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Ancient Wood and Climate Resilience: Prehistoric Pile Dwellings around the Alps

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Abstract
As climate change threatens heritage sites, modern settlements and landscapes around the world through flooding and rising sea levels, closer examination of prehistoric innovations may inspire solutions based on practices that have been tested for over 7000 years. Elevated architecture, natural ventilation systems and minimal hydrological impact provide actionable blueprints for sustainable building and planning today. By integrating these time-tested strategies with modern technology, the UNESCO World Heritage property of Prehistoric Pile Dwellings around the Alps can contribute to achieving the United Nations Sustainable Development Goals, transforming ancient techniques into modern climate adaptation tools.

Policy Recommendations

- Ratify and implement the 2001 UNESCO Convention in Austria and Germany to protect underwater cultural heritage from development and climate change threats.
- Create specialized archaeology programs by establishing permanent university and institutional programs focused on underwater and wetland archaeology to ensure expertise in conserving waterlogged artifacts.
- National and international agencies should provide funding to interdisciplinary research teams (archaeologists, architects, hydrologists, climate scientists) to develop integrated strategies for cultural preservation and climate resilience.

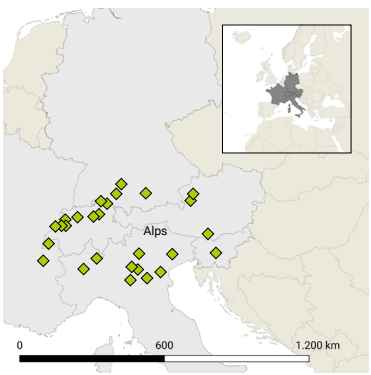
KEYWORDS

UNESCO World Heritage
prehistoric archaeology
water-adaptive architecture
climate resilience
cultural transmission networks

WATER ICONS

CLIMATE

Cfb + Dfb/Dwb/Dsb:
Temperate oceanic climate and humid continental climates (with dry winter or dry summer variants)



< Fig. 1 Remains of the wooden stilts of the pile dwelling site of Bevaix, Lake Neuchâtel, Switzerland (Source: Béat Arnold, with photographer's permission).

Introduction

A remarkable archaeological example of water management in the history of mankind has survived, thanks to the water itself. The remains of hundreds of prehistoric villages now submerged in lakes, bogs and rivers around the Alps serve as a testament to human ingenuity, technological progress and resilience, as well as adaptation to past environmental crises (fig. 1). Dating from 5000 to 500 BCE, these ruins provide unparalleled insights into the lives of prehistoric communities, because in comparison to mineral soil sites, the waterlogged conditions aid the preservation of organic material – especially the wooden construction piles. They are such outstanding archaeological treasures that a carefully selected collection of 111 sites across six countries (Switzerland, Austria, France, Germany, Italy and Slovenia) as of 2011 constitutes the transnational and serial World Heritage property "Prehistoric Pile Dwellings around the Alps" (UNESCO 2011). A common feature of these settlements is their deliberate location near or even within water bodies to benefit from a stable supply of freshwater and food (fish), and strategic defensive advantages while also remaining accessible to residents. This environmental context has played a crucial role in their preservation, architectural design and cultural development. This article explores the significance of water management in these prehistoric villages through three key themes: preservation, transmission and adaptation.

Preservation of Organic Material

Archaeologically, one of the most distinctive aspects of prehistoric pile dwellings is the ex-

^ Fig. 2 Model of an underwater pile dwelling excavation at the Musée archéologique du lac de Paladru, France (Source: Kuratorium Pfahlbauten/Cyril Dworsky, 2022).

ceptional preservation of organic materials, which is a direct result of the waterlogged conditions in which they were buried. The anaerobic environment created by these conditions inhibits the growth of microorganisms that normally decompose organic matter. This unique preservation condition has allowed for the survival of materials rarely found in terrestrial archaeological sites (Hafner et al. 2022; Hafner 2024; fig. 2). The range of preserved materials from these sites is vast and includes wooden piles, plant fibers, food remains, textiles and tools. For example, wooden piles used to support buildings – hence the term "pile dwellings" – have been found in remarkable condition, providing detailed information about the types of wood used, woodworking techniques employed and about the use of trees as a resource in general. Plant fibers, such as those used in basketry and cordage, have also been preserved, providing insight into the daily lives and technological capabilities of these communities.

Food remains, including seeds, nuts and animal bones, have been found in abundance, shedding light on the diet and subsistence strategies of the inhabitants (Antolín et al. 2022). Textiles, rarely conserved in other contexts, have been found at numerous sites, revealing information about clothing and textile production. Tools made of wood, bone and antler have also survived the millennia, providing evidence of the technological sophistication of these prehistoric communities. This exceptional preservation of organic materials at these sites contributes to their Outstanding Universal Value (OUV), as recognized by UNESCO. The detailed information gleaned from these materials allows archaeologists to reconstruct the daily lives, changes in social structure, and technological advances of prehistoric communities with a level of detail unparalleled in most other archaeological contexts. This preservation not only enhances our understanding of prehistoric life but also provides a unique window into the environmental conditions and changes that have occurred over millennia (Rey et al. 2025).

Transmission of Culture

Given the historical environmental challenges of non-regulated water bodies with regular changes of high water and low water and the mundane nuisance of mosquitos, the bold strategic decision to build pile dwellings in a wet environment close to the bank of waterbodies was not only a practical choice for construction but also a key factor in the economic and cultural development of the early settlers' circumalpine region. The lakes and rivers provided a reliable source of food and freshwater and aided the development of early trading routes, making them ideal locations for prehistoric settlements. The pile dwellers certainly participated in the extensive commerce networks that spanned the Alps and beyond during prehistory, starting in the fifth millennium BCE and ending in the first millennium BCE. Waterways allowed for highly efficient transportation of goods such as flint, amber and metal ores, which were traded over considerable distances (Rosenstock et al. 2016). For example, flint tools and ax-heads from the Alps have been found in prehistoric sites as far away as Northern Europe, for example in Scotland and Denmark, indicating the extensive reach of these trade networks (Pétrequin et al. 2008). Such connectivity played a crucial role in the exchange of skills, knowledge and cultural transmission between various communities, significantly contributing to the technological and cultural development of prehistoric pile-dwelling communities (Kowarik et al. 2020; Archäologisches Landesmuseum Baden-Württemberg 2016; fig. 3). The movement of people and goods along established routes enabled

^ Fig. 3 Reconstructed model of a Bronze Age dugout from Carinthia/bog of Sattnitz (Source: Kuratorium Pfahlbauten, Michael Tavernaro, 2014).

the sharing of technological innovations, such as new tool-making techniques, early metallurgy and agricultural practices. It also potentially allowed for the rapid spread of burial customs, artistic styles and religious beliefs. While there is no uniform "pile dwelling culture," this transmission certainly contributed to similar elements of cultural expression among prehistoric pile-dwelling communities across the Alpine region, reflected in similarities in material culture and technologies found at different sites (Affolter et al. 2023; Bahss and Bleicher 2023).

Adaptation to the Environment

The use of stilts in construction is a major defining characteristic of prehistoric pile dwellings, although this technique is also quite common in other archaeological contexts and is not the decisive argument for its OUV. Nonetheless, this architectural approach allowed the inhabitants to build their homes at levels high enough to stay dry, providing protection from floods and pests (Swierczynski 2017). In addition, building on the sparsely vegetated shores of the lakes meant that laboriously cleared areas inland could be used as potential farmland.

Wood as a building material is not only easy to work with, but was then, and is now, a renewable and easily accessible raw material. The use of wooden piles driven into the lake or riverbed provided a stable foundation for the structures, which were typically made of additional wood and other organic materials (fig. 4).

^ Fig. 4 Construction details of a reconstructed pile dwelling grid foundation at the Parco Archeo Natura a Fiavé, Italy (Source: Kuratorium Pfahlbauten, Cyril Dworsky, 2025).

Among the many pile dwelling structures that existed from the Neolithic to the early Iron Age, there were a variety of construction types. Houses were built with flat floors near shorelines, and even log constructions have been found. The landscape as well as regional building traditions influenced the architecture of these buildings (Bleicher 2018, fig. 5). Nevertheless, the architectural adaptation of elevated houses allowed both prehistoric and modern communities to thrive in challenging environments with changing water bodies, demonstrating the enduring relevance of this building technique.

The architectural features of wooden stilts as foundations certainly invite comparisons to modern settlements built in similar environments. One of the most well-known examples may be the city of Venice in Italy. Although the use of piles in Venice is more connected to the stabilization of the building ground by compression of the subsoil and reaching more stable and sound strata, the technique made it possible to build in unfavorable wet conditions, which are geographically important. As a result of millions of wooden piles driven into the soft, waterlogged soil of the lagoon, Venice was able to become a conveniently located and important center of commerce.

The comparison highlights the contemporary relevance of the architectural strategies employed by prehistoric pile dwellers in terms of dealing with difficult settlement areas. This is particularly becoming important in the context

^ Fig. 5 Interpretative life-size models of Neolithic houses in the Pfahlbaumuseum Unteruhldingen at Lake Constance in Germany (Source: Kuratorium Pfahlbauten, Cyril Dworsky, 2015).

of climate change, when rising sea levels and increased weather extremes pose significant challenges to modern communities and a decline in settlement space. Along with storms, floods are the most common and devastating natural disasters worldwide. The resilience of the prehistoric settlers and how they survived the periodic flooding of their villages is documented in layers of lake sediment (Swierczynski et al. 2017). This can inform and stimulate contemporary architectural responses. Although common practice in many regions and in history, modern housing development quite often ignores the danger of climate change. One of the key lessons from prehistoric pile dwellings is in fact the effectiveness of elevated building designs in mitigating the impact of flooding. While diverse modern examples of stilt constructions exist, architects today are increasingly exploring the use of elevated structures in flood-prone areas and may draw inspiration from the pile-dwelling strategy (Eck 2020).

In addition to flood protection, the pile-dwelling strategy offers benefits in terms of heat management in times of global warming. The elevated structures allowed air to circulate better than structures built directly on soil, helping

to regulate indoor temperatures. This principle is being applied in contemporary architecture using raised foundations and open floor plans, which enhance natural ventilation and reduce the need for artificial cooling (Bartolini 2021). The building strategy for waterlogged or unstable soils also offers inspiration for addressing other modern challenges of water management. Modern settlement areas frequently face issues related to soil surface sealing, where impermeable surfaces prevent water infiltration, leading to increased runoff and flooding. Building on stilts is a potential solution that can make it possible to develop contaminated sites and expands the amount of land available in growing societies. More and more land is being covered with impermeable materials, like asphalt and concrete, as well as buildings. This prevents rainwater from infiltrating the soil, leading to higher flood risks, reduced groundwater recharge, and impaired soil function. Sealed surfaces also intensify the urban heat effect, reducing biodiversity and fragmenting natural habitats. Creating minimally invasive foundations with piles reduces the impact on natural hydrology.

Conclusion

The UNESCO World Heritage property Prehistoric Pile Dwellings around the Alps offers a unique window into the lives of prehistoric communities and their ability to adapt to and manage natural resources. The exceptional preservation of organic materials at these sites provides unparalleled insights into the daily lives, social structures and technological advancements of these communities. The lessons learned from these ancient settlements continue to inform and inspire modern approaches to water management, architecture and cultural exchange. The architectural strategy of building on stilts, which has historically enabled inhabitants to thrive in challenging environments, remains highly relevant today, especially in the context of climate change.

The lessons learned from these ancient settlements must inform modern policy. Of primary importance is the implementation of the 2001 UNESCO Convention on the Protection of Underwater Cultural Heritage: The exceptional preservation of organic materials in waterlogged conditions in the prehistoric pile dwellings proves that underwater archaeological heritage contains irreplaceable evidence of human environmental adaptation. To protect this submerged cultural heritage from development and climate threats, countries should ratify and implement the 2001 convention. Austria and Germany must prioritize ratifying the convention in the coming years, as the other four the four other countries that are home to the Prehistoric Pile Dwellings have already done.

It is also crucial to establish underwater and wetland archaeology programs: The OUV of pile dwelling sites requires highly specialized conservation techniques for waterlogged materials and underwater excavation. Research institutions, universities and heritage agencies should create permanent positions for archaeologists and conservators trained in underwater archaeological methods to ensure continuous knowledge transfer.

Finally, we need transsectoral collaboration frameworks: The 7,000-year success of the pile dwellings in flood management, waterway networks and environmental adaptation underlines that such archaeological sites offer multi-sectoral perspectives and can provide valuable lessons. National and international funding agencies must support interdisciplinary teams – including archaeologists, architects, hydrol-

ogists and climate scientists – to develop integrated approaches that address both cultural preservation and climate resilience challenges within the SDGs.

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References

Affolter, Jehanne, Helena Wehren, Caroline Heitz, Regine Stapfer, Lea Emmenegger, Martin Hinz, Gisela Thierrin-Michael and Albert Hafner. 2023. "Linking Neolithic Lakeshore Settlements through Raw Material of Siliceous Artefacts." 2023. *Journal of Lithic Studies* 10 (1): 33. https://doi.org/10.2218/jls.4446.

Antolin, Ferran, Christoph Brombacher, Marlu Kühn, Bigna L. Steiner, Niels Bleicher and Stefanie Jacomet. 2022. "A New Look at the Late Neolithic Plant Economy from the Site of Zürich-Parkhaus Opéra (Switzerland): Methods, Activity Areas and Diet." In Hafner et al., *Settling Waterscapes*.

Archäologisches Landesmuseum Baden-Württemberg and Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart, eds. 2016. *4.000 Jahre Pfahlbauten* [4,000 years of pile dwellings]. Ostfildern: Jan Thorbecke Verlag.

4.000 *Jahre Pfahlbauten: [Begleitband Zur Großen Landesausstellung Baden-Württemberg 2016*. Jan Thorbecke Verlag.

Bahss, Anna, and Niels Bleicher. 2023. "Stability Through Movement: Theoretical and Practical Considerations of Social Space in Central European Neolithic Lakeside Settlements." *Journal of Archaeological Method and Theory* 30: 1378–1403. https://doi.org/10.1007/s10816-022-09582-6.

Bartolin, Olivia. 2021. "10 Wooden Stilt Houses that are Lifting Architecture off the Ground." 22 *ArchDaily*, June 22. https://www.archdaily.com/963300/10-

wooden-stilt-houses-that-are-lifting-architecture-off-the-ground.

Bleicher, Niels. 2018. *Steinzeit im Parkhaus*. NZZ Libro.

Eck, Jeremiah. 2020. "Climate Change and the Arrival of the Baseless House." *ArchDaily*, May 31. https://www.archdaily.com/940512/climate-change-and-the-arrival-of-the-baseless-house.

Hafner, Albert, Ekaterina Dolbunova, Andrey Mazurkevich, Elena Pranckenaite and Martin Hinz, eds. 2022. *Settling Waterscapes in Europe: The Archaeology of Neolithic and Bronze Age Pile-Dwellings*. Sidestone Press.

Hafner, Albert. 2024. "Waterlogged Sites." In *Encyclopedia of Archaeology*, edited by Efthymia Nikita and Thilo Rehren. Academic Press.

Kowarik, Kerstin, Julia Klammer, Helena Seidl da Fonseca, Jakob Maurer and Timothy Taylor. 2020. "From Lakeshore to Hilltop. Investigating Copper Age Landuse in the Attersee-Mondsee Region." In *Settling Waterscapes in Europe: The Archaeology of Neolithic and Bronze Age Pile-Dwellings*, edited by Albert Hafner, Ekaterina V. Dolbunova, Andrey N. Mazurkevich, Elena Pranckenaite and Martin Hinz, 233–50. Heidelberg: Propylaeum. https://doi.org/10.11588/propylaeum.714.

Pétrequin, Pierre, Alison Sheridan, Serge Cassen, Michel Errera, Estelle Gauthier, Lutz Klassen, Nicolas Le Maux and Yvan Pailler. 2008. "Neolithic Alpine Axe-heads, from the Continent to Great Britain, the Isle of Man and Ireland." *In Between Foraging and Farming*, edited by Harry Fokkens et al. Sidestone Press.

Rey, Fabian, Oliver Heiri, Lucia Wick, Erika Gobet, Sönke Szidat, Urs Leuzinger, Renate Ebersbach, Albert Hafner and Willy Tinner. 2025. "Neolithic Land Use and Forest Dynamics on the Swiss Plateau (Southwestern Central Europe)." *Quaternary Science Reviews*. Volume 360. https://doi.org/10.1016/j.quascirev.2025.109372.

Rosenstock, Eva, Silviane Scharl and Wolfram Silviane. 2016. "Ex oriente lux? – Ein Diskussionsbeitrag zur Stellung der frühen Kupfermetallurgie Südosteuropas." In *Von Baden bis Troia – Ressourcennutzung, Metallurgie und Wissenstransfer*, edited by Martin Bartelheim, Barbara Horejs and Raiko Krauß. Oriental and European Archaeology 3.

Swierczynski, Tina, Monica Ionita and David Pino. 2017. "Using Archives of Past Floods to Estimate Future Flood Hazards. *Eos* 98. https://doi.org/10.1029/2017EO066221.

UNESCO. 2011. Decision 35 COM 8B.35. https://whc.unesco.org/en/decisions/4306.

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