

Steeply sloping vineyards facing tomorrow's challenges: territorial externalities, wine tourism, climate change, biodiversity, robotization, global food challenge.

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Summary

Vineyards on steep slopes are most often the result of ancestral know-how, recognised as a UNESCO World Heritage Site for their dry stone construction know-how, and are sometimes threatened by the additional costs of producing grapes, the lack of manpower and the tightening of regulations. This type of viticulture has a high qualitative value, and many externalities, notably heritage and ecological. The abandonment of these vineyards contributes to a loss of local biodiversity, an abandonment of these rural areas, an increase in the risk of fire and sometimes of run-off and erosion, in addition to the loss of heritage value, which supports wine tourism. With regard to climate change, it is important to stress that these areas contribute to a generally higher carbon storage than natural areas. Finally, the increase in the world's population and the decrease in agricultural yields will probably result in the next few decades in a challenge to ensure food security at the global level, hence the importance for the wine sector of conserving these production areas that are not very valuable for food production.

Introduction

The feminine name "terrace" comes from the old Provençal *terrassa*, from *terra*, in the 12th century of the Christian era. According to the Robert dictionary, it corresponds to "a rise in the ground forming a platform", while terraced cultivation is "in sloping terrain, cultivation in tiers, supported by small walls". Terraced vineyards and, more generally, those on steep slopes, demonstrate the ability of winegrowers to adapt to extreme conditions. Jeronimo Garcia defines terraces as *"man's modification of the topography of sloping land in order to improve the use of resources: soil, water, climate"*. Very often the plain areas favoured agricultural and food production and the sloping areas allowed the winegrower to develop vineyards with more accessible land, which more often than not benefited from favourable sunshine conditions. This microclimatic particularity, as well as the access to less expensive land than that of the plains, has historically oriented the winegrower towards the hillside areas to produce quality wines.

History

Natural stone, a durable and solid material, a link between the earth and the sky, has passed on the way of life, beliefs, knowledge and know-how of successive civilisations over time. As André Beuret points out, *"Since man first appeared on earth and up to the present day, stone has been part of his immediate environment. It was first used as is for thousands of years and then transformed to give it particular and sought-after forms. They are works intended to perpetuate the memory of someone, a belief, an event. These megaliths can be found in all parts of the world. In our regions, the oldest are the menhirs and the dolmens, the latter being classified as funerary monuments. (...) Stone also shapes our landscapes through its colours, grain and forms and contributes to the identity of a region and its architecture"*. (Beuret A 2022.)



Figure 1: Vineyard terrace in the Lunahuana Valley, Peru.

We can imagine that man, who has mastered the use of stone, has been able to use it since the emergence of agriculture, around 10,000 years ago, to delimit agricultural plots and progressively create and stabilise slope areas, when local conditions allowed a simple superposition of blocks from rivers or mountains, sometimes cut, before developing the know-how of dry stone walls. As Maxence ANTONINI explains: *"The evolution of dry stone masonry has gone hand in hand with the evolution of human beings, since they decided to live in a solid building. This technique has not ceased to evolve over nearly 5,800 years, improving, regressing, stagnating, disappearing in favour of new techniques or being rediscovered according to the different regions where it has existed. The first traces of dry stone masonry in France are found in the eastern Languedoc region around 3,800 BC. (...) Nowadays, restanques (dry stone retaining walls) are appearing everywhere on the hillsides, allowing the cultivation of previously unexploited slopes and improving living conditions."*

Terraced farming has been used for hundreds of years in mountainous areas around the world. In South America, they are known by the Spanish term:

andenes. (Gleyze T. 2021) Of all the terraces in the world, those in the Peruvian Andes are the most extensive and were built on the steepest slopes. Moseley states that "the *andenes* are the greatest archaeological phenomenon in the Western Hemisphere (of the American continent)". The Caral civilisation, the oldest known civilisation in the Americas, from 3000 BC to 1600 BC, built temples in the form of truncated pyramids or superimposed terraces. Archaeologist R. Shady believes that the first cultivation terraces may date back to 2000 BC. In China, the construction of rice terraces dates back to ancient times, and this method of cultivating rice enabled Chinese farmers to cultivate sloping, hilly and mountainous land. The Honghe Hani Rice Terraces in the south-eastern part of Yunnan Province, a UNESCO World Heritage Site, are a masterpiece of the Hani minorities, who have lived in these remarkable landscapes for over 1300 years. In Europe it seems that it was the Chasserans (3800 BC to 2500 BC) who began to use an archaic form of dry-stone construction for a permanent habitat, laying large stones to create the bases (or underpinnings) and laying large slabs on the ground for their huts. The Ferrarians (-2,750 to -2,200 BC) and the Fonbuxians (-2,200 to -1,800 BC) perfected this process by erecting the walls of their dwellings in dry stone, without any binding material, on which a roof made of branches or thatch was placed and covered with a dry stone ridge. (Provansal M.1990)

Various writings highlight the creation of terrace walls in the ancient period.

+ In Palestine, authors mention agricultural terraces dating from the time of the "First Temple", i.e. 700-800 BC. (4).

+ In Greece, certain texts, by Herodotus in particular, suggest that terraces were known in the 4th century BC.

Observing the similarity of the irrigated terrace systems in Mallorca with those found in South Arabia, particularly in Yemen, medieval archaeologists have put forward the hypothesis of technical knowledge imported into the island during the Muslim period, due to the insertion of the Balearic archipelago into the area of Islamic civilisation in the Middle Ages. The medieval Muslim world carried out a real "agricultural revolution", the principles of which have been found in Andalusian agronomy treatises from the 11th and 12th centuries. M. Antonini 2010)

In addition to the low walls, many small buildings have been constructed using this technique, in particular the vineyard huts which are part of the small heritage of many vineyards.

At the end of the 19th century, the phylloxera crisis, in parallel with the development of animal traction, profoundly modified the management of wine-growing land, with the abandonment of crowded vineyards. In the middle of the 20th century, viticulture, like agriculture, integrated the contributions of modernity in the conduct of its technical itineraries.



Figure 2: Terraces made of stone blocks, most often recovered locally (top Laroque des Albères in Roussillon, Photo J. Rochard) and possibly cut (bottom archaeological site of Sacsayhuaman in Cusco, Peru. Photo Thomas Gleyze)

Then, gradually, the introduction of tractors and straddle carriers, imposed by the imperatives of productivity, sometimes led to a trivialisation or even a degradation of the landscape.

Several phenomena have occurred:

- Simplification of the landscape by enlarging the plots (reparcelling),
- Restructuring of the hillsides,
- Elimination of unitary landscape components (isolated or aligned trees, hedges, embankments, copses) or architectural components (crosses, vineyard huts etc.).



Figure 3: Monorail system in the Swiss vineyard of Lavaux in Switzerland. The terraces with steep slopes often require manual and arduous management of the plots.



Figure 4: Transporting the harvest by cable on a steep terrace in Ampuis in the northern Côtes-du-Rhône, www.domaine-burgaud.com, photo www.groupe6.fr

An ancestral know-how listed as a Unesco World Heritage Site



Figure 5. Intangible cultural heritage logo



Figure 6. Work and tools for the construction of dry stone walls in the 19th century. Illustration Museum of Ethnology of Valencia, wikipedia diagram.

The art of dry stone construction inscribed as a Unesco intangible cultural heritage since 28 November 2018. (Cornu 2018) This transnational nomination, led by Cyprus, is the result of joint work with seven other countries: Croatia, Cyprus, Greece, Italy, Slovenia, Spain and Switzerland. It corresponds to the know-how associated with the construction of stone structures, which consists of piling stones on top of each other without using any other material, except sometimes dry earth. Dry stone structures have shaped many different landscapes, allowing the development of different types of habitat, agriculture and livestock. These structures bear witness to the methods and practices used by populations from prehistoric times to modern times to organise their living and working spaces by optimising local natural and human resources. The construction of the dry stone wall anchored to the rock obeyed a few

intangible principles intended to offer the best resistance to the thrust of the earth: construction in headers (the long face of the block is placed in the thickness of the wall, its end in the facing), careful wedging so that the forces of friction fight against the thrust, inclination of the wall towards the upstream (fruit). (Lassure C. 2008) The holders and practitioners are the rural communities in which the element is deeply rooted, as well as professionals in the construction sector.

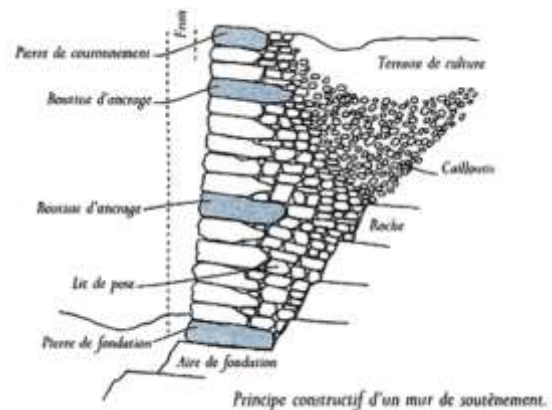


Figure 7 Schematic section of a retaining wall, construction elements. Diagram "La pierre sèche, mode d'emploi" by Christian Lassure, ed. Eyrolles, 2014

Roles of terraces

Terraced farming, especially on steep slopes, has many advantages:

+ Morphological

The installation of the terrace results first of all in a reduction of the slope, which changes the water regime and can also facilitate agricultural work.

+ Thermal

The thermal role of the terrace is related to the modification of the sun exposure, the modification of the wind exposure and above all to the accumulation of heat in the walls that is retransmitted by radiation, especially during the night.

+ Hydraulics

The terraces provide hydraulic control, which is particularly useful in regions with distinct climates, with dry summers and heavy rainfall.



Figure 8. Collection systems for intense rainfall in Banyuls. This vineyard is located on very steep slopes. The vines are terraced and interspersed with a network of canals designed to efficiently evacuate water during heavy rainfall. (Pitte J. R. 2002)

+ Pedological

One of the benefits of reworking the soil is that it increases the useful reserve, i.e. the volume from which the roots draw their water and minerals. Although limited, this water storage reduces the effects of a temporary drought, while it makes tilling the soil with traditional tools much easier.

+ Anti-erosion

By reducing the slope of the ground and by creating a multitude of obstacles that break the energy of the water that runs off, the terrace can have an anti-erosion role.

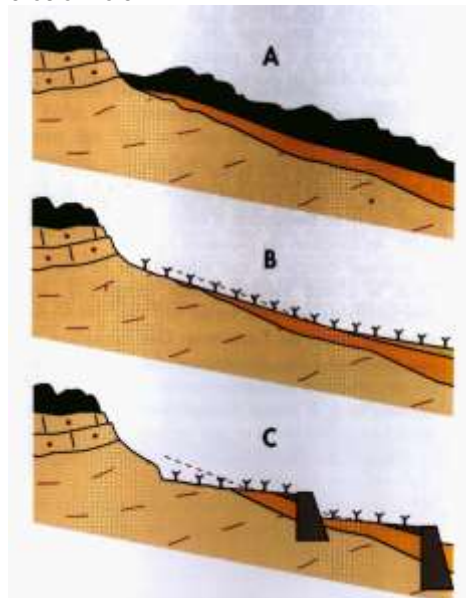


Figure 9. Anti-erosion role of terraces. A wooded slope, B vineyard plantation without terraces, followed by erosion and disappearance of the soil at the top of the slope and deposition at the bottom of the slope (= anthropogenic soil), C development with terraces, with disbursement of the soil and rock at the top of the slope, reversed as soil at the level of the low walls Diagram: Terroirs viticoles, Paysages et géologie en Languedoc, Jean-Claude Bousquet, Editions Ecologistes de l'Euzière, 2011.

+ Patrimonial

More than any other agricultural landscape, the terraced areas are living witnesses of local history. They illustrate the practices, uses, know-how and social relations of the societies and people who have successively built and used these areas. (Rochard J. 2015)

+ Landscape and ecological

Steeply sloping and terraced vineyards not only have a high landscape value, which contributes to the most

beautiful wine-growing landscapes in the world, some of which are recognised as world heritage by UNESCO. In these rugged reliefs there are often interesting biotopes, copses, bushes, shrubs, streams, slopes and walls, which support biodiversity. (Rochard et al., 2001)

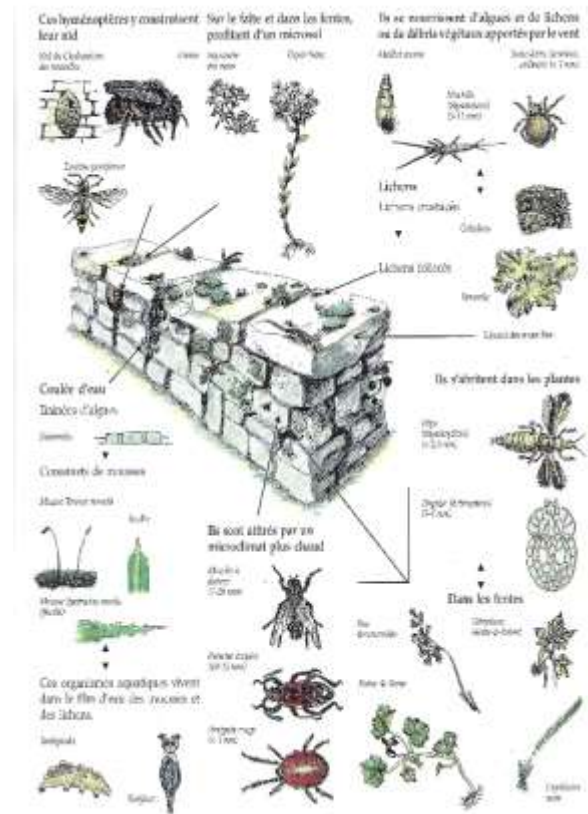


Figure 10. Ecological role of a low wall based on the Guide Illustré de l'Écologie, B. Fischesser, M.F. Dupuis-Tate, Editions de la Martinière, 2007.

+ Fire protection

Maintaining terraced vineyards limits the spread of fires, particularly around houses, and facilitates access for firefighters. Once the vines are abandoned, natural vegetation is created that is conducive to fires. Some regions, such as Banyuls in Roussillon, have developed aids to create fire belts close to urbanised areas. This aspect is all the more important as climate change is expected to increase the risk of fire in the coming decades.



Figure 11. Abandoned burnt terraces (in the Catalan region of Port Bou, Spain)



Figure 12. Preservation of the terraces facilitates access for the fire brigade to limit the spread of fires in Banyuls-sur-Mer, photo www.sdis66.fr

+ Eco-environmental attractiveness

The terraced landscapes, often of great beauty, as well as the ecological aspects contribute to an eco-winetouristic activity that benefits the image and the frequentation of the winegrowers, but also the whole territory.

Terraces face the food challenge

Historically, in Mediterranean regions, terraces were often an agronomic response to overpopulation in hilly areas, far from the trading areas. Jean François Blanc rightly points out that "the development of terraced slopes seems to us to be an interesting example of the millennial and universal effort of farmers to increase their production areas and thereby increase their food resources, at the cost of terrible physical efforts and constantly renewed emulation, using original construction techniques". Over the next few decades, the increase in the world's population, as well as the limitation of agricultural productivity, in particular in relation to climate change and possible international conflicts, could accentuate the global food challenge.

According to the Food and Agriculture Organisation of the United Nations (FAO), hunger continues to grow in the world. According to UN projections, the world will have 9.1 billion inhabitants in 2050, compared to 6.8 billion today. That is 34% more mouths to feed. Obviously, changes in eating habits will have an impact on future needs for agricultural raw materials. It is also important to consider the decrease in agricultural land used for food, linked in particular to the development of energy production (agrofuels, biogas, etc.) and the loss of productive areas, which are being used for housing, commercial, industrial and other uses. For example, a study by the

Ministry of Agriculture underlines that agricultural land has been losing 65,900 ha per year since 1982, i.e. approximately 7.7% less agricultural land.



Figure 13. Abandoned terraces in Sicily. Production costs, the technical constraints of soil management and the difficulty of finding personnel sometimes lead to the abandonment of terraced vineyards. Only a dynamic of wine tourism associated with a proactive policy of local and national authorities can maintain this endangered heritage value.

The FAO estimates that the planet's agricultural production will have to increase by 70% to meet the food needs of all its inhabitants by 2050. Although agricultural production yields have increased significantly since the middle of the 20th century, they are tending to stabilise or even decrease due to environmental constraints, the progressive limits of plant breeding and probably climate change, which could, depending on the region, increase the risk of water stress.

The vine, apart from the production of table grapes, is the source of a cultural product, wine, which is not directly involved in the challenge of food self-sufficiency. It is conceivable that, as has already been the case historically at the local level, the priority of potentially agricultural surfaces could be directed towards food crops, by integrating in addition, in public strategies, the consumption of water and inputs and the sustainable impacts of the wine industry. In this way, the historical logic of establishing vineyards on hillsides and terraces, which prevailed until the end of the 19th century, could well reappear in the 21st century.



Figure 13. Evolution of soft wheat yield in the French region of Centre Val de Loire Source ORACLE DRAAF scheme www.centre-val-de-loire.developpement-durable.gouv.fr

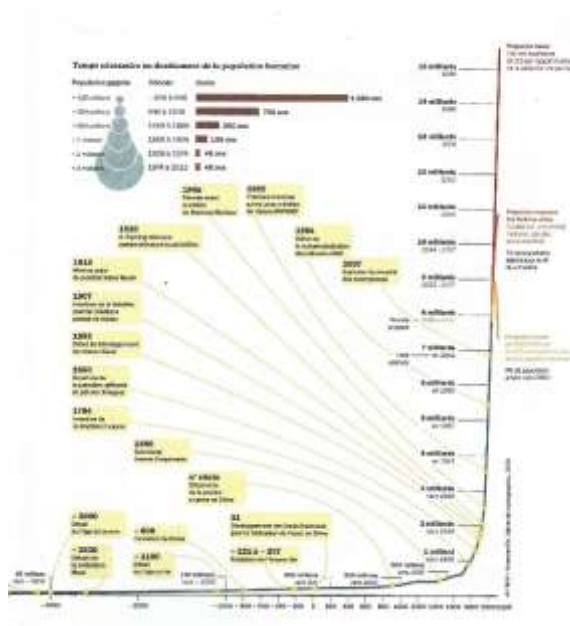


Figure 14. Evolution of the world population since 3000 BC and projection into the 21st century 2. Source: Atlas de l'anthropocène , F Gemenne and A Rankovic, Ed Sciences-Po 2019

Conclusion

Steep slope vineyards, most often the result of ancestral know-how, are sometimes under threat due to the additional costs of producing grapes, the lack of manpower and the tightening of regulatory aspects. Nevertheless, this type of viticulture has a high qualitative value and numerous externalities, particularly in terms of heritage and ecology. (Blanc J. F. 1984) The abandonment of these vineyards contributes to a loss of local biodiversity, to the desertification of these rural areas, to an increase in the risks of fire, runoff and erosion, as well as to a loss of heritage value, which supports wine tourism. It is important that these heroic, fragile vineyards can integrate the challenges of tomorrow within the professional world, but also at the level of regional, state and European community decision-makers, who intervene in the regulations and financial tools. With regard to climate change, if the system of terraces makes it possible to optimise sunlight, traditional agro-forestry approaches as well as the adaptation of grape varieties and management methods could be envisaged. With regard to mitigation, it is important to emphasise that these territories contribute to a carbon storage generally superior to that observed in natural areas, an aspect that should be quantified and defended in a perspective of strengthening this issue.

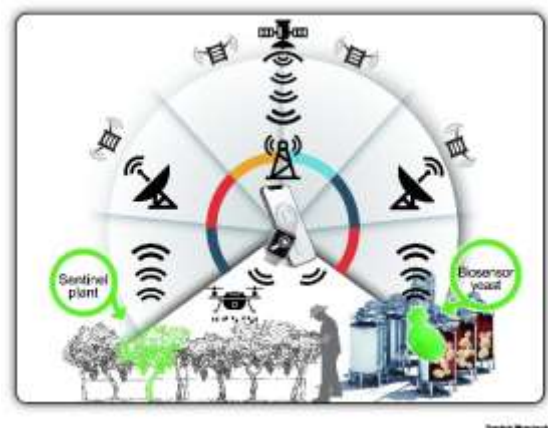


Figure 15. introduction of digital and robotic technology in vineyards and wineries. Diagram A. Dixon et al.

The gradual introduction of digital technology and robotisation, given the difficulty of finding a workforce in these areas with a certain amount of hard work, will probably make it possible to respond to the particularities of technical itineraries, provided that technological advances take into account the specificities of steep slopes. Finally, the increase in the world's population and the decrease in agricultural yields will probably result in the next few decades in a challenge to ensure global food security, hence the importance for the wine sector of preserving wine production areas on slopes, without prejudicing the areas intended for food production.

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