Triora e il sistema idrico della Repubblica di Genova (1261 - 1797)

Riassunto. Triora, nell'Estremo Ponente della Liguria, in Alta Valle Argentina, arroccata sul Monte Trono, nel massiccio del Monte Saccarello, il più alto della regione, è un borgo costituitosi nel Medio Evo. Le prime frequentazioni sono attestate all'età del Bronzo Antico, da parte di popolazioni liguri.

Il territorio è percorso dal torrente Argentina, dal Tanarello, ramo sorgentifero del fiume Tanaro, principale affluente del Po, e dal Negrone. Si attribuisce il nome Triora proprio alla presenza dei tre corsi d'acqua Tale ricchezza idrica ha favorito la captazione dalle numerose sorgenti verso le fontane e le cisterne del borgo, che ancora oggi le conserva.

Il sistema idrico prevedeva e in parte ancora prevede il deflusso delle acque dalle fontane e dalle cisterne attraverso canali in pietra, rivestiti da ciappe in ardesia (ne territorio di Triora ci sono cave di ardesia), che passano radenti ai muri delle case, scendendo lungo i tornanti del borgo e facendo scaricare le acque verso le fasce sottostanti. Tale sistema era stato realizzato nei secoli in cui Triora, dal 1261 al 1797, era una importante Podesteria al confine Nord-Ovest della Repubblica di Genova.

Le principali fontane, ancora visibili, sono la fontana soprana e quella sottana, quest'ultima costruita nel 1480, come risulta dall'iscrizione apposta. La cisterna centrale, collocata tra la piazza e la via sottostante, è posta in un tratto semibuio fra un groviglio di archi e volte; è sormontata da due artistici delfini, simboleggianti proprio l'acqua. Nella piazza della Chiesa Collegiata fu scavato un grande pozzo che raccoglieva l'acqua proveniente da lontane sorgenti, fra le quali una a circa tre chilometri dal paese. La cisterna centrale si rivelò di vitale importanza in caso di assedio e di siccità. Altre fontane erano quelle del Castello, del Poggio, del Manè, delle Spianate e di San Dalmazzo, dove sussiste ancora l'antica cisterna.

Parole chiave: torrenti, sorgenti, ardesia, fontana, cisterna

Session 2 - From the sacred vision of water to a careful management of this resource

Chairman: Khaled AbuZeid

Regional Water Director, Centre for Environment & Development for the Arab Region & Europe (CEDARE)

In some geographical contexts and in some civilizations, water has taken on a sacred value: sacred because it carries values, sacred because it is heavily used in religious functions. These aspects are transversal to the two shores of the Mediterranean. Knowing these aspects and preserving them allows for the preservation of cultural identities that have strongly characterized the Mediterranean environment in the past. In this case, it makes sense to talk about the transmission of a specific intangible heritage linked to the material heritage that is still visible in some territorial contexts, at least as ruins. From this intangible heritage linked to the sacredness of water, another intangible heritage comes, at least for the past and for some civilizations: the habit to a careful management of this resource. Where water is a scarce resource, where it is difficult to intercept, transport and conserve it, these good practices of careful management were well rooted in the operational practices of the populations. Sometimes in the current context, these aspects have been partly lost or are being lost; reasoning on these aspects therefore becomes essential especially for the new generations.

Session 2 - De la vision sacrée de l'eau à une gestion prudente de cette ressource

Dans certains contextes géographiques et dans certaines civilisations, l'eau a pris une valeur sacrée : sacrée parce qu'elle est porteuse de valeurs, sacrée parce qu'elle est fortement utilisée dans les fonctions religieuses. Ces aspects sont transversaux aux deux rives de la Méditerranée. Connaître ces aspects et les préserver permet de préserver des identités culturelles qui ont fortement caractérisé l'environnement méditerranéen dans le passé. Dans ce cas, il est logique de parler de la transmission d'un patrimoine immatériel spécifique lié au patrimoine matériel qui est encore visible dans certains contextes territoriaux, au moins sous forme de ruines. De ce patrimoine immatériel lié à la sacralité de l'eau, découle un autre patrimoine immatériel, du moins pour le passé et pour certaines civilisations : l'habitude d'une gestion prudente de cette ressource. Là où l'eau est une ressource rare, où il est difficile de l'intercepter, de la transporter et de la conserver, ces bonnes pratiques de gestion prudente étaient bien ancrées dans les pratiques opérationnelles des populations. Parfois, dans le contexte actuel, ces aspects ont été en partie perdus ou sont en train de se perdre ; le raisonnement sur ces aspects devient donc essentiel notamment pour les nouvelles générations.

الجلسة 2 - من الرؤية المقدسة للمياه إلى الإدارة الدقيقة لهذا المورد

في بعض السياقات الجغرافية وفي بعض الحضارات، اكتسبت المياه قيمة مقدسة. مقدسة لأنها تحمل قيمًا ولأنها تستخدم بكثافة في الوظائف الدينية. إن معرفة هذه الجوانب المستعرضة لضفتي البحر الأبيض المتوسط والحفاظ عليها، يسمح بالحفاظ على الهويات الثقافية التي ميزت البيئة المتوسطية بقوة في الماضي. في هذه الحالة، من المنطقي الحديث عن نقل تراث غير مادي مرتبط بالتراث المادي الذي لا يزال مرئيًا في بعض السياقات الإقليمية، على الأقل كأطلال.

من هذا التراث غير المادي المرتبط بقدسية المياه، يأتي تراث غير مادي آخر، بالنسبة للماضي وبالنسبة لبعض الحضارات: عادة الإدارة الدقيقة لهذا المورد. حيث تكون المياه موردًا نادرًا، يصعب جلبها ونقلها والحفاظ عليها. ولقد كانت هذه الممارسات الجيدة للإدارة الدقيقة متجذرة جيدًا في الممارسات التشغيلية للسكان. في بعض الأحيان في السياق الحالي، فقدت هذه الجوانب جزئيًا أو أصبحت منعدمة؛ ومن ثم أصبح التفكير في هذه الجوانب أمرًا ضروريًا خاصة بالنسبة للأجيال الجديدة

Knowledge and enhancement of heritage at risk: ice-houses in mountain territories

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Abstract. Throughout history, the collection and distribution of water in its different forms has always been a challenge for humanity. Today, as we face water scarcity, we must come up with innovative ways to collect water; similarly, in the past, people had to find ways to preserve ice during summer. This led to the creation of ice-houses, structures designed to maintain cold temperatures even during the hot summer months.

Mediterranean countries had widespread ice storage and distribution systems. Snow was collected at high altitudes and stored in mountain ice-houses, like the Ronco Biellese ice-house, while in other cases artificial lakes (such as the Ice-house Lake in Salbertrand) were created specifically for ice production. There were two types of ice-houses: those located near the production areas, used for storing ice until summer, and those situated in the villages of the plains, where ice was stored after purchase.

Today, ice-houses are facing the risk of being forgotten. While some of them have been long lost to memory or fallen into disrepair, others are still being used, for example for aging wine. Only a small number of ice-houses, such as the Madonnina ice-house in the Ecomuseum of the Pistoia Mountain, are being protected and enhanced as part of the local built heritage.

This contribution focuses on two main goals. Firstly, it analyses the construction materials of the ice-houses in relation to the characteristics of the ground in the surrounding area. Secondly, it aims to raise awareness around this heritage to endure its preservation and promote its enhancement. This can be achieved by documenting the ice-houses and the system used for ice preservation in a more structured manner and, by doing so, guaranteeing a more lasting preservation and effective appreciation of ice-houses.

Keywords: ice-houses, built heritage, heritage conservation, construction materials

Sacred Wells: pagan survivals and Christian worship

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Abstract. This contribution aims to reflect on the relationship between the pagan cult of water and Christian architecture in Italy. In particular, the research intends to investigate the survival of certain religious sites, such as sacred wells, subsequently inserted inside churches in the Middle Ages or in whose vicinity Christian buildings were constructed.

The pagan religion maintained the sacrality of the elements through which it was celebrated, later transformed or relocated to meet the needs of Christianity. Some archival testimonies report the survival of some polytheistic ritual forms in the Middle Ages and attempted repression of superstitions related to the survival of the ancient world by ecclesiastical authorities. Pagan beliefs underwent a progressive transformation of their sacred characteristics: if at first the holy well was dedicated to the ancient gods, it was adapted to the devotional rites of the Christian saints. Sometimes some wells dedicated to gods of ancient religions were replaced with similar structures reinterpreted in a Christian context. The spirituality of the doctrines underwent a radical change, although the physical elements necessary for the celebration of rites remained intact.

In Italy, some examples of this process can be observed in the santuario di Santa Vittoria in Monteleone Sabino (Rieti), the basilica di San Bartolomeo all'Isola (Rome), and in Sardinia, in the cases of sacred wells inserted inside hypogeous nuragic temples near which Christian churches and villages were erected in the Middle Ages. The most interesting examples that deserve further study are Santa Cecilia and San Salvatore (Oristano).

Through the analysis of sources, architectures and liturgical rituals, the essay aims to reflect on the preservation of pagan sites of worship in the Medieval period through the theme of the centrality of water, a spiritual element common to different religions and thanks to which pre-Christian sacred structures have been preserved.

Mots clés : Sacred well, pagan culture, Christian architecture, Middle Ages, Italy

La Foggara, un savoir-faire et un ordre socio-spatial

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Résumé. Dans les villes du Sahara, l'eau revêt une grande importance, elle est considérée comme une bénédiction divine, qui donne et entretient la vie, purifie l'humanité et la planète. Compte tenu de sa rareté, l'eau ; devient un élément précieux, où son captage, son usage et son partage nécessitent un traitement et un savoir aussi développés à la hauteur du génie de l'homme.

A Timimoun (une ville du sud -ouest de l'Algérie), la Foggara était l'unique moyen de captage des eaux, rendues disponibles grâce à la nappe de l'Erg et de la nappe Albienne.

L'accès à l'eau devient alors un droit sacré et le début d'une chaîne de sacralité, qui imprime l'urbain à Timimoun. Le tracé du passage des Foggara détermine l'implantation des Ighamawen (forteresses), car leurs emplacements correspondent aux endroits où débouchent les Foggara. A travers la répartition des Kesria (système répartiteur), on arrive à lire la stratification sociale ; la segmentation par famille et par personne, où chaque Kesria porte un nom et une histoire. Ce tracé structure le spatial, hiérarchise le social et devient une véritable science de la parcellisation.

Par ailleurs le débit des Foggara détermine le terroir cultivable (palmeraie), condition sine qua non de l'établissement humain. De cet élément (eau) naissent des Djena (palmeraies) et toute une chaîne de Ksour (cités) dans la région du Touat, du Gourara et du Tidikelt.

A travers cette communication nous présenterons les différentes phases du développement urbain du Ksar de Timimoun en relation avec la Foggara, l'ordre social qui en résulte, la survie de ce système d'irrigation et son devenir en tant qu'espace-temps.

الفجارة ، الدراية والنظام الاجتماعي المكاني

ملخص

في المدن الصحراوية، للمياه أهمية كبيرة، فهي تعتبر نعمة من هلا، تمنح الحياة وتحافظ عليها، وتطهر الإنسانية والكوكب لندرتها، المياه؛ يصبح عنصرًا ثمينًا، حيث يتطلب التقاطه واستخدامه نظرًا ومشاركته معالجة ومعرفة متطورة تقع ضمن عقيدة الإنسان.

في تيميمون (مدينة تقع في جنوب غرب الجزائر)، كانت الفجارة هي الوسيلة الوحيدة للتقاط المياه، والتي أصبحت متاحة بفضل طبقة المياه الجوفية في العرق وطبقة المياه الجوفية في البيان وبذلك يصبح الحصول على الماء حقًا مقدسًا وبدائية سلسلة من المقدسات التي يطبعها الحضر في تيميمون. يحدد مسار ممر الفجارة إنشاء الغامواوين (الحصون)، أين مواقعها تتوافق مع أماكن ظهور الفجارة. ومن خلال توزيع نظام التوزيع الكسري يمكننا قراءة التمايز الاجتماعي؛ التقسيم حسب العائلة والشخص، حيث يكون لكل كسرية اسم وقصة. يقوم هذا التخطيط ببناء المكاني، وينظم التسلسل الهرمي الاجتماعي ويصبح علمًا حقيقيًا للتجزئة علوة على ذلك، فإن تدفق الفجارة يحدد الأراضي الصالحة للزراعة (بساتن النخيل)، وهو شرط ال غنى عنه للاستيطان البشري. هذا العنصر (الماء) الذي يؤدي إلى نشوء جنة (واحة النخيل) وسلسلة كاملة من (مدن) القصور بمنطقة توات وغورارة وتيديكلت

من خلال هذا العمل، سنعرض المراحل المختلفة للتطور الحضري لقصر تيميمون فيما يتعلق بالفجارة، والنظام الاجتماعي المستنتج منها، واستمرار نظام الري هذا ومستقبله كمكان-زمان

From open courtyards to enclosed sanctuaries: Techniques for the assessment of ablution spaces in Marrakech's historic mosques

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Abstract. This research examines techniques for evaluating ablution spaces in historic mosques in Marrakech, focusing on the transition from open courtyards to closed sanctuaries. The study uses a multidisciplinary approach, combining architectural analysis, archeology and 3D scanning technologies to capture detailed data on the layout, functionality and materials of ablution spaces. By exploring these spaces across different eras, the research highlights developments and continuities in the design of ritual ablutions, as well as their impact on the spiritual and social experience of the faithful. The results provide an in-depth perspective on Islamic architecture in Marrakech, highlighting the importance of these spaces in the region's cultural and religious heritage.

The study aims to capture detailed spatial and structural data on ablution areas within mosques. Using architectural survey methods and 3D modeling technologies, the study collects precise information on the configuration, materials and dimensions of these spaces. The aim is to understand how these areas are integrated into the overall structure of mosques and how they meet ritual and practical requirements. The data collected will allow us to better understand architectural variations and identify trends and innovations in the design of these sacred spaces, while respecting Islamic theological and cultural principles.

The expected outcome of this study is to highlight the urgent preservation needs of these spaces, propose potential restoration strategies and foster a more informed approach to the management of water-related heritage in religious architectural contexts. Ultimately, this investigation contributes significantly to a broader understanding of how traditional elements of Islamic architecture can be safeguarded and enhanced to meet current demands without compromising their inherent historical and cultural significance.

Keywords: 3D scan, Architectural conservation, Islamic architecture, Ablution spaces, Marrakech mosques, Heritage preservation

“Venice is in the water, but has no water”. From historical knowledge an example of sustainability and resilience

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Abstract. The phrase "Venice is in water but has no water" uttered in 1466 by Marin Sanudo fully expresses the conditions under which the lagoon city was born and developed. In truth, Venice did not only lack water, which other historic cities could take from nearby rivers, but also lacked all building materials, such as wood, stone, and metal, and even as for clay, lagoon deposits were not always suitable.

These conditions evidently did not stop the development of the lagoon city, nor did they hinder the lives of its inhabitants. In this contribution we will focus particularly on the issue of water supply for food purposes, an indispensable element for human life.

The main source of drinking water supply in Venice was rainwater, which was collected from roofs and pavements and stored in water cisterns known as wells. Every Venetian roof was lined with clay tiles, and all rainwater was collected in large channels made of Istrian stone that were concave on the inside and then carved on the outside according to the relevant period. These were connected to clay ducts placed in the walls of the buildings, and flowed into cisterns. These are now spread throughout the city in numbers of 600; they are no longer used, many having been closed after the advent of the aqueduct in 1884; during the Serenissima Republic there were many more. They consisted of a pit of varying size depending on the importance of the well; this was lined with clay or bricks and filled with sand, which served to filter the water that descended through conduits placed at the ends of the basin. The whole thing was then lined with paving of trachyte stone from the Euganean Hills, and a conduit remained in the center to reach the bottom.

This system worked very well in periods of regular rainfall, but in case of drought, teams assigned by the Republic would recharge the well with water taken from the mouths of the Brenta River. Other teams, on the other hand, were in charge of protecting the water entry points in case of high tide, to prevent brackish water from entering. In addition to promoting a state of the art of this research, which could profitably continue, the paper aims to highlight how these systems today could be put back into operation to complement existing ones and be used as an action to adapt the effects of climate change.

Keywords: Venice, drinking water, historic wells, sustainability, climate change

Gestione de l'eau et adaptation au contexte territorial : les structures du passé en Ligurie lues avec les outils de l' «archéologie des ressources naturelles» (Italie)

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Résumé. L'expérience humaine accumulée sur un territoire laisse souvent des traces parfois plus évidentes, parfois moins visibles, surtout à première vue. Ces traces, sont d'autant plus significatives que le contexte environnemental dans lequel elles se situent est particulier et, à certains égards, difficile. C'est ce qui a été constaté, dans le cadre de cette recherche universitaire, dans certaines vallées de l'ouest de Gênes (vallée de Polcevera) et de la Riviera di Levante (Recco, Lavagna, S. Colombano Certenoli). La Ligurie, et en particulier la partie du territoire analysée par la recherche, est constituée de pentes abruptes proches de la mer ; ces pentes sont sillonnées par de nombreux petits et moyens cours d'eau, avec un régime torrentiel marqué : cela implique (et a impliqué) certains mois de l'année une pénurie d'eau (et la nécessité relative d'une utilisation judicieuse pour les cultures) et à d'autres périodes, un excès d'eau avec des inondations soudaines (et la nécessité relative de contenir l'eau afin d'éviter les dommages). Le pontage des rivières (ex.17 barrage pour un ruisseau, Freta, de 600 m), les canaux souterrains et les bassins d'accumulation (ex. Cian di sciai à San Colombano Certenoli...) ont été les travaux mis en œuvre au fil du temps pour répondre aux besoins de ces territoires particuliers. La recherche a été menée sur un double front : 1) analyse directe in situ avec les outils de l'archéologie du terrain en hauteur, 2) analyse documentaire. L'objectif: mettre en évidence et souligner l'équilibre atteint entre l'homme et l'environnement, même dans des contextes difficiles d'exploitation maximale des ressources environnementales. En effet, l'effet obtenu par ces interventions n'a pas été totalement déstabilisant mais a rendu possible un équilibre entre l'homme et l'environnement, tout en modifiant l'environnement lui-même. Tout ceci dans le but, pour l'avenir, d'une plus grande conservation de ce milieu bâti et d'éventuelles suggestions pour de futures interventions sur un environnement de plus en plus fragile et de plus en plus soumis à des événements extrêmes.

Mots clés : gestion de l'eau, barrages, canaux, Ligurie, structures historiques

Gestione dell'acqua e adattamenti al contesto territoriale: strutture del passato in Liguria lette con gli strumenti dell'archeologia delle risorse naturali (Italia)

Riassunto. L'esperienza umana accumulata in un territorio lascia spesso tracce, talvolta più evidenti, talvolta meno, soprattutto ad uno sguardo superficiale. Queste tracce, sono tanto più significative quanto più il contesto ambientale in cui si collocano è particolare e, per alcuni aspetti, difficile. E' quanto è stato rilevato, attraverso una ricerca universitaria, nel Ponente genovese (val Polcevera) e nella Riviera di Levante (Recco, Lavagna, S. Colombano Certenoli). La Liguria, e in particolare la parte del territorio analizzata dalla ricerca è costituita da pendii ripidi a ridosso del mare; questi pendii sono solcati da molti ruscelli di piccola e media dimensione, a spiccato regime torrentizio: questo comporta (e comportava) in alcuni mesi dell'anno scarsità d'acqua (e relativa necessità di un utilizzo sapiente per le colture) e in altri periodi, un eccesso d'acqua con piene improvvise (e relativa necessità di contenimento dell'acqua per non avere danni). Imbrigliamenti dei rivi (es. 17 briglie per un rivo, Freta, di 600m), canali sotterranei e bacini di accumulo (es. Cian di sciai a San Colombano Certenoli...) sono state le opere messe in atto nel tempo, per dare una risposta alle esigenze di questi particolari territori. La ricerca si è svolta su di un duplice fronte: 1) analisi diretta in situ con gli strumenti dell'archeologia dell'elevato, 2) analisi con ricerche bibliografiche e d'archivio. Scopo: far emergere e sottolineare l'equilibrio che si era ottenuto tra uomo e ambiente, anche in contesti difficili e di massimo sfruttamento delle risorse ambientali. L'effetto ottenuto con questi interventi, infatti, non era totalmente destabilizzante ma rendeva possibile un equilibrio tra uomo e ambiente, pur modificando di fatto l'ambiente stesso. Tutto questo con la finalità, per il futuro, di una maggiore conservazione di questo ambiente costruito e di eventuali possibili suggerimenti per interventi futuri su un ambiente sempre più fragile e sempre più sottoposto ad eventi estremi.

Parole chiave: Gestione dell'acqua, briglie, canali, Liguria, strutture storiche

Gestion durable des ressources en eau souterraines: le cas du système des ghouts dans la région du Souf

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Résumé. Le système ghout est né dans la région du Souf, une enclave sablonneuse du Sahara algérien, caractérisée par des conditions climatiques extrêmes et une topographie particulière. Cette région, bien que située en retrait des grands axes transsahariens, a su développer un système d'agriculture unique grâce à sa capacité à gérer les ressources en eau disponibles.

Malgré l'absence d'eau en surface, le Souf possède d'importantes ressources en eau souterraine. La nappe phréatique peu profonde, la nappe de l'Albien et la nappe du Pontien. La nappe phréatique, particulièrement importante pour l'agriculture locale, est alimentée principalement par les précipitations tombées sur les plateaux rocheux au sud de l'erg. Face à ces conditions difficiles, les habitants du Souf ont développé une technique agricole unique appelée "ghout". Cette méthode consiste à creuser de profondes excavations (10 à 20 mètres) pour rapprocher les palmiers de la nappe phréatique. Les palmiers peuvent ainsi puiser directement l'eau sans irrigation de surface. La création et l'entretien des ghouts nécessitent un travail considérable et constant, notamment pour lutter contre l'ensablement. Cette technique a permis la culture de la variété de dattes Deglet Nour, à haute valeur commerciale.

Le système ghout a profondément façonné le paysage du Souf, créant une "palmeraie en miettes" particulière. Il s'accompagne également de règles sociales précises concernant la propriété, l'implantation et l'entretien des ghouts, témoignant d'une gestion collective et raisonnée de l'espace.

Bien que des techniques similaires existent ailleurs au Sahara, le système du Souf se distingue par son caractère systématique et son ampleur on en compte plus de 9700 ghouts. Il témoigne de l'adaptation remarquable d'une société initialement nomade à un environnement difficile, aboutissant à la création d'un paysage et d'une identité uniques.

Cependant, les évolutions récentes, telles que l'urbanisation accélérée, l'exploitation pétrolière et gazière, et les réformes agraires, posent de nouveaux défis à cet équilibre fragile entre l'homme et son environnement, mettant à l'épreuve la résilience du système traditionnel.

Mots clés : Ghout ; Souf ; Système Hydraulique ; Ingénierie ; résilience

Sustainable management of groundwater resources: the case of the ghout system in the Souf region

Abstract. The ghout system originated in the Souf region, a sandy enclave of the Algerian Sahara, characterized by extreme climatic conditions and a particular topography. Although located away from the major trans-Saharan routes, this region has developed a unique agricultural system thanks to its ability to manage the available water resources.

Despite the absence of surface water, the Souf has significant groundwater resources. The shallow phreatic aquifer, the Albien aquifer and the Pontian aquifer. The phreatic aquifer, particularly important for local agriculture, is mainly recharged by precipitation falling on the rocky plateaus south of the erg.

Faced with these difficult conditions, the inhabitants of Souf developed a unique agricultural technique called "ghout". This method involves digging deep excavations (10 to 20 meters) to bring the date palms closer to the water table. The date palms can thus directly tap water without surface irrigation. Creating and maintaining ghouts requires considerable and constant work, especially to fight against sand encroachment. This technique has allowed the cultivation of the Deglet Nour date variety, with high commercial value.

The ghout system has profoundly shaped the landscape of Souf, creating a characteristic "shattered palm grove". It is also accompanied by precise social rules concerning ownership, establishment and maintenance of ghouts, testifying to collective and reasoned management of space.

Although similar techniques exist elsewhere in the Sahara, the Souf system is distinguished by its systematic nature and scale - there are more than 9,700 ghouts. It demonstrates the remarkable adaptation of a once nomadic society to a difficult environment, leading to the creation of a unique landscape and identity.

However, recent developments such as accelerated urbanization, oil and gas exploration, and agrarian reforms are posing new challenges to this fragile balance between man and his environment, testing the resilience of the traditional system.

Keywords: Ghout, Souf, Hydraulic system, Engineering, resilience.

The forms of water in the history and transformation of the Sicilian Landscape

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Abstract. The form of water encompasses numerous fields of study and offers multiple reflections in areas such as naturalistic studies and territorial organization, technique and technology, urban planning and architecture, the construction of space and landscape.

This contribution aims to explore the multiple forms of water related to its use and management that have contributed to the definition of the landscape. In this context, the theme transcends any temporal limits and is presented in a diachronic perspective. The panorama is that of Sicily, a land scorched by the sun where water constitutes a very precious resource.

Through an architectural reading, different forms of water are to be investigated: the natural ones (water or lake systems) that, especially in the past, have enabled the birth and transformations of urban settlements, often becoming identity elements; and those in which water is an element to be controlled, regulated, and conserved, both for agricultural production and for the survival of communities. As an indispensable element of daily life, water, in its "treatments," imposes certain and privileged forms, becoming an architectural expression. This control has manifested itself throughout history through two procedures: excavation, the oldest and most immediate action, which proceeds with the excavation of wells and underground conduits; and addition, which has allowed for a suggestive management and led to the creation of works such as reservoirs, constructions to protect springs, aqueducts, piezometric towers, water tanks, and more recently, dams.

These structures have left a lasting and historical imprint on the territory, marking also due to the relationships they establish with places - the relationship of water with man and with the landscapes he inhabits, also expressing through their forms the symbolic values of water and the representativeness of architecture.

Keywords: Water infrastructure, Countryside, City, Architecture, Sicily

Le forme dell'acqua nella storia e nella trasformazione del paesaggio siciliano

Riassunto. La forma dell'acqua, investe numerosi campi di studio e offre molteplici riflessioni quali l'ambito naturalistico e l'organizzazione del territorio, la tecnica e la tecnologia, l'urbanistica e l'architettura, la costruzione dello spazio e del paesaggio. Il contributo intende esplorare le molteplici forme dell'acqua legate al suo utilizzo e alla sua

gestione che hanno contribuito alla definizione del paesaggio. In questo contesto, il tema supera ogni limite temporale e si presenta in una prospettiva diacronica. Il panorama è quello della Sicilia, terra arsa dal sole in cui l'acqua costituisce un bene molto prezioso. Attraverso una lettura architettonica si vogliono indagare differenti forme dell'acqua: quelle naturali (sistemi idrici o lacustri) che, soprattutto nel passato, hanno consentito la nascita e le trasformazioni degli insediamenti urbani, diventandone in molti casi elementi identitari; quelle in cui l'acqua è elemento da controllare, regimentare e da conservare, tanto . Tale controllo si è manifestato nel corso della storia attraverso due procedure: lo scavo, azione più antica e più immediata, che procede con l'escavazione di pozzi e di condutture sotterranee; l'aggiunzione che ne ha consentito una gestione suggestiva e portato alla realizzazione di opere come gli invasi, le costruzioni a protezione delle sorgenti, gli acquedotti, le torri piezometriche, i serbatoi idrici, le dighe nei tempi più recenti.

Queste strutture hanno lasciato un'impronta duratura e storica nel territorio, segnando - anche a motivo delle relazioni che instaurano con i luoghi - il rapporto dell'acqua con l'uomo e con i paesaggi che egli abita, esprimendo inoltre attraverso le forme i valori simbolici dell'acqua e la rappresentatività dell'architettura.

Parole chiave: Infrastruttura idraulica, Campagna, Città, Architettura, Sicilia

Hydrogeological and hydrochemical study of the Foggaras of the Touat region (Fenoughil), South West Algeria

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Abstract. The Foggaras is the main source of water in the life of the population of Adrar's oases region, the population growth and the development in various economic domains (agriculture, industry, and tourism) are related to the diversity of water resources, this required new techniques for the exploration and exploitation of water. The last contributed to the decreasing of under groundwater level of the Intercalary continental water table and negatively affected the Foggaras water's quantity.

This situation affected the quantity and quality of water of the Foggaras. This latter its water level has been reduced and the quality of this water has been degraded. Many Foggaras were forsaken as a result they dried. This study gave us a general view about the situation of the Foggara of Fenoughil by depending on the previous data, besides giving some suggestions for protecting this system as a human heritage.

Keywords: foggaras; Intercalary Continental, Adrar; oases; hydrochemistry

Poster Session

**Chairman: Giovanni Pancani,
Università di Firenze, RIPAM permanent committee**

This session shows applications of ancient water systems, and case studies.

Session posters

Cette session présente des applications de systèmes hydrauliques anciens et des études de cas.

جلسة المصقات

تتناول هذه الجلسة تطبيقات أنظمة المياه القديمة ودراسات الحالة

Harnessing Traditional Khettara Systems for Modern Thermal Regulation in Marrakech

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Abstract. This work represents the initial phase of an ongoing study focused on repurposing the Khettara, a sustainable underground water tapping system historically used in arid climates for centuries. The Khettara system is currently in decline due to the mechanization of irrigation and excessive underground water pumping, leading to extreme depletion of resources. The aim is to reclaim this ancient system, which has been neglected over the past few decades, for a sustainable purpose. The underground canals, being close to steady ground temperatures, could be utilized for cooling or heating to contribute to building thermal comfort at the chosen study site in Marrakech El Haouz, Morocco.

There have only been a few studies, mostly in Iran and Algeria, with a variety of parameters and settings. This study involves constructing a real-life scenario to assess feasibility and simulating it to evaluate effectiveness. Several phases are required: selecting the geographic context, mapping the Khettara, gathering climatic data, onsite investigation, determining heating and cooling demand, conceptualizing the building model, and studying suitable systems. Upcoming phases include system modeling and dynamic thermal simulation.

Marrakech was selected due to the cohabitation of Khettaras with the urban perimeter. The specific study case is a Khettara west of the Agdal Gardens. The Khettara has a length of 321 meters and a depth difference of 6.42 meters. Additional climatic factors will be included. By averaging mean monthly and wall temperatures, the operative temperature is calculated to determine thermal comfort using ASHRAE-55 compliance, establishing cooling and heating needs. This scenario involves using the Khettara as a Canadian well system with a steady ground temperature of about 21°C. If the simulation proves effective, energy consumption will be reduced, limited to ventilation operation, with minimal underground installation costs due to the existing Khettara infrastructure.

Keywords: Khettara, Thermal Comfort, Sustainable Cooling, Underground Water Systems, Dynamic Thermal Simulation

Khettara: Traditional System of Transporting Groundwater in Morocco

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Abstract. Morocco is among the rare countries that are still own an active system of transportation of water, through underground galleries, called: "Khettara". This system was built since the Almoravids dynasty 1000 years ago and exists in several regions of Morocco.

Khettara is a gravitationally system for transporting water from groundwater through the arid desert in order to irrigate oases. It is an ecological system that does not require any mechanical effort or thermal energy, it does not emit any greenhouse gases.

The Khettara extends over a distance of almost 20 km. It is composed of about a hundred wells that are about 10 m apart from each other, forming a chain of bridges. The wells served as an aeration circuit that facilitated the removal of sand and waste.

The distribution of water to different beneficiaries is done democratically on the basis of an equitable division, because the flow of water depends on the water table and its level which varies in volume.

The Khettara is still working in Morocco, several families are directly or indirectly, benefiting from economic activities generated by his activity. At present, the Khettara is in danger of falling into disrepair and is threatened by the years of drought, which imposes a rural exodus.

Keywords: Morocco, Khettara, groundwater, oases, gravitationally system

Water management and land defense: Roman artificial lake emissaries

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Abstract. Among the water management systems, those built to protect the lake shores in central Italy are particularly interesting, especially because these structures are little known today and generally inaccessible.

In ancient times, controlling water levels in lakes without natural outlets led to the construction of extraordinary works. These were designed both to allow water to flow out during high water periods to prevent flooding and to create new farmland. This latter goal led to the partial draining of Lake Fucino during Roman times and its complete draining in the late 19th century, just before the hydroelectric industry transformed the mountain landscape by creating new artificial reservoirs.

Studies and surveys of the artificial outlets built in Roman times, first for the lakes of Nemi and Albano near Rome and later for Lake Fucino in Abruzzo, allow us to compare the construction techniques used in different periods, the effectiveness of these hydraulic systems over time, their impact on the landscape and society, and especially their current state.

A system of wells and service tunnels (descenderies) enabled the excavation of underground outlets over a kilometer long for the lakes in the Alban Hills, and up to over five kilometers for the Fucino basin, showcasing the boldness of the builders of that time.

Despite various studies dedicated to the archaeological understanding of these structures, their current state of preservation shows significant issues due to partial or complete inaccessibility and accidental events that have blocked the conduits, therefore preventing further investigations.

Keywords: Roman Emissaries, Nemi lake, Albano lake, Fucino lake, current situation

Gestione dell'acqua e difesa della terra: emissari lacustri artificiali di epoca romana

Riassunto. Tra i sistemi per la gestione delle acque, quelli realizzati per la difesa delle coste lacustri nel centro Italia presenta diversi motivi di interesse, in particolare per il fatto che tali strutture appaiono oggi poco conosciute e sono generalmente non accessibili.

Il controllo delle acque nei laghi privi di emissari naturali determinò, nell'antichità, la costruzione di opere straordinarie sia per consentire il deflusso nei periodi di piena ed evitare le inondazioni, sia per ottenere nuove terre da coltivare. Quest'ultimo motivo determinò il prosciugamento del lago Fucino, che fu parziale in epoca romana e totale nella seconda metà dell'Ottocento, poco prima che l'industria idroelettrica trasformasse, all'opposto, il paesaggio montano realizzando nuovi bacini artificiali.

Gli studi e i rilievi compiuti sugli emissari artificiali costruiti in epoca romana, dapprima per i laghi di Nemi e di Albano nei dintorni di Roma, poi per il lago Fucino in Abruzzo, permettono di confrontare le tecniche costruttive utilizzate in periodi diversi, l'efficacia di tali sistemi idraulici nel tempo, l'impatto che hanno apportato al paesaggio ad alla società e soprattutto la situazione attuale di queste opere.

Un sistema di pozzi e gallerie di servizio (discenderie) consentì lo scavo di emissari sotterranei lunghi oltre un chilometro nel caso dei laghi sui Colli Albani, fino a superare la lunghezza di cinque chilometri nel caso del bacino del Fucino, manifesto dell'audacia dei costruttori dell'epoca.

Nonostante diverse ricerche dedicate alla conoscenza archeologica di tali strutture, la situazione conservativa evidenzia notevoli criticità dovute sia alla parziale o impossibile accessibilità, sia ad eventi accidentali che hanno ostruito i condotti e impediscono quindi ulteriori indagini.

Parole chiave: Emissari Romani, lago di Nemi, lago di Albano, lago Fucino, situazione attuale

Sustaining Heritage: Geospatial analysis and enhancement of Morocco's Khettaras

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Abstract. This study explores the architecture and construction of khettaras, an ancient underground water irrigation system in Morocco. Khettaras exemplify the ingenuity of early Moroccan civilizations in managing scarce water resources in arid regions. The research delves into the structural design and construction techniques of khettaras, emphasizing their historical development, engineering principles, and the materials used. Through comprehensive field studies and analysis, the study documents the current state of these systems, highlighting the challenges they face due to modernization, climate change, and neglect.

Furthermore, the research underscores the cultural and socio-economic significance of khettaras, advocating for their preservation as part of Morocco's heritage. Geospatial data, including satellite images and aerial photographs, were utilized to map the khettaras using GIS. Surveys and interviews with local users and managers were conducted to gather qualitative data. The results indicate that khettaras, although constructed incrementally, exhibit a high level of efficiency in water distribution and are not randomly developed. The study proposes recommendations for optimizing khettaras, including structural improvements and water management strategies. By integrating modern techniques without disrupting traditional methods, this research aims to enhance the sustainability and efficiency of khettara networks in arid regions.

Keywords: Cultural heritage, Water irrigation systems, Khattaras, Qanat, GIS

Assessing the Impact of Climate Change on the Water-Energy-Food Nexus in Southeastern Morocco: A Case Study of the Wadi Guir Watershed

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Abstract. Globally, addressing the Water-Energy-Food Nexus in the context of climate change remains a paramount challenge. This study examines this issue through the integrated management of the ecosystem, focusing on the Wadi Guir basin in southeastern Morocco. Climate change scenarios from 2019 to 2060 were derived using a statistical downscaling model, specifically concentrating on the RCP 8.5 scenario to assess its impact on the Water-Energy-Food Nexus. The non-parametric Pettitt test was used to analyze rainfall trends, and NDVI time series were utilized to evaluate agricultural productivity.

The findings indicate a decreasing trend in interannual average rainfall for the RCP 2.6 and RCP 4.5 scenarios, contrasting with an upward trend for the RCP 8.5 scenario. Additionally, all scenarios show an upward trajectory in interannual average temperatures. Consequently, there is a projected decline in discharge variation, decreasing from 0.045 Mm³ in 2019 to 0.030 Mm³ in 2060, coupled with intensified evaporation. Analyzing the NDVI time series from 2000 to 2023 revealed an increase from 0.11 to 0.38, despite reduced rainfall, suggesting groundwater overexploitation. Furthermore, the RCP 8.5 scenario predicts a negative impact on solar energy production in the region, highlighting the environmental and natural resource management challenges posed by climate change.

This research underscores the imperative of developing adaptation strategies and decision-making frameworks tailored to climate change, ensuring the sustainable management of natural resources and ecosystems.

Keywords: Water-Energy-Food Nexus, RCP scenarios, ecosystem, Wadi Guir watershed, climate change.

Session 3 - Water and the landscape: changes and possibilities for conservation

**Chairman: Fabio Fratini,
RIPAM permanent committee**

In this session, the aspects of water in terms of collection, transport and storage are analyzed, and how these works at different levels can affect the landscape. In fact, all these works have created major changes in the landscapes in the past, whether desert, agricultural or urban. In some cases, the most recent transformations have completely erased these traces, in other contexts, however, even if partially, they are still visible. In this last case, making people understand that ruins, apparently with little meaning, are instead the expression of a culture of water gone by, can be of great help also for their conservation and as a warning for the future. In this session, we wanted to deal with both interventions in non-urbanized areas (desert or rural) and those in urban areas. In some historical contexts, water has not only been associated with essential needs but also as a creative and artistic element of architecture within gardens and nymphaeums. In these cases, understanding and preserving these aspects is a fundamental part of the conservation of a certain type of architecture.

Session 3 - L'eau et le paysage : changements et possibilités de conservation

Dans cette session, nous analysons les aspects de l'eau en termes de captage, de transport et de stockage, et la manière dont ces travaux à différents niveaux peuvent affecter le paysage. En effet, tous ces travaux ont créé des changements majeurs dans les paysages du passé, qu'ils soient désertiques, agricoles ou urbains. Dans certains cas, les transformations les plus récentes ont complètement effacé ces traces, dans d'autres contextes, cependant, même si elles sont partiellement visibles. Dans ce dernier cas, faire comprendre aux gens que des ruines, apparemment sans signification, sont en fait l'expression d'une culture de l'eau révolue, peut être d'une grande aide également pour leur conservation et comme un avertissement pour l'avenir. Dans cette session, nous avons voulu traiter à la fois des interventions dans des zones non urbanisées (désertiques ou rurales) et celles dans des zones urbaines. Dans certains contextes historiques, l'eau a été associée non seulement à des besoins essentiels mais aussi à un élément créatif et artistique de l'architecture dans les jardins et les nymphées. Dans ces cas, comprendre et préserver ces aspects est une partie fondamentale de la conservation d'un certain type d'architecture.

الجلسة 3 - المياه والمناظر الطبيعية: التغيرات وإمكانيات الحفاظ عليها

في هذه الجلسة، سيتم تحليل جوانب المياه من حيث التجميع والنقل والتخزين، وكيف يمكن لهذه الأعمال أن تؤثر على المناظر الطبيعية على مستويات مختلفة. في الواقع، خلقت هذه الأعمال تغييرات كبيرة في المناظر الطبيعية في الماضي، سواء كانت صحراوية أو زراعية أو حضرية. في بعض الحالات، محت التحولات الأخيرة هذه الآثار تمامًا، ولكن في سياقات أخرى، حتى ولو جزئيًا، لا تزال مرئية. في هذه الحالة الأخيرة، يمكن أن يفهم الناس بأن الأطلال التي تبدو بلا معنى، هي بدلاً من ذلك تعبير عن ثقافة المياه التي مضت، هذا الأمر مفيد جدًا أيضًا للحفاظ عليها وكتحذير للمستقبل. في هذه الجلسة، أردنا التعامل مع كل من التدخلات في المناطق غير الحضرية (الصحراوية أو الريفيّة) وتلك الموجودة في المناطق الحضرية. في بعض السياقات التاريخية، لم يرتبط الماء بالاحتياجات الأساسية فحسب، بل أيضًا كان كعنصر

إبداعي وفني للهندسة المعمارية داخل الحدائق والنيمفايات. في هذه الحالات، يعد فهم هذه الجوانب والحفاظ عليها جزءًا أساسيًا من الحفاظ على نوع معين من الهندسة المعمارية.

Water supply and management of Lake Garda lemon houses: A close connection between irrigation and the landscape

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Abstract. Lemon houses (limonaie) are ancient terraced citrus gardens that shape the landscape along the NW shore of Lake Garda (Northern Italy). Thanks to lake's microclimate, to gardens' SE exposure and to the development of an original labour—intensive agricultural technique, lemon houses allowed a fruitful and international citrus trade, that, already settled during the 16th Century – and despite the sensitivity of lemon trees to cold temperatures –, flourished during the Little Ice Age and reached its maximum development between the 18th and 19th Century.

Most of the lemon houses were irrigated, because, as already referred by the Renaissance agronomist Agostino Gallo, the irrigated trees produced much more numerous, beautiful and early fruits than the not—irrigated ones. Gallo cursory refers that gardeners devote a great labour to bring the water to the trees, because every one requires more than 100 liters per irrigation – a lower limit of the traditional practice of providing between 100 and 300 liters per irrigation in the warm season. Gallo's note is even more valuable because it stresses that – despite some gardens hadn't still been irrigated – already in the middle 16th Century some complex water supply system were already operational. Afterwards, many gardens were built and required to capillary develop the water supply in a complex network of channelization.

Aiming at shedding light on the complex relationship between the limonaie and their landscape, we analyze with an interdisciplinary approach two groups of irrigated gardens (the right of the Fosso dei mulini and the Valle di san Martino, both in Gargnano). They show most of the typical features of the irrigation system, with a complex structure of channels and flumes, natural and artificial springs, cisterns, stilling basins and spillways, still partially recognizable and functioning. A precious 1719 map found in the Archivio di Stato di Venezia depicts the stream intakes at the beginning of the 18th Century and the diritti d'acqua (water rights) which ruled the Valle di san Martino system and timed the irrigation shift.

The study depicts a landscape deeply innervated by a dense network of vital fluxes that contributed to let the citrus trade flourishing for more than three centuries.

Keywords: Lake Garda lemon houses, Mediterranean citrus garden, Water scarcity, Traditional and ancestral irrigation, Labour—intensive landscape

Approvvigionamento e gestione dell'acqua delle limonaie del Garda: Uno stretto legame tra irrigazione e paesaggio

Riassunto. Le limonaie sono antichi giardini d'agrumi terrazzati che modellano il paesaggio lungo la sponda nordoccidentale del Lago di Garda (Nord Italia). Grazie al microclima gardesano, all'esposizione a sud—est dei giardini e allo sviluppo di un'originale tecnica culturale ad alta intensità di manodopera, le limonaie consentirono un fruttuoso commercio internazionale di agrumi, che, già sviluppato nel XVI secolo – e nonostante la sensibilità dei limoni al freddo –, fiorì durante la Piccola Età Glaciale e raggiunse il suo massimo sviluppo tra il XVIII e il XIX secolo.

La maggior parte delle limonaie erano irrigate, perché, come già riferiva l'agronomo cinquecentesco Agostino Gallo, gli alberi irrigati producevano frutti assai più numerosi, belli e precoci di quelli non irrigati. Gallo riferisce che i giardinieri dedicavano grande sforzo per portare acqua agli alberi, perché ognuno ne richiede più di 100 litri per irrigazione – un limite inferiore, questo, rispetto alla pratica tradizionale di fornirne tra 100 e 300 litri per irrigazione nella stagione calda. La nota di Gallo è ancora più preziosa perché sottolinea che – nonostante alcuni giardini non fossero ancora irrigati – già a metà del Cinquecento complessi sistemi di approvvigionamento e distribuzione dell'acqua erano già operativi. Successivamente furono realizzati numerosi altri giardini che resero necessario sviluppare una complessa rete di canalizzazione e approvvigionamento per garantire l'acqua necessaria per gli alberi. Con l'obiettivo di far luce sul complesso rapporto tra le limonaie e il loro paesaggio, analizzeremo, con un approccio interdisciplinare, due gruppi di giardini irrigati (la destra del Fosso dei mulini e la Valle di san Martino, entrambi a Gargnano). Essi presentano infatti gran parte dei caratteri tipici del sistema irriguo, con una complessa struttura di canali e canalette, sorgenti naturali e artificiali, cisterne, bacini di calma e sfioratori, ancora parzialmente riconoscibili e funzionanti. Una preziosa mappa del 1719 rinvenuta nell'Archivio di Stato di Venezia raffigura le prese, all'inizio del XVIII secolo, e i diritti d'acqua che regolavano il sistema della Valle di San Martino e ne stabilivano il turno di irrigazione.

Lo studio restituisce l'immagine un paesaggio profondamente innervato da una fitta rete di flussi che hanno contribuito a far prosperare il commercio degli agrumi per più di tre secoli.

Parole chiave Limonaie del lago di Garda, Mediterranean citrus garden, Scarsità d'acqua, Irrigazione tradizionale e ancestrale, Labour—intensive landscape

Water, mills and channels: between rural archaeology and history. Case studies from western Ligurian Apennines (17th- 21st c.)

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Abstract. Through the discussion of different case studies located in the Ligurian Apennines under investigation by the Laboratory of Environmental Archaeology and History, this paper aims at discussing the role of system to manage and control of water resources in relation to the economies of mountain slopes. The focus will be on the transformations, analysed through archaeological methods, of the artefacts which materialised these systems: sluices, irrigation channels and regulated streams (used also as pathways), water mills, hydraulic hammers etc.

If from one side the archaeological analysis allows to reconstruct uses, functions and construction techniques, uses of these artefacts, from the other the topographic and contextual analyses allows to bring to lights their social role both in term of tools to build and claim access rights to resources (the ambiguity between channels and pathways it is particular interesting in this sense), from the other as catalysts and places of construction of social relationships. This second element seems of particular interest today, due to the growing phenomena of heritagisation of the water mills. In many countries, these buildings are becoming places around which different collectivities meet and recognise themselves. As an example, we will discuss about the mill of Foppiano (hamlet of Foppiano, municipality of Rovegno, Trebbia valley), where investigation documented the water catchment, adduction system, and he transformation of the structure, and around which, after the abandonment of its productive function, an association (“The Friends of the Foppiano Mill”) was born, which takes care of its visits and has become a meeting and aggregation place.

Keywords: rural archaeology, water mills, access rights, social relationships

Water supply in military coastal systems in XIX e XX century in Sardinia (Italy). Knowledge and musealization

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Abstract. The paper illustrates an interdisciplinary research, carried out in collaboration with the Ministry of Defence, on water reserves in coastal defence systems, with a particular focus on water management systems in the batteries of the Archipelago of La Maddalena and the north-eastern coast of Sardinia.

During the period of the Great Fortifications in the second half of the 19th century, an important element for the construction of military fortifications, besides the strategic location, was the availability of a spring. The first activity of the military officers landed on the island was precisely to count the springs and wells and to plan the construction of tanks, depots and dams for supply. In particular, on the island of La Maddalena, water supply became immediately an absolutely primary need to be addressed with large infrastructural interventions as there were scarce natural resources. Water resources had to be sufficient to make the soldiers self-sufficient in case of conflict and especially siege. In addition to the needs of the drinkable, water had to be used to maintain a certain level of hygiene to avoid the spread of diseases, but also for the realization of works, the so-called "working water".

To this purpose, through a careful work of water planning, an effective system for collecting and channelling rainwater was designed and built, as well as for exploiting the springs, not only in the archipelago but also on the Sardinian coast. A list drafted by the Navy in the mid-twentieth century reports 147 tanks, of various sizes and capacities.

Among these, the water storage of Cala Battistoni, in Baia Sardinia, built since 1906, is particularly important since it represented the water reserve for the adjacent batteries M9 and M105 of Capo Tremonti, the M11-M333 Battery of Punta Battistoni and the anti-ship Cappellini, but also ensured the supply of military infrastructure of La Maddalena through the tankers that docked in the adjacent pier, demolished in 2000.

The complex consists of a main building, partly underground, comprising 9 water tanks with a total capacity of 1,800 m³. There is also a discharge chamber, a take-off chamber, a filter room and the pipes to and from the spring.

The research, in addition to documenting the peculiarities of the site of Cala Battistoni in the territorial system of water management in military garrisons, has developed a proposal for restoration and reuse of the site as a museum of the Navy, but also as a service infrastructure for bathing, with the redevelopment of the beach and pier.

Keywords: military heritage, hydraulic infrastructures, naval museum

L'approvvigionamento idrico nei sistemi difensivi costieri del XIX e XX secolo in Sardegna (Italia). Conoscenza e musealizzazione

Riassunto. Il contributo illustra la ricerca svolta sul sistema delle riserve idriche nei sistemi difensivi costieri, con un focus particolare sul sistema di gestione delle acque nelle batterie dell'Arcipelago di La Maddalena e della costa nord-est della Sardegna.

Nel periodo delle Grandi Fortificazioni della seconda metà del XIX secolo, un importante elemento per la costruzione dei presidi militari, oltre alla localizzazione strategica, era la disponibilità di una sorgente. La prima attività degli ufficiali militari sbarcati sull'isola è stata proprio quella di censire le sorgenti e i pozzi presenti e di progettare la costruzione di cisterne, depositi e dighe per l'approvvigionamento. In particolare, nell'isola di La Maddalena, l'approvvigionamento idrico divenne subito un'esigenza assolutamente primaria da fronteggiare con grandi interventi infrastrutturali in quanto si disponeva di risorse naturali esigue. Le risorse idriche dovevano essere tali da rendere autosufficienti i soldati in caso di conflitto e soprattutto di assedio. Oltre alle esigenze potabili, l'acqua doveva servire a mantenere un certo livello di igiene per evitare la diffusione delle malattie, ma anche alla realizzazione delle opere, la cosiddetta "acqua da lavoro". A tal fine, attraverso un'accurata opera di pianificazione delle acque, venne progettato e costruito un efficace sistema di raccolta e canalizzazione delle acque piovane, oltre che di sfruttamento delle sorgenti, non solo nell'arcipelago, ma anche sulla prospiciente costa sarda. Un elenco della Marina Militare della metà del Novecento riporta l'indicazione di 147 cisterne, di varie dimensioni e capacità.

Tra queste, è particolarmente rilevante il deposito idrico di Cala Battistoni, in località Baia Sardinia, realizzato dal 1906, che rappresentava la riserva idrica per le adiacenti batterie M9 e M105 di Capo Tremonti, la Batteria M11-M333 di Punta Battistone e l'opera antinave Cappellini, ma assicurava anche il rifornimento delle infrastrutture militari di La Maddalena attraverso le navi cisterna che attraccavano nell'adiacente molo, demolito negli anni 2000.

Il complesso si compone di manufatto principale, in parte interrato, comprendente 9 cisterne idriche di capienza complessiva di m³ 1.800. Sono poi presenti un casotto di mandata, un casotto di presa, un locale filtri e le condotte da e per la sorgente.

La ricerca, oltre a documentare le peculiarità del sito di Cala Battistoni nel sistema territoriale di gestione delle acque nei presidi militari, ha sviluppato una proposta di restauro e riuso del sito come museo della Marina Militare, ma anche come infrastruttura di servizio alla balneazione, con la riqualificazione della spiaggia e del molo

Parole chiave: patrimonio militare, infrastrutture idrauliche, museo navale

Water supply system in Ottoman Damascus and Constantine: Comparative study

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Abstract. Water management has received great attention among the diverse civilizations around the Mediterranean. Faced with the aridity of the climate, ancient people in the southern Mediterranean have invented efficient methods to get or collect water and provide it to the different properties of various scales. The still existing remains of the early hydraulic structures are eloquent evidence of the advanced ingenuity.

This paper studies two Mediterranean cities: Damascus (Syria) and Constantine (Algeria) during the Ottoman era (between the 16th and 20th Centuries) in order to understand and reconstitute their water supply systems, using a comparative approach. The work is based on bibliographic research and field observation. It cross-references the information collected by taking into consideration the similarities and variations between the two cities.

Despite the differences, the research results show that water supply systems in Damascus and Constantine have had some common aspects and originate from earlier designs (e.g. Roman). Both cities had to face many challenges to secure sustainable water supply. The traditional techniques have proved to be able to adapt to the natural topographical and climatological constraints of these regions.

The successive persistent efforts made to come up with a qualified supply system for collecting, storing and distributing water in both cities has led to a remarkable and sophisticated hierarchy, starting from the urban network and ending up with domestic consumption. This also highlights the importance of the institutions charged of water management during the Ottoman era and the professions related to it, as well as the key role played by the waqf in sustaining these structures.

Keywords: water ; system ; hydraulic ; Damascus ; Constantine.

Système d'alimentation en eau dans Damas et Constantine à l'ère ottomane: Etude comparative

Résumé. La gestion de l'eau a revêtu une grande attention de la part des diverses civilisations du pourtour méditerranéen. Face à l'aridité du climat, les anciens sud méditerranéens ont inventé des méthodes efficaces pour capter, collecter et acheminer l'eau vers les différentes propriétés aux échelles variées. Les vestiges encore existants des premières structures hydrauliques témoignent d'une ingéniosité avancée.

Cet article étudie deux villes méditerranéennes: Damas (Syrie) et Constantine (Algérie) pendant l'ère ottomane (entre le 16ème et le 20ème siècle) afin de comprendre et de restituer leurs systèmes d'alimentation en eau tout en adoptant une approche comparative. Le travail se base sur la recherche bibliographique et l'observation sur terrain. Il croise les informations collectées en prenant en considération les similitudes et les variations entre les deux villes.

Malgré les différences, les résultats de la recherche montrent que les systèmes d'alimentation en eau de Damas et de Constantine présentent certains aspects communs et trouvent leur origine dans des conceptions antérieures (romaines, par exemple). Les deux villes ont dû relever de nombreux défis pour assurer un approvisionnement en eau durable. Les techniques traditionnelles utilisées se sont avérées capables de s'adapter aux contraintes naturelles topographiques et climatologiques de ces régions.

Les efforts constants successifs déployés pour mettre au point un système d'alimentation efficace pour la collecte, le stockage et la distribution de l'eau dans les deux villes ont abouti à une hiérarchie remarquable et sophistiquée, commençant par le réseau urbain et se terminant par la consommation domestique. Cela souligne, également, l'importance des institutions chargées de la gestion de l'eau pendant l'époque ottomane et des métiers qui y sont liées, ainsi le rôle clé joué par le waqf dans la durabilité de ces structures.

Mots clés : eau ; système ; hydraulique ; Damas ; Constantine

Le développement environnemental et technologique - Valorisation du patrimoine méditerranéen, « El Hnaya et La Foggara »

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Résumé. Cette étude explore la relation que pourrait entretenir du patrimoine matériel de la Tunisie et de l'Algérie comme critère de ressemblance....

La réflexion tente d'étudier l'importance de promouvoir un développement technologique pour contemporanéiser l'Aqueduc de Zaghuan « El Hnaya » et La Foggara en Algérie comme patrimoine mondial.

Cette transposition fonctionne principalement sur ce principe qui consiste à cerner le problème en même temps que d'en chercher la réponse. De ce fait elle apparaît comme un adjuvant appréciable dans le domaine patrimonial.

Ceux sont que des exemples, ayant subis des aménagements suite aux nouvelles mutations allant vers le numérique et les nouvelles technologies.

Dans ce sens, notre problématique s'articule essentiellement autour de deux axes qui font faces à la limite de promouvoir les pratiques fonctionnelles de ces deux corpus.

C'est précisément sous un angle ontologique et la priorité accordée à l'environnement inclusive et durable.

Ce développement permet de concilier ces deux dimensions à condition d'innover les modes de vie, de production et de consommation grâce aux progrès technologiques et à l'action collective. Cette intervention présente les défis posés par le développement durable au niveau des représentations, afin d'analyser et de maîtriser les multiples transitions et enjeux patrimoniaux.

Mots clés : développement durable, environnement, innovation, éco-design.

Historical Evolution of Water Management in Liguria: From Agricultural Landscapes to Coastal Gardens

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Abstract. Liguria is a Mediterranean region characterized by predominantly hilly terrain facing the coast. Long rivers are scarce, but there are numerous streams and small waterways. Maritime Liguria, the part of the region adjacent to the sea, has always been a land of great agricultural diversity (vegetable crops, vineyards, olive groves, orchards, etc.), despite the limited presence of surface water.

In the past, water usage was always defined by a contrast between communal management of public resources and the individualism of private properties (villas, gardens, and orchards, etc.). Nevertheless, a rich network of inter-farm paths, parish churches, small villages, along with villas, parks, gardens, and agricultural estates, structured not only the Genoese capital but also all other parts of the region.

This paper aims to investigate the historical evolution of wise and sustainable water management; this has transformed an arid Mediterranean landscape into a fertile and lush land. Through the analysis of historical documents and, especially, rich cartography, the transformations of the Ligurian landscape can be observed, including the creation of terraces to cultivate on steep terrain, and the construction of canals, ditches, wells, and cisterns for water management and regulation.

In the agricultural landscape, emblematic cases of water management include the coastal cultivations of Chiavari, the vegetable plain of Marinella, the olive grove on Palmaria Island, and the vineyard on Tino Island.

In the parks attached to noble estates, admired and described by foreign travelers, the theme of water arises not only from the presence of lush Mediterranean vegetation, with reduced irrigation needs, but also from significant systems of grottoes, nymphaea, waterfalls, and ponds that characterize almost all Ligurian gardens, from medieval monastic gardens to the important acclimatization parks introduced by the English in the late 19th century.

Keywords: Landscape Architecture, Mediterranean, Terracing, Gardening, Historical Cartography

Historical water drainage systems in Palermo (Sicily) in medieval and modern examples. Qanat, water towers, cisterns

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Abstract. During the period of Islamic domination, Sicily inherited some forms of water drainage, probably borrowed from North Africa by the Romans, constituting surviving Qanat network systems (recently cataloged and topographically identified in relation to the water source for the metropolitan city of Palermo), aimed at irrigating agricultural crops, in the Palermo plain, coming from the nearby mountains in the medieval period, while, instead, the water supply of the inhabited center was based on a system of private wells, which fished from a shallow free water surface.

To these networks, some dated by ceramic remains to the 12th century, was added, in the 15th century, a water system relating to the distribution of water, which used the so-called water towers or castles (still visible in some part of the city), divided into two typologies, for the distribution of the urban network and for rural irrigation, functioning until the 19th century, but in fact not very efficient in satisfying the real needs of users, and in controlling their use of sources, then overcome by the construction of an aqueduct connected to the Madonie Mount (near Palermo) water sources according to a process of centralization of resources and controlled distribution of water. The topic of networks is substantially modified in relation to the need to establish the economic quantification of the use of the resource by individual users.

In addition to the urban water networks, another interesting water installation in Palermo concerns the water tanks designed by the engineer PierLuigi Nervi in the Real Park of Favorita, carried out by Ferdinand III of Bourbon, between Palermo and the village of Mondello, as hunting estate and place of agricultural experimentation. The tank, designed in 1935 by Eng. Pierluigi Nervi, commissioned by Italian Navy in 1935, has been carried out for diesel storage. Currently decommissioned, there is a proposal for a museum project. However, such a structure, in an optimal state, could be converted instead, into a drainage basin and water storage tank.

Palermo, historic center between water and greenery: a possible future?

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Abstract. Palermo is experiencing years of change. Starting from the redevelopment of its historic center, which began more than twenty years ago, citizens have gradually reclaimed the city's historic spaces and public areas. This has also led to the redevelopment of the green areas, with an - hopefully - increasingly sustainable perspective. Even the growing tourism has somehow changed some settlement issues.

Furthermore, the recent effects of climate change and the pandemic have shown everywhere the importance, on the one hand, of correct management of water resources and, on the other, of the presence of green areas in inhabited centers and, in particular, historic gardens of great monumental and naturalistic value of which Palermo is rich; these instances intertwine and gain strength while the specter of drought looms with consequences both for the inhabitants and for the conservation of the gardens and monumental parks.

On these issues in the historic city of Palermo there are some episodes that show how it is necessary to rethink the management of greenery and water resources, starting from virtuous examples such as that of the Botanical Garden and the initiatives for the redevelopment of the Oreto river and its forgotten ecosystem, to reach the great theme of the redevelopment of its South Coast, of the so-called Cala, the ancient port of the city with the remains of Castellammare, in a necessary dialogue - although not always sought and/or thought about - with the pre-existences and with sea.

A situation emerges in which Palermo will have to develop, in dialogue with its historical contexts, shared policies for a greater acceptance of the demands of environmental sustainability, which will also have an impact on the choice of restoration policies for the monumental heritage, for an overall improvement of the life of the historic town.

Keywords: Palermo, water, historic gardens, resource management

Palermo, centro storico tra acqua e verde: un futuro possibile?

Riassunto. Palermo vive anni di cambiamento. A partire dalla riqualificazione del suo centro storico, iniziata ormai più di venti anni fa, i cittadini si sono riappropriati progressivamente degli spazi storici della città e delle aree pubbliche. Ciò ha portato a riqualificare anche le aree verdi, in un'ottica - si spera - sempre più sostenibile. Anche il crescente turismo ha in qualche modo cambiato alcune istanze insediative.

Inoltre i recenti effetti del cambiamento climatico e della pandemia hanno mostrato dappertutto l'importanza, da una parte, di una corretta gestione delle risorse idriche e, dall'altra, della presenza di aree verdi nei centri abitati e, in particolare, dei giardini storici di grande valore monumentale e naturalistico di cui Palermo è ricca; queste istanze intrecciano e acquistano forza mentre lo spettro della siccità incombe con conseguenze sia per gli abitanti che per la conservazione dei giardini e dei parchi monumentali.

Su questi temi nella città storica di Palermo vi sono alcuni episodi che mostrano come sia necessario ripensare la gestione del verde e delle risorse idriche, a partire da esempi virtuosi come quello dell'Orto Botanico e le iniziative per la riqualificazione del fiume Oreto e del suo ecosistema dimenticato, per giungere al grande tema della riqualificazione della sua Costa Sud, della cosiddetta Cala, l'antico porto della città con i resti del Castellammare, in un necessario dialogo - seppur non sempre cercato e/o pensato - con le preesistenze e col mare.

Emerge un quadro in cui Palermo dovrà sviluppare, in dialogo con i suoi contesti storici, politiche condivise per un maggiore accoglimento delle istanze della sostenibilità ambientale, che dovranno incidere anche nella scelta delle politiche di restauro del patrimonio monumentale, per un complessivo miglioramento della vita dell'abitato storico.

Parole chiave: Palermo, acqua, giardini storici, gestione delle risorse

L'aqueduc de la rive droite de la Soummam, un essai de restitution

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Résumé. La période antique romaine a marqué à jamais le territoire algérien par de nombreux ouvrages hydrauliques dont les ponts aqueducs, les ponts saut, les cascades, les bassins et tant d'autres. Le nombre d'aqueducs hérités de cette période est estimé à plus de 39 unités dont la totalité n'est pas fonctionnelle aujourd'hui. Certains se présentent sous forme d'aqueducs aériens par contre d'autres sont enterrés ou semi-enterrés. Le manque d'intérêt pour ces ouvrages hydrauliques de la part des pouvoirs publics et de la communauté scientifique a sensiblement influencé leur état de conservation. Non classés pour la plupart, ils ne cessent de subir des dommages et se dégradent de jour en jour. Un des cas les plus représentatif reste ments du tracé. Les travaux de terrassement et de nouvelles constructions sont parmi les causes principales de sa destruction.

Un essai de restitution d'un segment de cet ouvrage antique participera sans aucun doute à un regain d'intérêt pour la sauvegarde et la préservation du moins de ce qui reste de cet héritage.

Mots clés : Romaine, ouvrages hydrauliques, aqueducs, Tubusuptu, restitution, héritage.

The aqueduct on the right bank of the Soummam River, an attempt at restitution

Abstract. The Roman ancient period forever marked the Algerian territory with numerous hydraulic structures including aqueducts, jump bridges, waterfalls, basins, and many others. The number of aqueducts inherited from this period is estimated at over 39 units, of which not all are functional today. Some are in the form of aerial aqueducts, while others are buried or semi-buried. The lack of interest in these hydraulic structures from the public authorities and the scientific community has significantly influenced their state of preservation. Mostly unclassified, they continue to suffer damage and deteriorate day by day. One of the most representative cases is the aqueduct on the left bank of the Soummam River, which partly supplies the ancient city of Tubusuptu or Tiklat. Today, it is only visible in a few small segments of its path. Excavation work and new constructions are among the main causes of its destruction.

An attempt to restore a segment of this ancient structure will undoubtedly contribute to a renewed interest in the preservation and conservation of at least what remains of this heritage.

Keywords: Roman, hydraulic structures, aqueducts, Tubusuptu, restore, heritage.

The water and marble of the Apuan (Italy)

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Abstract. At the beginning of the 18th century, the small town of Carrara was the political and administrative centre that with the neighbouring Principality of Massa was part of a tiny territorial state under the Cybo-Malaspina family. Formed in the second half of the 15th century, the small state on the southern borders of Lunigiana remained intact until the 19th century. It had a small extension of about 50 square kilometres and a predominantly mountainous conformation, in fact it only included the basin of the Carrione river, a short and tumultuous watercourse that descends rapidly from the Apuan Alps towards the sea, after crossing a narrow strip of plain called Avenza. The city was located on the left bank of the river, in a valley on the extreme slopes of the Apuan Alps, and its original nucleus was established around the year 1000, a short distance from the Roman Luni. It was precisely from the port of the ancient city of Luni that the marble blocks extracted from the quarries of Carrara departed. The marble block was quarried and then sawed; a saw with a wooden frame, a sieve and bucket for the sand, and an amphora for the water. Shortly after the end of the Middle Ages, looms were installed along watercourses to harness hydraulic power, and sawmills were built as close as possible to the extraction site near the canals in the narrow valleys around Carrara. The water from the canals was diverted by means of fishponds to animate the many buildings intended for the use of marble, and a new system built by a wheel moved by a water jump, made a single blade sharpened on a vertical frame go up and down on the marble.

Keywords: Water, Marble, Apuan Alps, stone processing

L'Acqua e il Marmo delle Apuane (Italy)

Riassunto. Agli inizi del secolo XVIII la piccola città di Carrara era il centro politico ed amministrativo che con il confinante Principato di Massa faceva parte di un minuscolo stato territoriale sotto la famiglia Cybo-Malaspina. Formatosi nella seconda metà del secolo XV, il piccolo stato ai confini meridionali della Lunigiana rimane intatto fino al secolo XIX. Esso aveva una piccola estensione di circa 50 chilometri quadrati ed una conformazione prevalentemente montuosa, infatti comprendeva soltanto il bacino del fiume Carrione, un breve e tumultuoso corso dell'acqua che dalle Alpi Apuane scende velocemente verso il mare, dopo aver attraversato una esigua striscia di pianura denominata Avenza. La città era posta sulla sponda sinistra del fiume, in una valle alle estreme pendici delle Alpi Apuane e il suo nucleo originario si era costituito intorno all'anno 1000, a breve distanza dalla romana Luni. Proprio dal porto dall'antica città di Luni partivano i blocchi di Marmo estratti dalle cave di Carrara. Il blocco di marmo veniva estratto e poi segato; una sega con telaio in legno, un setaccio e un secchiello per la sabbia, un'anfora per l'acqua. Poco dopo la fine del medioevo i telai vennero installati lungo i corsi d'acqua per sfruttare la forza idraulica e le segherie venivano costruite il più vicino al luogo di estrazione in prossimità dei canali nelle strette vallate nei dintorni di Carrara. La derivazione dell'acqua dei canali avveniva mediante pescaie per animare i molti edifici destinati per l'uso dei marmi e un nuovo sistema costruito da una ruota mossa da un salto d'acqua, faceva andare su e giù sul marmo un'unica lama affilata ad un telaio verticale.

Parole chiave: Acqua, Marmo, Lavorazioni, Alpi Apuane

Session 4 - Water in reuse and memory recovery projects. From analysis to project

Chairman: Khadija Baba

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In many Mediterranean contexts the presence of water determined the birth of settlements, and also of specific productive activities that drew energy for their work from water. Often, in the past, canalizations and hydraulic systems have changed the territory, qualifying it; in other cases, today, the abandonment of these productive systems, the abandonment of hydraulic structures in favor of new and other systems has left sites on the territory that now ask to be recovered, restored and, in some cases, reused.

In the session, some examples of detailed and interdisciplinary study of these contexts are examined with the aim, also, of their recovery. The particularity of these sites requires, in fact, in some cases, particular precautions even in the preliminary study of the project: an accurate survey, studies on any specific materials used, precautions taken in the processing and in the installation of the materials... All this leads to an accurate knowledge and is an essential premise for their conservation

Session 4 - L'eau dans les projets de réutilisation et de récupération de la mémoire. De l'analyse au projet

Dans de nombreux contextes méditerranéens, la présence de l'eau a déterminé la naissance d'établissements, mais aussi d'activités productives spécifiques qui tiraient de l'eau l'énergie nécessaire à leur travail. Souvent, dans le passé, les canalisations et les systèmes hydrauliques ont modifié le territoire, le qualifiant ; dans d'autres cas, aujourd'hui, l'abandon de ces systèmes productifs, l'abandon des structures hydrauliques au profit de nouveaux et d'autres systèmes ont laissé des sites sur le territoire qui demandent maintenant à être récupérés, restaurés et, dans certains cas, réutilisés.

Au cours de la session, quelques exemples d'étude détaillée et interdisciplinaire de ces contextes sont examinés dans le but, également, de leur récupération. La particularité de ces sites nécessite, en effet, dans certains cas, des précautions particulières même dans l'étude préliminaire du projet : un relevé précis, des études sur les éventuels matériaux spécifiques utilisés, des précautions prises dans le traitement et dans l'installation des matériaux... Tout cela conduit à une connaissance précise et constitue une prémisses essentielle pour leur conservation.

الجلسة 4 - المياه في مشاريع إعادة الاستخدام واستعادة الذاكرة. من التحليل إلى المشروع في العديد من السياقات المتوسطية، كان وجود المياه يحدد ولادة المستوطنات وكذلك الأنشطة الإنتاجية التي استمدت الطاقة لعملها من المياه. في كثير من الأحيان في الماضي، كانت القنوات والأنظمة الهيدروليكية تغير المنطقة وتؤهلها في حالات أخرى. اليوم، ترك التخلي عن هذه الأنظمة الإنتاجية وعن الهياكل الهيدروليكية لصالح أنظمة جديدة وغيرها، مواقع على الأرض تتطلب الآن استعادتها وترميمها، وفي بعض الحالات إعادة استخدامها في الجلسة، سيتم فحص بعض الأمثلة للدراسة التفصيلية ومتعددة التخصصات لهذه السياقات بهدف استعادتها أيضًا. تتطلب خصوصية هذه المواقع في الواقع، في بعض الحالات، احتياطات خاصة حتى في الدراسة الأولية للمشروع. مسح دقيق

ودراسات حول المواد المستخدمة، واحتياطات في معالجة وتركيب المواد... كل هذا يؤدي إلى معرفة دقيقة وبشكل فرضية
أساسية للحفاظ عليها

The "memory" of the presence of water in restoration projects. Some cases in Arab-Norman architecture in Sicily

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Abstract. The contribution aims to analyze the criteria and outcomes that have followed, from the end of the nineteenth century to today, in the restoration projects carried out on Arab-Norman architecture in Sicily. In particular, the relationship of the restoration project with the theme of the "memory" of the presence of water will be analysed. This type of architecture, with their gardens and water, created a construction unicum, identified by historiography as the "Arab-Norman" architecture of Sicily.

It is interesting to underline that since 2015 UNESCO has recognized "Arab-Norman Palermo and the Cathedrals of Cefalù and Monreale" as a world heritage site, identifying not only the individual Norman monuments, but the itinerary that connects both the architecture and the landscape that binds them. It is an architectural culture that produced structures serving both housing, religious architecture and the agricultural production that characterized these places, showing that inseparable link with the building culture of Arab origin which took shape in the presence of: Scirocco rooms, fishponds, mills and in the dense underground network of qanats. Water has shaped these landscapes and was integrated into the construction of these architectures, as a fundamental element for the use of the buildings and for the cultivation of the gardens.

The objective of the contribution lies in the comparison between past and present project choices and in the analysis of the transformations that have affected this socio-economic context and the landscape over the last two hundred years. The theme will be developed by making a critical synthesis of the project proposals which have highlighted the desire to bring out the presence of water and the "memory" of its presence, through the conservation and enhancement of the architecture and construction techniques that yield the presence of water which transformed these places and was essential for the use of these architectures. For Palermo, the entire Arab-Norman UNESCO itinerary will be the object of study and also the architectures that have not yet been recognized by UNESCO, but which are clearly symbols of these material and immaterial monumental values. These are values that are found in the construction techniques, typologies and relationship with uses and which place this architecture in the culture that links Sicily to the entire Mediterranean monumental heritage.

Keywords: Arab-Norman, restoration project, UNESCO, historic gardens, construction techniques.

La "memoria" della presenza dell'acqua nei restauri. Alcuni casi nell'architettura arabo-normanna in Sicilia

Riassunto. Il contributo si propone di analizzare i criteri e gli esiti che si sono susseguiti, dalla fine dell'Ottocento ad oggi, nei progetti di restauro realizzati sull'architettura arabo-normanna in Sicilia. In particolare verrà analizzato il rapporto del progetto di restauro con il tema della "memoria" della presenza dell'acqua. Questo tipo di architettura, con i suoi giardini e l'acqua, creava un unicum costruttivo, identificato dalla storiografia come l'architettura "arabo-normanna" della Sicilia.

È interessante sottolineare che dal 2015 l'UNESCO ha riconosciuto "Palermo arabo-normanna e le cattedrali di Cefalù e Monreale" come patrimonio dell'umanità, individuando non solo i singoli monumenti normanni, ma l'itinerario che collega sia l'architettura che gli spazi esterni che li legano. Si tratta di una cultura architettonica che ha prodotto strutture a servizio sia della tipologia residenziale, sia dell'architettura religiosa, sia della produzione agricola che ha caratterizzato questi luoghi, mostrando quel legame inscindibile con la cultura edilizia di origine araba che ha preso forma nella presenza di: stanze dello Scirocco, peschiere, mulini e in una fitta rete sotterranea di qanat. L'acqua ha modellato questi paesaggi ed è stato un elemento della costruzione, integrata nel progetto di queste architetture, come elemento fondamentale per la fruizione degli edifici e per la coltivazione dei giardini.

L'obiettivo del contributo risiede nel confronto tra scelte progettuali passate e presenti e nell'analisi delle trasformazioni che hanno interessato questo contesto socio-economico e il paesaggio negli ultimi duecento anni. Il tema verrà sviluppato operando una sintesi critica delle proposte progettuali che hanno evidenziato la volontà di far emergere la presenza dell'acqua e la "memoria" della sua presenza, attraverso la conservazione e la valorizzazione delle architetture e delle tecniche costruttive che ne restituiscono ancora il ricordo della sua presenza. d'acqua che trasformò questi luoghi e fu fondamentale per la fruizione di queste architetture. Per Palermo sarà oggetto di studio l'intero itinerario UNESCO arabo-normanno e anche le architetture non ancora riconosciute dall'UNESCO, ma che sono chiaramente

simbolo di questi valori monumentali materiali e immateriali. Sono valori che si ritrovano nelle tecniche costruttive, nelle tipologie e nel rapporto con gli usi e che collocano questa architettura nella cultura che lega la Sicilia all'intero patrimonio monumentale del Mediterraneo.

The fulling mills in Remole, Bagno a Ripoli (Florence)

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Abstract. Le Gualchiere di Remole sono situate nel comune di Bagno a Ripoli, a pochi chilometri dalla città di Firenze, sulla riva sinistra del fiume Arno. La prima documentazione dell'edificio risale ad un'inchiesta dei Capitani di Parte Guelfa del 1425, che ritrae l'opificio con un aspetto architettonico molto simile a quello odierno e consente di datarlo al secolo XIV. Nelle Gualchiere, attraverso macchinari azionati dalla forza motrice dell'acqua, si praticava una particolare lavorazione della lana detta era gualcatura o follatura, che rendeva l'intreccio del panno più compatto e aderente per ottenere un tessuto adatto alla creazione di abiti. Dal 1541 al 1770 il complesso delle Gualchiere diviene proprietà dell'Arte della Lana e in seguito viene consegnato alla Camera di Commercio. Dopo circa undici anni l'opificio viene acquisito dall'Opera del Duomo per ritornare verso la fine del secolo di nuovo un bene della Camera di Commercio. In seguito si hanno vari passaggi di proprietà, fino a quando nell'Ottocento l'edificio viene riconvertito ad uso di mulino ed acquisito dal Comune di Firenze nel 1918. Dopo la fine della seconda guerra mondiale, insieme alle circostanti campagne, anche le Gualchiere vengono abbandonate e a seguito dei danni provocati dall'alluvione del 1966, cadono nel definitivo degrado. Il complesso ad oggi è ancora integro e costituisce una fondamentale testimonianza storica nel territorio fiorentino.

Dal 2009 sono iniziati degli studi relativi al funzionamento della trasformazione dell'energia fornita dall'acqua in energia meccanica da utilizzare sia per la gualchieratura degli stracci, sia successivamente per il mulino per la macina dei cereali. A questo fine sono stati realizzati i rilievi degli esterni e degli interni dell'opificio utilizzando tecnologie laser scanner e telerilevamento da drone per fotomodellazione SfM (Structure from Motion).

Keywords: Survey, Architecture, Fulling mills, Cultural heritage, Late medieval building

De la restitution du réseau hydraulique de Muslubium, l'antique port disparu

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Résumé. Toute source ou point d'eau est souvent propice à l'apparition d'un lieu de vie et/ou d'activité humaine. Muslubium Horrea, un important port maritime datant de l'époque antique, a été récemment découvert dans la ville de Bejaia (Algérie), et dont une source d'eau abondante située à 5000 m en amont aurait joué un rôle important à l'origine de sa création. Même après l'éclipse physico-historique de cet antique port, cette source dénommée par les romains Kefrida (Aqua Frigida), a toutefois continué tout au long du 19^{ième} siècle à alimenter d'autres villages proches lors de la régence ottomane et plus tard le centre de Bejaia du temps de l'occupation française.

Cet article traite de la restitution cartographique d'un réseau hydraulique antique disparu alimentant le port maritime de Muslubium Horrea depuis la source Kefrida (Aqua Frigida), situé exactement dans le lias du Mont Adrar N'Fad, avec des captages placés sur trois sommets de différentes hauteurs.

La compilation des récits historiques existants et l'interprétation découlant de la superposition de cartes géographiques anciennes et de cartes archéologiques et géologiques du 19^{ième} siècle ont permis d'identifier les trois points de captage de Kefrida ainsi qu'une inscription lapidaire témoignant de l'aménagement de la source. L'enquête de terrain a en outre permis la mise au jour de vestiges archéologiques d'un aqueduc en pierre et de trois drains. Ces données, confirmées par des relevés de terrain et des relevés photogrammétriques au drone, ont permis d'établir une carte montrant le contexte géo-archéologique du réseau hydraulique de la source de Kefrida à Muslubium.

Mots clés : Source, Aqua Frigida, Muslubium Horrea, réseau hydraulique, relevés, restitution cartographique.

On the restitution of the hydraulic structure of Muslubium, the lost ancient port.

Abstract. Any spring or water source is often an ideal location for human life and/or activity. Muslubium Horrea, an important seaport dating from ancient times, was recently discovered in the town of Bejaia (Algeria), where an abundant source 5000 m upstream is thought to have played an important role in its creation. Even after the physical-historical eclipse of this ancient port, this source, named Kefrida (Aqua Frigida) by the Romans, continued throughout the 19th century to supply other nearby villages during the Ottoman regency and later the center of Bejaia during the French occupation.

This article deals with the cartographic restitution of a vanished ancient hydraulic network supplying the seaport of Muslubium Horrea from the Kefrida source (Aqua Frigida), located exactly in the lias of Mont Adrar N'Fad, and with catchments placed on three peaks of different heights.

The compilation of existing historical accounts and the interpretation derived from the superimposition of ancient geographical maps and 19th-century archaeological and geological maps enabled to identify the three Kefrida catchment points, as well as a lapidary inscription testifying to the development of the source. The field survey also uncovered the archaeological remains of a stone aqueduct and three drains. These data, confirmed by field and photogrammetric drone surveys, were used to draw up a map showing the geo-archaeological context of the hydraulic structure at the Kefrida spring in Muslubium.

Keywords: Spring, Aqua Frigida, Muslubium Horrea, hydraulic structure, surveys, cartographic restitution.

Scan to GIS methodologies for the multi-scalar representation of water landscapes

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Abstract. This paper illustrates part of a broader research aimed at outlining an investigation methodology for the digital representation of water landscapes in the Po Valley (Italy). The management of water resources accompanies the history of the settlement system in northern Italy from earliest times. Canalisations and hydraulic elements have changed the territory appearance, signifying the space and qualifying the image and identity of different cultures that have inhabited and live in it. To represent such amphibious landscapes, the drawer must operate a critical synthesis, transforming the complexity of infinite relationships into an ordered network of signs and symbols. In digital representation, this network is structured in models and information systems that collect and support various data.

In the Ticino region, the system of irrigation infrastructures originates with the plain drainage, carried out by the Romans, and finds its more organic systemisation with studies of Leonardo da Vinci, who contributes to enriching navigable canals with locks and hydraulic engineering works. Today, this cultural dimension plays a central role in determining the territory's identity, characterised by a rich natural environment and numerous historical and multifunctional hydraulic heritage, which, abandoned after industrialisation, need to be recognised, recovered, and safeguarded.

In response to this need, the research proposes a methodology structured in phases: from integrated image-based and range-based technologies to mesh-nurbs modeling, to expeditious census, and finally to structuring and populating of a 3D G.I.S. The information system is intended to take the form of a multi-scalar semantic model, in which volumes, surfaces, lines, and points are assembled and associated with specific data to constitute a unique dynamic organism. Through the structuring of the 3D G.I.S., the research aims to facilitate landscape knowledge, visualization, and management, making explicit relationships between elements that compose it and defining novel strategies to increase awareness of the water heritage.

Keywords: amphibious landscapes, hydraulic heritage, integrated survey, 3D G.I.S., Po Valley.

Irrigation systems in oases: case of khettarat

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Abstract. Nowadays, the issue of water is becoming increasingly complex, affecting several critical aspects on both local and global scales. These include access to drinking water, irrigation water, water pollution, water resource management, and wastewater management.

With current climate changes, the impacts on hydrological cycles are becoming more severe, leading to extreme phenomena such as prolonged droughts, floods, and changes in precipitation patterns.

Given that agriculture is the sector that consumes the most water, it will be directly affected by the availability and distribution of water. This underscores the importance of finding solutions with integrated approaches that combine effective public policies, technological innovations, appropriate community management, and international cooperation.

Among the techniques used in oases, the system known as "khettarat" is a traditional irrigation system that has been developed in arid and semi-arid regions, notably in the Maghreb (Morocco, Algeria, Tunisia) and other parts of the Middle East. This system is particularly well-suited for areas where water is scarce and where it is essential to use available resources efficiently.

We will describe this system and examine how well it can address water stress, while not forgetting the role of water as a strategic resource, especially in regions where resources are limited. Therefore, raising awareness about the importance of water conservation and sustainable practices is crucial for improving water resource management.

Keywords: drought, resources, water, oasis, khettarat

Sahrij Labgar : un ouvrage hydraulique millénaire à Marrakech (Maroc). Interrogations et comparaisons

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Résumé. Un projet de recherche conjoint entre l'Université de Marrakech, l'Université de Gênes et l'ISPC CNR de Firenze a été lancé en 2023 et s'est concentré sur le réservoir de Sahrij Labgar.

Ce réservoir, qui date du 12e siècle, a été construit par la dynastie Almohadi ; il était relié à un vaste système de khattaras. Les premières analyses ont révélé un système de construction particulier qui utilisait principalement le matériau présent sur place : la terre. Des données intéressantes sont également ressorties de la caractérisation de ce sol, qui semblerait avoir des caractéristiques très particulières qui le rendraient particulièrement résistant, même dans des environnements humides. Sur la base de ces premières recherches, il a donc été décidé de poursuivre les travaux de recherche. Le bassin, comme on l'a dit, est très ancien : il a donc été décidé de procéder à une analyse stratigraphique complète de toute la structure afin de mettre en évidence les modifications ou les transformations effectuées à différentes époques. Par la suite, les matériaux utilisés seront caractérisés pour les différentes phases. Le but de cette analyse est de comprendre si l'utilisation de matériaux particuliers est un choix délibéré fait à une période donnée (et abandonné par la suite) ou si, au contraire, il s'agit d'une constante dans le temps. Pour la même raison, des comparaisons seront faites avec d'autres ouvrages hydrauliques de la région. Les comparaisons possibles avec des artefacts de la même période mais appartenant à des contextes territoriaux différents pourraient donc être intéressantes. Les questions auxquelles nous voulons tenter de répondre sont les suivantes : l'utilisation de sols particuliers est-elle liée à un contexte territorial ou s'agit-il plutôt d'une pratique de construction répandue sur un vaste territoire ? La connaissance de ces structures sous plusieurs angles est un premier pas vers la conservation de ce patrimoine culturel particulier et intéressant.

Keywords: Mots clés : Sahrij Labgar, ouvrage hydraulique millénaire, Marrakech

Sahrij Labgar: una struttura idraulica millenaria a Marrakech (Marocco). Interrogativi e confronti

Riassunto. Un progetto di ricerca congiunto tra l'Università di Marrakech, l'Università di Genova e l'ISPC CNR di Firenze è stato avviato nel 2023 e si è concentrato sul bacino artificiale Sahrij Labgar di Marrakech. Questo bacino, che risale al XII secolo, fu costruito dalla dinastia Almohadi ed era collegato a un vasto sistema di khattaras. Le prime analisi hanno rivelato un particolare sistema costruttivo che utilizzava principalmente materiali locali: la terra. Dati interessanti, inoltre, sono emersi dalla caratterizzazione di questa terra che sembrerebbe avere caratteristiche molto particolari che la renderebbero particolarmente resistente anche in contesti umidi. Sulla scorta di queste prime ricerche, si è quindi deciso di continuare il lavoro, pur con degli ausili alla ricariciti ricerca. Il bacino, come si è detto, è molto antico: si è deciso quindi di procedere con un'analisi stratigrafica completa di tutta la struttura con lo scopo di evidenziare eventuali modifiche o trasformazioni effettuate in tempi diversi. Successivamente per le varie fasi verranno caratterizzati i materiali utilizzati. Con questa analisi si vuole capire se l'utilizzo di particolari materiali è una scelta voluta effettuata in un particolare periodo (e poi successivamente abbandonata) o se, al contrario, è invece una costante nel tempo. Per lo stesso motivo, verranno effettuati confronti con altre strutture idrauliche presenti in zona. Di interesse, poi, potrebbe essere l'eventuale confronti con manufatti della medesima epoca ma appartenenti a contesti territoriali differenti. Gli interrogativi a cui si vuole cercare di dare una risposta sono: l'utilizzo di particolari terre è legato ad un contesto territoriale o è piuttosto una pratica costruttiva diffusa in un'area molto vasta? La conoscenza di queste strutture da più punti di vista è un primo passo per la conservazione di questo particolare ed interessante patrimonio culturale.

Parole chiave: Sahrij Labgar, struttura idraulica millenaria, Marrakech

Built City and Dug City. An opportunity for reconnection

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Abstract. The territorial context encompassing the current city of Agrigento, the ancient Akragas, and the respective domains of both, also contains a subterranean heritage of significant interest. This heritage consists of man-made meandering cavities, wells, and large chambers carved into the golden calcarenite from the Greek domination period up to the Chiamontan era. These hypogea, representing a grand hydraulic and hydrogeological management system and reaching depths of up to 30 meters below ground level, extend from Kolymbetra (an ancient hydrological basin), pass through the Collina Sacra, intersect the Hellenistic-Roman residential nucleus, and then extend north towards the Colle di Girgenti. Crossing the Taglio di Empedocle, they reach the Rupe Atenea to the east. Of the multiple accesses to the hypogean complex, many are no longer clearly discernible due to the diachronic transformations of the urban space, which have often obscured the relationship with these pre-existing structures, altering the functionality of the ancient infrastructures for water supply and their above-ground outlets. Currently identified access points include the one in Piazza del Purgatorio – marked by the gate designed by Alaimo – those corresponding to Gates I and V, and the Temple of the Dioscuri.

The interpretative analysis of these underground architectures allows for the simultaneous narration of the historical periods and the respective extraction and construction techniques that characterized this territory, revealing a formal correspondence between the built and the excavated heritage. This relationship connects the constructed city with the geological one, offering an opportunity to reconnect the epigeal, archaeological, and contemporary urban areas, which often overlap, creating conditions of contrast.

Through the project aimed at the knowledge, enjoyment, enhancement, and renewed use of the excavated city, opportunities are intended to be generated for reestablishing a dialogic interrelationship – functional, urban, social, cultural, natural, and landscape-related – that has long been forgotten.

Keywords: Underground, Akragas, Hydraulic, Archaeological, Heritage

Città costruita e città scavata. Un'opportunità di riconnessione

Riassunto. Il contesto territoriale che racchiude l'attuale città di Agrigento, l'antica Akragas e le relative pertinenze di entrambe, contiene anche un patrimonio sotterraneo di notevolissimo interesse, costituito da cavità artificiali meandriformi, pozzi e grandi camere scavati nella calcarenite dorata a partire dal periodo di dominazione greca, e sino a quello chiamontano. Tali ipogei, costituendo una grandiosa opera di regimentazione idraulica e di captazione idrogeologica, e raggiungendo perfino i 30 metri al di sotto della linea di terra, si estendono dalla Kolymbetra (che costituiva un antico bacino idrologico), passando per la Collina Sacra, e intercettando il nucleo abitativo ellenistico-romano, si protendono poi verso nord sul Colle di Girgenti, e superando il Taglio di Empedocle, raggiungono ad est la Rupe Atenea. Dei molteplici accessi al complesso ipogeo, molti non sono più chiaramente leggibili a causa delle trasformazioni diacroniche dello spazio urbano che spesso ha negato la relazione con tali preesistenze, alterando il funzionamento degli antichi apparati infrastrutturali per l'approvvigionamento idrico e i relativi sbocchi fuori terra. Di questi, sono stati attualmente individuati quello di Piazza del Purgatorio – segnalato dalla porta progettata da Alaimo -, quelli in corrispondenza delle Porte I e V, e del Tempio dei Dioscuri.

L'analisi interpretativa delle architetture sotterranee permette la narrazione simultanea dei periodi storici e delle relative tecniche estrattive e costruttive che hanno caratterizzato tale territorio, palesando un corrispettivo formale tra il Patrimonio costruito e quello cavato, che mette in relazione la città edificata con quella geologica, offrendo un'opportunità di riconnessione degli ambiti urbani epigei, archeologici e contemporanei, che spesso si sovrappongono ponendosi in condizione di contrasto.

Attraverso il progetto per la conoscenza, la fruizione, la valorizzazione e il rinnovato uso della città scavata, si intende generare occasioni di ricucitura di un rapporto dialogico di interrelazione – funzionale, urbana, sociale, culturale, naturale e paesaggistica – ormai dimenticato.

Parole chiave Sottosuolo, Akragas, Idrogeologico, Archeologia, Patrimonio

The Aqueduct of Ain Zeboudja: Last Witness of Hydraulic Works from the Regency of Algiers during the Ottoman Period, Between Influences and Constructive Innovations

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Abstract. Before the 16th century, Algiers had only one or two springs and a few wells. During the Ottoman period between 1587 and 1830, the Regency of Algiers was supplied by a network of aqueducts. These were of Ottoman construction, unlike in other cities of the Ottoman Empire such as Aleppo and Tunis, where aqueducts were inherited from earlier periods between the 15th and 19th centuries.

The hydraulic network consisted of several aqueducts, among them the Ain Zeboudja Aqueduct (also known as the Aqueduct of Val d'Hydra), which captured water from the Sahel and transported it to all parts of the city. Unfortunately, this network was not maintained, and today, the only remaining testament to it is a part of the Ain Zeboudja aqueduct. The Ain Zeboudja Aqueduct, known as the Val d'Hydra Aqueduct, was built around 1619 by Sharif Khudja Basha and is the last aqueduct constructed by the Ottomans. It was supplied by artificial springs from Ben Aknoun, located more than 10 kilometers southwest of the medina. To increase flow, builders used artificial drainages and perpendicular pipelines to contour lines, collecting aquifer runoff from galleries filled with dry stones to filter water. It supplied water to four fountains and the Tagarins area, distributing water to 14 fountains.

The Ain Zeboudja Aqueduct exhibits distinctive architectural features such as double-level bridges, some with arcades, and others more massive. Although only a small fraction of these structures still stand, their study is highly valuable as they represent the last tangible evidence of urban hydraulic archaeology and provide insight into specific architectural and construction techniques.

Keywords: Hydraulic works, Ain Zeboudja Aqueduct, Regency of Algiers, Ottoman period, architectural and construction typologies.

L'Aqueduc de Ain Zeboudja Dernier témoins des ouvrages hydrauliques de la régence d'Alger à la période Ottomane entre influences et innovations constructives

Abstract. Résumé. Riassunto. Avant le XVI^e siècle, Alger ne disposait que d'une ou deux sources et de quelques puits. A la période ottomane entre 1587 et 1830, la régence d'Alger était alimentée par un ensemble d'aqueducs. Ces derniers sont d'édification ottomane, contrairement à d'autres villes de l'empire ottoman entre le XV^e et XIX^e siècle, tels que Alep et Tunis, dont les aqueducs étaient un héritage des périodes antérieures.

Le réseau hydraulique était constitué de plusieurs aqueducs dont on compte l'aqueduc de Ain Zebouja (Aqueduc du val d'Hydra) qui captaient l'eau du sahel et l'acheminait vers tous les quartiers de la ville.

Malheureusement ce réseau n'a pas été entretenu et il n'en demeure aujourd'hui comme unique témoignage qu'une partie de l'aqueduc de Ain zeboudja.

L'aqueduc de Ain Zeboudja dit du Val d'Hydra a été construit vers 1619 par Sharif Khudja Basha, c'est le dernier aqueduc réalisé par les ottomans. Il était alimenté des sources artificielles de Ben Aknoun, situées à plus de 10 kilomètres au Sud-Ouest de la médina. Pour augmenter le débit, les constructeurs ont eu recours à des drainages artificiels et des canalisations perpendiculaires aux courbes de niveau, collectant ainsi les ruissellements aquifères des galeries remplies de pierres sèches pour filtrer l'eau. Il alimente quatre fontaines, ainsi que la zone des Tagarins et distribue l'eau à 14 fontaines.

L'aqueduc de Ain Zeboudja relève des particularités constructives tels que des ponts à double niveau dont certains sont à arcades, et d'autres plus massifs. Bien que les parties de ces ouvrages encore debout, ne représentent qu'une petite fraction de la longueur de ces adductions, leur étude est très intéressante et précieuse dans la mesure où ils constituent les dernières traces matérielles d'une archéologie hydraulique urbaine et le témoignage de typologies constructives et techniques spécifiques.

Mots clés : Ouvrages hydrauliques, Aqueduc de Ain zeboudja, Regence d'Alger, période Ottomane, typologies architecturales et constructives

Les Foggaras système hydraulique à sud Algerian: patrimoine ou un système durable?

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Résumé. La zone désertique de l'Algérie représente environ 90% de sa superficie totale, et en 2018, sa population a atteint 3 600 000 personnes, soit 10,5% de la population de l'Algérie, et la plupart d'entre eux vivent dans des oasis où l'homme interagit avec son environnement et où l'eau est disponible. le principal facteur de sa stabilité, il a donc inventé le système les Foggaras . Il s'agit d'une méthode hydraulique permettant d'extraire l'eau des profondeurs du sol et de la distribuer dans un système qui évite le gaspillage d'eau, garantit la justice sociale et améliore l'économie de la région, dont dépend sur la durabilité de la culture du palmier.

Il semble que le mot Al-Foggara, selon ce qui est communément connu, soit dérivé Vertèbres car l'apparence de la surface en forme de colonne vertébrales, une série de puits en forme d'épine, coulant depuis des zones élevées dans la direction de la pente du terrain, où la source principale est constituée des puits ayant la plus grande profondeur et le débit le plus fort, jusqu'à ce qu'elle atteigne la surface de la Terre. Profitant de la loi de la gravité, lorsque l'eau atteint la surface de la Terre, elle est distribuée selon. à un système spécial.

Cependant, les anciens systèmes hydrauliques des Foggaras se sont caractérisés par leur faible pompage des eaux souterraines, ce qui a conduit, au cours des cinq dernières décennies, à la mise en œuvre de plusieurs programmes de développement agricole moderne basés sur l'exploitation des eaux souterraines dans de nouvelles zones de développement.

À cette étude nous faisons la lumière sur les facteurs qui ont conduit à un déclin du recours au système Foggaras traditionnel et, d'autre part, démontrer le potentiel de durabilité de cet ancien patrimoine hydraulique.

النظام الهيدروليكي الفقاراس جنوب الجزائر: تراث أم نظام مستدام

ملخص

تمثل مساحة الصحراء في الجزائر حوالي 90% من مساحتها الجبلية، وفي عام 2018، بلغ عدد سكانها 3,600,000 نسمة، أي 10.5% أي 10.5% من سكان الجزائر، ويسكن أكثرهم بالواحات ايمن يتفاعل اننسمان مم بيتيم، والماء مم العامل الرئيسي استقراره، فابتكر نظام الفقاراس، ومي أسلوب ري نسمترا الماء ممن عم الأرض، وتوزيع بظظام بمظم ممد الماء ويضمن العدالة انجتماعية، ويعزز اقتصاد بالمطقة، الذي يعتمد على استدامة زراعة الطريل ويبدو أن لفظ الفقارة حسب ما ممو شمائي، مشمت ممن الفقرة ألن المظهر السطحي للفقارة ممو تسلسل اليمار علمي شمكل العمود الفقري، تناسب من المظاط المرتفعة فمي انجماه المظمدر الأرضي، حيم يكمون المظلم الرئيسي انبمار ذا العمم الكمبر والتمدق يوز وف نظام خاص. الأقوي، إلى أن تصل إلى سطح الأرض مستقيدة من قانون الجاذبية، وعظما يصل الماء إلى سطح الأرض ع ان أن النظمة ميدروولوجية القديمة للفقاراس أصمبح تتميز بضمع ضمرها للمياه الجوفية، مما أدى خمالل العقود الرسمة الأخيرة إلى تفيذ عدة برامج حديثة لتنمية الزراعة القائمة على استغلال المياه الجوفية بالمظاط التطوير الجديدة، وجماء دراستظا هذه لتسليط الضوء على العوامل التي أدا يتراج اعتماد على نظام الفقاراس التقليدي، ومن ناحية أخمري، إظهار إمكانيمة استدامة .مذا التراث ميدروولوجي القدي

Session 5 - Climate change and new perspectives in landscape and heritage management

Chairman: Michele Civiero

member of the Italian delegation at the first edition of “Across the Sea”

Wise environmental interventions, attentive to the physical characteristics of places. This was the nature of Roman centuriations, Arab and Norman hydraulic systems in Sicily, the recovery of underground water and in the transport of water to the surface in Morocco and Algeria. In the past, these systems proved to be adaptable to climate change. Sometimes socio-economic changes have caused their abandonment and accelerated their degradation. Research in documents testifies this.

Their re-adaptation and reuse may be possible: forecasting studies based on digital terrain models, with GIS information systems and predicted extreme climate events show how in some cases these ancient systems may still be current and may have a role in the future, even taking into account ongoing climate change.

A combination of several actions is desirable: on the one hand the recovery of ancient hydraulic systems, on the other a combination of “nature-based solutions, like urban greening, parks and rooftops, ...

Session 5 - Changement climatique et nouvelles perspectives dans la gestion du paysage et du patrimoine

Interventions environnementales judicieuses, attentives aux caractéristiques physiques des lieux. C'était le cas des centuriations romaines, des systèmes hydrauliques arabes et normands en Sicile, de la récupération des eaux souterraines et du transport de l'eau vers la surface au Maroc et en Algérie. Dans le passé, ces systèmes se sont révélés adaptables au changement climatique. Parfois, les changements socio-économiques ont provoqué leur abandon et accéléré leur dégradation. Les recherches dans les documents en témoignent.

Leur réadaptation et leur réutilisation peuvent être possibles : des études de prévision basées sur des modèles numériques de terrain, avec des systèmes d'information SIG et des événements climatiques extrêmes prédits montrent comment, dans certains cas, ces systèmes anciens peuvent encore être actuels et avoir un rôle à jouer dans le futur, même en tenant compte du changement climatique en cours.

Une combinaison de plusieurs actions est souhaitable : d'une part la récupération des systèmes hydrauliques anciens, d'autre part une combinaison de « solutions basées sur la nature, comme la végétalisation urbaine, les parcs et les toits, ...

*الجلسة 5 - تغيير المناخ والآفاق الجديدة في إدارة المناظر الطبيعية والتراث
التدخلات البيئية الحكيمة التي تراعي الخصائص الفيزيائية للأماكن كانت تميز طبيعة المستوطنات الرومانية والأنظمة
الهديد وليكية العربية والنورماندية في صقلية واستخراج المياه الجوفية ونقلها إلى السطح في المغرب والجزائر. في
الماضي، أثبتت هذه الأنظمة قدرتها على التكيف مع تغيير المناخ. في بعض الأحيان تسببت التغييرات الاجتماعية
والاقتصادية في التخلي عنها وتسريع تدهورها. وتشهد الأبحاث في الوثائق على ذلك*

قد يكون إعادة تكييفها وإعادة استخدامها ممكنًا: تُظهر دراسات التنبؤ القائمة على نماذج التضاريس الرقمية مع نظم المعلومات الجغرافية والأحداث المناخية المتوقعة، كيف أن هذه الأنظمة القديمة قد لا تزال قائمة في بعض الحالات وقد يكون لها دور في المستقبل، حتى مع مراعاة تغير المناخ المستمر من المرغوب فيه الجمع بين عدة إجراءات: من ناحية استعادة الأنظمة الهيدروليكية القديمة، ومن ناحية أخرى الجمع بين... الحلول القائمة على الطبيعة، مثل التشجير الحضري والحدائق وأسطح المنازل

Hassi Labiad khattara, Morocco

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Abstract. This contribution to the conference is a short video on the restoration project of the khattara in Hassi Labiad, Morocco.

Hassi Labiad is a village at the base of Erg Chebbi, the largest dune complex in northeastern Morocco. The Berber population is approximately 1,500.

This ancient aqueduct got wrecked because of atmospheric events. A restoration project has been started to repair it, with Italian funds from Regione Emilia-Romagna and CADF “l’acquedotto del Delta”, for an initiative of the NGO named “bambinineldeserto.org” (Childrend in the desert).

This video describes some phases and details of this operation, the reparation of a 200 meters long section of the khattara, and a new extension of 150 more meters.

Keywords: Kkhattara, Cooperation, Hassi Labiad

Rivers, Lakes, and Seas: Reflections on the Significance of Water in Egyptian Children's Literature

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Abstract. As an essential element of nature, water in all its forms represents life. In Egypt, water, has important geographical, historical, cultural, and social significance. In fact, the River Nile has always been viewed as the cradle of Egypt's great civilization. In ancient Egypt, the Nile, was revered and, therefore, several myths and deities were associated with it. In these myths, the Nile emerged as an ambivalent and potent symbol of life, death, regeneration, purification, and resurrection. Influenced by such myths, Egyptian literature along the ages depicted water as a fascinating and intriguing symbol. In numerous literary works, water, especially the Nile, is used as a theme or motif to reflect social, cultural, and political themes. In children's literature, water is equally significant. It is a symbol that is employed by children's writers to send moral, educational, and ecological messages to children. This study offers a critical analysis of the symbolism of water in selected literary works for children. The study aims to highlight the literary and cultural significance and symbolism of water in these selected works and how it is utilized to reflect certain themes, messages, and lessons.

Keywords: Water, Nile, Children's literature, Symbolism, Cultural and literary significance of water

Blue Centuriation: The Hydraulic Heritage of Roman Centuriation of Padua for Climate Change Adaptation

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Abstract. Roman centuriations were not merely agrarian planning interventions intended for land allocation; they also represented advanced engineering adapted to the area's physical characteristics. This study evaluates the hydraulic network of Roman centuriation in the northeast of Padua (Italy), characterised by a regular network of ditches, as a potential and effective system for adapting to the impacts of climate change, particularly those prevalent in this area: prolonged droughts, intense precipitation, and consequential flooding. Rethinking their role in contemporary environmental management is important, especially considering their diminishing state.

The paper begins with a review of the initial design of Padua's centuriation, current territorial issues, and climate change challenges in the study area, as well as the evolution of the centuriation's hydraulic network in recent years. Based on available digital terrain models (LiDAR data) and orthophotographs from 2008 and 2022, and utilising geographic information systems (GIS), the sections of the water ditches were examined to determine their volumes, i.e., their water storage capacity. Geographical distribution and volumes were analysed by each centuria, as well as their evolution over 14 years.

Despite the reduction of the hydraulic grid of Padua's centuriation, the volumes obtained per centuria ditch network demonstrate its potential as an important water regulation system. With consideration of hydrogeological characteristics (soil permeability, underground water table, evapotranspiration coefficient, slope), enhancement of the hydraulic network is proposed as an alternative to the planned construction of water tanks. Interventions and measures are proposed and aim to integrate the preservation of historical heritage with efficient hydraulic management, thereby restoring the "blue" component of the centuriation.

Keywords: Roman centuriation, water regulation, climate change effects, GIS, Padua

Centuriazione Blu: Il patrimonio idraulico della centuriazione romana di Padova per l'adattamento al cambiamento climatico

Riassunto. Le centuriazioni romane non furono soltanto interventi di pianificazione agraria per l'assegnazione di terre; rappresentarono anche interventi ambientali sapienti, attenti alle caratteristiche fisiche del luogo. Questo studio intende valutare l'eredità idraulica della centuriazione romana a nord-est di Padova, caratterizzata da una rete regolare di fossi, come potenziale ed efficace sistema di adattamento agli impatti generati dai cambiamenti climatici, in particolare le siccità prolungate e le precipitazioni intense e conseguenti alluvioni. Rivalutare il loro ruolo nella gestione ambientale contemporanea è cruciale, soprattutto considerando il loro stato di degrado.

Il paper inizia con una revisione del progetto iniziale della centuriazione di Padova, delle problematiche territoriali attuali e degli estremi climatici previsti per questo territorio, nonché dell'evoluzione della rete idraulica della centuriazione negli ultimi anni. Basandosi su modelli digitali del terreno (dati LiDAR) e ortofoto dal 2008 e 2022, utilizzando sistemi informativi geografici (GIS), è stata esaminata la sezione dei fossati per determinarne i volumi, cioè la loro capacità di stoccaggio dell'acqua. La distribuzione e i volumi sono stati analizzati per ciascuna centuria, così come la loro evoluzione nel corso di 14 anni.

Nonostante la riduzione della rete idraulica della centuriazione di Padova, i volumi ottenuti per la rete dei fossati delle centurie dimostrano ancora il suo potenziale come importante sistema di regolazione delle acque. Si propone il miglioramento della rete idraulica come alternativa alla costruzione pianificata di microinvasi, che è stata messa in discussione a causa del loro impatto sugli habitat e sui flussi naturali dei fiumi. Con riferimento ai parametri idrogeologici (permeabilità del suolo, falda acquifera sotterranea, coefficiente di evapotraspirazione, pendenza), si suggeriscono alcune linee di intervento in grado di coniugare eredità storica ed efficiente gestione idraulica, ripristinando la dimensione "blu" della centuriazione.

Parole chiave: centuriazione romana, assetto idraulico, cambiamenti climatici, GIS, Padova

Water management and climate change adaptation: insights from traditional water systems in the Palermo countryside (Sicily, IT)

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Abstract. Water, an essential resource for every living organism, not surprisingly recurs in creation myths and in most initiation and purification rituals: the supply of water has been a constant concern since the dawn of humanity and it has conditioned the first human settlements and crops. Water management (at all stages of collection, transport, storage, supply, and use) has relied in Sicily on traditional ingenious systems that have evolved over time. In particular, western Sicily preserves precious evidence of multiple forms of widespread and consolidated water systems during the Arab and Norman periods, thanks to the favourable climatic conditions and hydrogeological characteristics of the land, which supported the development of a solid agricultural sector.

With regard to solutions related to the collection of groundwater, one can mention the qanāt, passive (gravity-fed) devices for capturing and transporting water, wells and underground fountains; with regard to the collection of surface water, one can include the khandaq, extensive channels that had the function of deriving water from watersheds, and the gammitti, a network of surface drainage trenches for draining marshy ground.

With regard to transport, the components of an articulated system should be mentioned: water towers (castidditti) to regulate the hydraulic energy in transporting it to the users; the saïe, canals, of various hierarchies, for irrigating the countryside; the penstocks made of catusi (truncated cone interlocked elements) of terracotta. With regard to storage, tradition counted underground cisterns (stagnuna) to store water and counteract evaporation, while for supply, senie (small wooden wheels driven by pack animals to extract water from wells) were used. The strong rootedness of traditional water systems to their natural and anthropic contexts did not cease until the 19th century, with the introduction of steam engines and the first drilled wells, which decreed their definitive decline and abandonment. These systems have gained renewed interest in the contemporary interest, in light of the water scarcity that constitutes an environmental challenge in increasingly large areas (including the Mediterranean) due to climate change.

The proposed contribution aims to offer a systematic reading of the traditional water systems of western Sicily in order to clarify a comprehensive view of them. Similar interpretation, aware of their potentialities and limitations, can critically explore the cues for climate change adaptation measures.

Keywords: Traditional Water System; qanāt; khandak; Environmental Design; Climate Change Adaptation

Gestione dell'acqua e adattamento al cambiamento climatico: spunti dai sistemi idrici tradizionali dell'agro palermitano (Sicilia, IT)

Riassunto. L'acqua, risorsa essenziale per ogni organismo vivente, non a caso ricorre nei miti legati alla creazione e in gran parte di riti iniziatici e di purificazione: l'approvvigionamento dell'acqua, è stata una costante preoccupazione sin dagli albori dell'umanità e ha condizionato i primi insediamenti umani e le coltivazioni. In Sicilia la gestione dell'acqua, in tutte le fasi di raccolta, trasporto, accumulo, erogazione e utilizzo, si è avvalsa di tradizionali sistemi ingegnosi, che si sono evoluti nel tempo. In particolare, la Sicilia occidentale custodisce preziose testimonianze di molteplici forme di sistemi idrici diffusi e consolidati durante il periodo arabo e normanno, grazie alle favorevoli condizioni climatiche e alle caratteristiche idrogeologiche dei terreni, che hanno sostenuto lo sviluppo di una solida agricoltura.

Per quanto riguarda le soluzioni collegate alla raccolta di acque sotterranee, si ricordano i qanāt, dispositivi passivi (funzionanti per gravità) di captazione e trasporto, i pozzi e le fontane sotterranee; per quanto riguarda la raccolta delle acque di superficie, vanno annoverati i khandaq, estese canalizzazioni che avevano la funzione di derivare l'acqua dagli impluvi e i gammitti, rete di trincee di drenaggio superficiali per il prosciugamento dei terreni acquitrinosi. Per quanto riguarda il trasporto, vanno ricordate le componenti di un articolato sistema: le torri d'acqua (castidditti) per regolare l'energia idraulica nel trasporto alle utenze; le saïe, canali di varie gerarchie per l'irrigazione delle campagne; le condotte forzate costituite da catusi (elementi troncoconici ad incastro) di terracotta. Per quanto riguarda l'accumulo, la tradizione annoverava le cisterne sotterranee (stagnuna) per immagazzinare l'acqua e contrastare l'evaporazione, mentre per l'erogazione venivano utilizzate le senie, piccole ruote di legno azionate da animali da soma per l'estrazione dell'acqua dai pozzi.

Il forte radicamento ai contesti naturali e antropici dei sistemi idrici tradizionali è venuto meno solamente nel corso del XIX secolo, con l'introduzione delle macchine a vapore e dei primi pozzi perforati, che hanno decretato il loro definitivo declino e abbandono. Nell'interesse contemporaneo tali sistemi hanno acquisito un rinnovato interesse, alla

luce della scarsità di acqua che costituisce una sfida ambientale in aree sempre più estese (inclusa quella mediterranea) a causa dei cambiamenti climatici.

Il contributo proposto ambisce ad offrire una lettura sistematica dei sistemi idrici tradizionali della Sicilia occidentale finalizzata a chiarire una loro visione complessiva. Una simile lettura, assieme alla consapevolezza di potenzialità e limiti, può esplorare criticamente gli spunti per misure di adattamento al cambiamento climatico.

Parole chiave: Sistemi idrici tradizionali; qanāt; khandak; Progettazione Ambientale; Adattamento al cambiamento climatico

Historic fresh-water sources in the coastal Mediterranean Town of Piran

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Abstract. The Mediterranean town of Piran in Slovenia faces several climate challenges through the intensification of weather events. Among them are sea level rise, coastal flooding and erosion, storm surges and torrential rains, as well as landslides, droughts, and heatwaves. The threats are seasonally spread throughout the year, but the duration and intensity of the events is compromising the out-dated drainage, predominantly giving rise to diminished fresh-water availability. Analysis of the historic town centre and its infrastructure suggests to implement the combination of nature-based solutions like urban greening, parks and rooftops with preservation of historic water cisterns, terraced slopes and water-permeable pavements using traditional stone-works. These measures are believed to restore the urban water-cycles, address water-scarcity induced by droughts and heatwaves as well as to assist in diminishing floods. The manuscript will illustrate how revalorization of historic water cisterns/sources can contribute cost-effectively to the re-use and re-purpose of fresh-water.

Assessment of Flood Mitigation Strategies: A Case Study of the Aït Athmane Center in the Errachidia Region

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Abstract. The development of impoverished and marginalized populations is becoming increasingly threatened by the risks associated with climate change. Severe weather events, like floods, can have an impact on infrastructure, ecosystems, agriculture, water, and other important sectors.

The flood risk in Aït Athmane, which is 28 kilometers north of Errachidia, Morocco, is the main subject of our study. This area is especially susceptible to flooding and overflows from the Ziz Wadi tributary, which passes through the territory of Aït Athmane. This study's specific objectives are to evaluate the effects of flooding in this area and suggest various adaptation strategies.

The methodology used involved processing GIS data for the basin's hydrological study, statistically analyzing the maximum daily rainfall at the "Foum Tillich" rainfall station using HyfranPlus software, and estimating peak flow using a variety of empirical formulas. The "HEC-RAS" hydraulic modeling program was then used to perform a hydraulic simulation, which was an essential step in understanding these values for Aït Athmane Wadi, a tributary of Ziz Wadi. GIS software was used to create the maps, which were then superimposed to identify locations that would be vulnerable to flooding.

The findings indicate that, for varying return periods, flows range from 60.13 m³/s to 92.69 m³/s, with a time of concentration of 125.55 min. An overflow risk is indicated by hydraulic study, endangering nearby residents and their crops. In certain areas, these floods can reach three meters. Numerous strategies have been recognized and put forth to lessen the effects of this important risk. These primarily entail straightforward mechanical adjustments like building gabion weirs, elevating retaining walls along the Wadi's banks, and creating crossing structures.

Keywords: Climate Change, Flooding, Aït Athmane, Hydraulic Modelling and GIS Software.

L'aqueduc d'Hippone : Témoin du temps passé

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Résumé. L'étude des vertiges de l'aqueduc d'Hippone (antique Annaba - Algérie), sera présentée dans une analyse démonstrative basée sur la relecture d'écrits antiques qui ont fixé leur accent sur les réseaux hydriques antiques. Par-delà nous nous posons la question suivante : à quoi cela tient le système hydrique d'Hippone par rapport aux recommandations établies par Vitruve dans le livre III De architectura datant du Ier siècle avant notre ère ? Ces recommandations stipulaient qu'avant d'utiliser une eau, il faut d'abord tester ses qualités en observant les habitants vivaient à proximité s'ils paraissent en bonne santé, cette eau peut être potable.

La détermination de la dimension de nécessité absolue de la construction de l'aqueduc d'Hippone réalisé grâce aux avancées des hydrauliciens romains qui ont pu construire des réseaux de captage et de cheminement de l'eau du mont de l'Edough distant de 12 kms et à 1000 mètres d'altitude. Des premières fouilles exécutées sur le site antique d'Hippone et sa région autorisées officiellement en 1838 après la publication de la première circulaire sur la législation des fouilles en Algérie, il a eu des preuves scientifiques que la construction de l'aqueduc d'Hippone atteste qu'il a été construit au IIème siècle après notre ère sous le règne de l'empereur Trajan.

D'ailleurs en 1902 Gsell attestait dans Enquête administrative sur les travaux hydrauliques anciens en Algérie, pour utiliser l'eau du mont de l'Edough, il a fallu intensifier le débit de la source et construire un réseau de canalisations colossal jusqu'à Hippone.

Nous pouvons dire que l'objectif général de cette analyse démonstrative vise de fournir des données analytiques d'une teneur informative fiable sur les techniques souterraines et aériennes des conduites d'eau de l'aqueduc d'Hippone, ouvrage ayant résisté aux aléas temporels et climatiques, aux destructions endogènes et exogènes des hommes. Dans cette optique sera analysé plusieurs aléas comme la vulnérabilité, la durabilité et la perception des populations romanisées par rapport à l'aqueduc d'Hippone.

Méthodologiquement cette démarche analytique consiste surtout à partir des réseaux hydriques romains fructifier notre discussion et évaluer les résultats informatifs obtenus.

Du point de vue de la discussion et du résultat nous nous concentrerons sur l'attachement de la valeur vitale de l'eau, principal élément indispensable à toute forme de vie. Car sans eau, aucun organisme ne peut vivre, croître, et se reproduire. Cette valeur est certes perçue dans l'imaginaire antique à travers deux idées essentielles celle du don de la vie et celle du don de purificateur.

Mots clés : Réseaux ; hydriques ; antiques ; aqueduc ; aléas temporels ; Hippone ; Algérie

Session 6 - Climate change and new perspectives for compatible water management

Chairman: Alessandro Leto

Founder and director of the international research and higher education center "Water Academy for a Sustainable and Responsible Development"

Water, climate change, the influence of changes on possible water pollution are some of the topics covered in this session. Sustainable green technologies will also be discussed.

Integrated visions between historical knowledge of water management, contemporary needs, the interactions that exist between water, agriculture, energy production and the ecological approach are considered in projects presented in this session. Water will also be examined in its different aspects: water with drinkable characteristics and water with different degrees of salinity. Studies will be presented for a more effective characterization and consequently a more correct use.

Among the different aspects that the "water" issue entails there is also that of the involvement of stakeholders and in any case of citizens: today as in the past. The session shows how water resource management models combine tradition, innovation and sustainability

Session 6 - Changement climatique et nouvelles perspectives pour une gestion compatible de l'eau

L'eau, le changement climatique, l'influence des changements sur une éventuelle pollution de l'eau sont quelques-uns des sujets abordés dans cette session. Les technologies vertes durables seront également abordées.

Des visions intégrées entre les connaissances historiques de la gestion de l'eau, les besoins contemporains, les interactions qui existent entre l'eau, l'agriculture, la production d'énergie et l'approche écologique sont envisagées dans les projets présentés dans cette session. L'eau sera également examinée sous ses différents aspects : eau aux caractéristiques potables et eau à différents degrés de salinité. Des études seront présentées pour une caractérisation plus efficace et par conséquent une utilisation plus correcte.

Parmi les différents aspects que comporte la question « eau », il y a aussi celui de l'implication des parties prenantes et dans tous les cas des citoyens : aujourd'hui comme par le passé. La session montre comment les modèles de gestion des ressources en eau combinent tradition, innovation et durabilité.

الجلسة 6 - تغيير المناخ وأفاق جديدة لإدارة متوافقة للمياه

المياه وتغير المناخ وتأثير التغيرات على تلوث المياه المحتمل هي بعض المواضيع التي يتم تناولها في هذه الجلسة. كما سيتم مناقشة التقنيات الخضراء المستدامة

تتناول المشاريع المقدمة في هذه الجلسة الرؤى المتكاملة بين المعرفة التاريخية بإدارة المياه والاحتياجات المعاصرة والتفاعلات القائمة بين المياه والزراعة وإنتاج الطاقة والنهج البيئي. كما سيتم فحص المياه في جوانبها المختلفة: المياه ذات الخصائص الصالحة للشرب والمياه بدرجات متفاوتة من الملوحة. سيتم تقديم دراسات من أجل توصيف أكثر فعالية وبالتالي استخدام أكثر صحة

ومن بين الجوانب المختلفة التي تنطوي عليها قضية "المياه" هناك أيضًا مشاركة أصحاب المصلحة وفي حال من الأحوال المواطنين: اليوم كما في الماضي. توضح الجلسة كيف تجمع نماذج إدارة موارد المياه بين التقاليد والابتكار والاستدامة

New Era in Solving Water Scarcity for Agriculture-Food Systems Using Green Technology: From Theory to Application in MENA Region

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Abstract. The lack of water, the climate/green technology and increasing anthropogenic activity have severe impacts on agriculture- food security as well as public health in the Mediterranean and MENA region, particularly in Jordan that suffers from severe water shrinkage. The emission of harmful substances as toxic heavy metals, organic compounds, solid waste and pharmaceutical residues are released to local municipal wastewater systems, where very low amount of this wastewater have special treatment to re-use again, which results in serious threats to water-agriculture-food sectors in Mediterranean and MENA region.

This presentation highlights the unsustainable current technique for saving the natural resources and the urgent need for immediate sustainable management technique based on Green Chemistry that should build bridges between water-agriculture-food recourses. The focus of this presentation is on three main points; 1) Sustainable Green Technologies. 2) Enhance awareness-behavior's program of local citizens toward water-agriculture-food security, and 3) strategies and policies for supporting Science.

This presentation highlights a new era of using new green technology for water-agriculture-food security and the appropriate strategies that overcome the challenges of moving forward from theory to implementation: 1) Institutional, regulatory, financial and technical facilities for Green/Climate technologies. 2) Transfer and joining forces to create synergies for appropriate green technology collaboration. 3) Encourage research and innovation in water scarcity vs. food security. 4) Upscaling of green technology deployment in the fields of environmental protection, natural resource efficiency and water-food security. 5) Private sector engagement.

Keywords: Mots clés : Wastewater treatment, Green Technology, Agro-food system, MENA region.

Hydrological modeling to support the co-design of water management strategies revitalizes traditional water uses

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Abstract. The introduction of participatory processes that directly and actively involve stakeholders has been gaining significant importance in the formulation of water management policies. This approach facilitates the sharing of knowledge among practitioners, scientists, and policymakers. For policies to be sustainable and enduring, the decision-making process must embrace an inclusive, multisectoral perspective. This vision integrates historical knowledge of water management with contemporary needs, considering the interconnections between water, agriculture, and energy production, while adhering to ecological limits. In this context, the use of hydrological models takes on a key role, not only to describe the current state of resources use, but also to evaluate the impact on resources of different management strategies. However, it is fundamental to properly structure the information pathway from the stakeholders to the model, as well as the return pathway of model results to the stakeholders. An instance of how models can be applied to this context is the use, within the PRIMA NEXUS-NESS and AG-WAMED projects, of the spatially distributed hydrological model WATNEEDS, developed at Politecnico di Milano. The projects aim at co-creating management strategies in 9 different case studies, defined as Nexus Ecosystem Labs (4 NELs) and LIVING LAB (4 LLs) respectively located in 5 different countries of the Mediterranean area: Spain, Italy, Tunisia, Algeria (only LL), and Egypt. The total of 9 case study are very different from each other in terms of characterizations and problématiques, but they all present major sustainability challenges that can be conceptualized in terms of WEF Nexus. In the context, WATNEEDS has been enhanced in terms of spatial ductility and range of possible model scenarios, with the aim to describe the current status of water resources in each case study and to evaluate the management alternatives proposed by the different stakeholders. Among the alternatives the model can analyze, we report changing the crop calendar, implementing new crops or redistributing the existing crops in the territory, changing or modernizing the irrigation systems, and moving towards indoor cultivation techniques. As an example, we present the results of the case study in Tunisia, where traditional 'jessour'—small dams built across gullies and wadi thalwegs to create a succession of terraces that partially retain surface water and sediments essential for crop growth—are currently abandoned. Local farmers, repeatedly and more harshly affected by droughts in the last years combined with deeper and more saline water available in groundwater storage, now see these structures as a potential solution to be revived. Using a hydrological model, we are examining the advantages and potential for reusing these traditional structures, along with adopting other technical solutions such as using brackish water and switching to more drought-tolerant crops. By providing tools and indicators to aid in the decision-making process, we demonstrate how hydrological models can evaluate co-created and participatory policy decisions, highlighting their crucial role in defining shared and sustainable management strategies.

Keywords: hydrological modeling, irrigation. Co-designed solutions

Offshore groundwater aquifers: a promising resource? Insights from the RESCUE project

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Abstract. Freshwater resources in worldwide coastal areas are suffering intense pressure from population growth, pollution, over-exploitation, and climate change. In the global freshwater supply, groundwater plays a crucial role, providing 49% of the water for domestic use and 25% for irrigation (Margat and Van der Gun, 2013). Concerns on future freshwater availability have risen after recent protracted water shortages in Europe and the circum-Mediterranean coastal areas (Toreti et al., 2023), as well as after the predicted increase in dry years due to global warming and climate change (WHO, 2022). In response, research has pointed to the untapped potential of deep-coastal and offshore aquifers, which hold fresh or low-salinity water. Recent studies suggest that the volume of water sequestered in continental shelf is vast: 300–500 *10³ km³ under water depths of less than 60 m within 110 km of the coastline (Mark A. Person & A. Micallef, 2022). This resource could secure a steady state supply of water for societal consumption, particularly in times of hydroclimatic extremes.

The goals of the RESCUE (RESources in Coastal groundwater Under hydroclimatic Extremes) project are to understand these freshwater aquifers volumes and accessibility, to assess their economic feasibility, to create guidelines for their sustainable use, and disseminate findings to policymakers. The research involves two scales of hydrogeological modeling—local and regional. The local-scale study area is located in Northern Italy, a region with significant water scarcity, and a regional-scale study in the UK, where data allows for near-continental-scale modeling. A preliminary regional scale model of the Northern Adriatic basin and Venetian Friulian Plain is currently being developed at University of Trieste and OGS. The project will foster collaboration between academia, industry, and policymakers to ensure that its findings are actionable and relevant to current water management challenges. The expected outcomes are 1) the development of modelling digital tools to evaluate freshwater volumes and quality; 2) the engagement of academic research with end users in industry; 3) Improvement of global water security in the long term; 4) Supporting decision making and ensure stakeholders involvement; 5) Increase citizens' awareness and engagement for an inclusive water governance.

The role of geophysics in identifying, characterising and protecting groundwater

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Abstract. The application of geophysical methods to hydrogeology is becoming more and more popular and a specific term to indicate it, hydrogeophysics, is now of common use. The increasing popularity is due to its ability to evaluate many features of the subsurface of hydrogeological interest, including non only the presence of water, but also water saturation, porosity, salinity, etc. along relatively large areas.

In this work, we focus on two methods: seismics and geoelectrics.

The former allows to create an image of the geological features of the subsurface and to evaluate the elastic properties of the ground. Based on this, hydrogeologically important parameters such as V_p , V_s and their ratio can be estimated, as well as the depth of the water table. Furthermore, in the case of data acquired at sea, the difference in acoustic impedance between salt and freshwater makes it possible to detect freshwater outputs at the seafloor.

The output of the geoelectrical survey is a map of the electrical resistivity of the ground. This allows to detect the different lithologies and their level of water-saturation, but also the salinity of the water saturating the rocks. In fact, the higher the salinity, the more ions can conduct the electricity and therefore the less resistive is the medium. Electrical resistivity surveys are therefore ideal for the detection of saltwater intrusions.

The combination of both seismic and geoelectrical surveys in a joint petrophysical inversion allows the computation of the main hydrogeological parameters (clay content, porosity, water saturation and conductivity) along the entire survey line. These parameters are generally computed in laboratory experiments on small samples, while geophysics allows to compute them along relatively large profiles.

LTA, history of an Italian aqueduct

Roberta PALETTA

Livenza Tagliamento Acque - Servizio Acquedotto

Abstract. The joint-stock company Livenza Tagliamento Acque (LTA), an Italian public company with a workforce of 197 employees, has been a benchmark in integrated water service management for decades, serving over 300,000 citizens in 42 municipalities across Friuli-Venezia Giulia and Veneto Regions.

LTA's historical roots date back to 1912 with the establishment of the "Consorzio Acquedotto Basso Livenza" (Basso Livenza Aqueduct Consortium), whose goal was to build a water infrastructure fundamental to the development of local communities. Despite interruptions due to world wars, the consortium evolved and expanded from the 1950s onwards, adapting to the growing needs of the population and the socio-economic changes of the territory.

From the 1970s onwards, due to significant urban development and changing consumption habits, a new general project was necessary to adapt the infrastructure. In the 1990s, with the entry into force of new laws on the management of public services, the Consortium was transformed into a special consortium company, assuming responsibility also for the management of sewerage and wastewater treatment. Finally, in 2003, the Consortium became a joint-stock company, "Acque del Basso Livenza S.p.A.", continuing its activity of providing quality water services to the Basso Livenza river area.

In 2014, LTA was born from the merger of two historical entities operating in the water sector: Acque del Basso Livenza and CAIBT (Consorzio Acque Irrigue Bonifiche e Trasformazioni del territorio). In 2017, with the merger of LTA and "Sistema Ambiente" (a company specializing in environmental services), LTA presence in the territory was increased. In this way, LTA represents a single point of reference for citizens for the management of services related to water and the environment.

In recent decades, LTA has consolidated its position as an efficient and responsible water resources manager, investing significantly in the modernization of infrastructure, the search for technologically advanced solutions, and the promotion of sustainable practices. The company has demonstrated a strong commitment to environmental protection, the valorization of water resources, and the improvement of the quality of life of citizens.

The 2022-2024 Industrial Plan, approved by the Shareholders' Meeting, outlines an ambitious strategy that places environmental, social, and economic sustainability at its core. Thanks to an investment plan of over 104.9 million euros, LTA intends to consolidate its role as a leader in the sector, addressing future challenges and guaranteeing an increasingly efficient and high-quality service.

LTA's commitment is realized in numerous projects, including the replacement of obsolete water networks, the upgrading of treatment and purification of water, and the promotion of environmental education initiatives. These interventions not only improve the quality of service offered to citizens but also contribute to the economic development of the territory, generating added value and creating new opportunities.

In conclusion, LTA represents a model of excellence in water resources management, combining tradition, innovation and sustainability.

Keywords: Mots clés : aqueduct, water management, sustainability, advanced solution, well

Authors index

ABDELMALEK; 63
 ABDERRAHIM MAHINDAD; 65
 ABELLAN SANTISTEBAN; 14
 ACCAINO; 82
 ADMOU; 29; 63
 AÏT LAHSSAINE; 40; 75
 AIT SAID; 75
 AL BAKAIN; 79
 ALAOUÏ; 37
 ALBERGEL; 40
 ANELLO; 33
 AZROUR; 62
 BABA; 36; 39
 BARONE; 57
 BARONTINI; 43
 BARTOLOMUCCI; 38
 BAYOUMY; 70
 BEKKOUCH; 34
 BENABBAS; 16
 BETTONI; 43
 BIGONGIARI; 59
 BIZZARRI; 14
 BOUDJELLA; 21
 BOULEMAREDJ; 76
 BOUSTIL; 16
 BRAHAMIA; 28
 BRANDUINI; 19
 BRARA; 60
 BULGARI; 43
 BURLANDO; 50
 CAMPISI; 51
 CAZZANI; 43
 CHEIKHI; 36
 CHIARELLI; 80
 CHIRI; 46
 CIRANNA; 38
 CONCOLLATO; 69
 CORRADIN; 81
 DA COL; 82
 DAHLI; 53
 DARWISH; 48
 EL ADNANI; 20
 EL HAFYANI; 40
 EL RHAFARI; 36; 37
 EL-ARABY; 22
 ESSAFRAOUI; 40; 75
 EZZAHRA; 20
 EZZEROUALI; 18
 FERRARESE; 71
 FIORINO; 46
 FORMATO; 26
 FRATINI; 26; 63
 FREDIANI; 54
 GALLI; 80
 GANAZZOLI; 64
 GARDELLA; 23
 GENOVESE; 52
 GERMANÀ; 72
 GHRAB; 49
 GIORGI; 82
 GOUMIH; 20
 HADDAD; 15
 HAMD AOUI; 18
 HARIDI; 76
 IBNOUSSINA; 20; 29; 62; 63
 IOTTI; 69
 KABIRI; 40; 75
 KADDOUR; 66
 KADIRI; 40; 75
 KADRI
 Assia; 32
 Salima; 32
 KAMECHE; 17
 KARKOURI; 18
 KASSOU; 75
 KRALJ; 74
 KREMENIĆ; 71
 LA PLACA; 61
 LAARO USSI; 36
 LAGHZIL; 62
 LAMIA; 63
 LAOUANE; 20

LAOUIER; 76
LASGAA; 34
LIMAM; 63
MARGAGLIOTTA; 33
MARTÍN CIVANTOS; 14
MATICH; 63
MATTEOLI; 59
MATSTONE; 26
MAZIRH; 63
MESSAOUDI; 40; 75
MEULENBERG; 74
MORO; 45
MOUKHENACHI; 28
MOUSSANNIF; 29
NOUNAH; 36; 37; 39
OBLAK; 62; 69
OUARET LADJOUZE; 60
OUDINA; 49
PACIOTTI; 14
PALETTA; 83
PALIAGA JANKOVIĆ; 74
PALMIERI DEL BEATO; 38
PANCANI; 59
PANETTA; 45
PANICCO; 27
PANTAROTTO; 31
PARRINELLO; 61
PELI; 43
PICOTTI; 82
PIRAS; 45
PITTALUGA; 31; 63
PIU; 45
POULOT; 16
RAFIQ; 18
REDANA; 30
RESCIC; 26; 63
RICHIUSA; 64
RULLI; 80
SAHLI; 18
SAÏFI; 76
SAIGHI; 48
SAOUCHI; 66
SEGHIRI; 53
SIMOU; 39
SLIGHOUA; 15
STAGNO; 14; 45
SULEIMAN; 15
TODARO; 72
TROVÒ; 30
VAROTTO; 71
VERNAZZA; 23
ZANATI; 34

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