Ancient water catchment techniques for proper management of Mediterranean ecosystems

P. Laureano

IPOGEA,Vico Conservatorio s.n.,75100 Matera, Italy (E-mail: *ipogea@ipogea.org*)

Abstract Traditional knowledge from the ancient techniques and practices of a territory passed on through the generations and used for water harvesting, soil management, use and protection of natural areas, rural architecture, and for organising urban centres. Today, traditional knowledge is in danger and its disappearance would not only cause the loss of people's capability to keep and pass on the artistic and natural heritage, but also the loss of an extraordinary source of knowledge and cultural diversity from which appropriate innovative solutions could be derived today and in the future. UNESCO launched a global programme for an inventory assigned to IPOGEA -Research Centre on Traditional and Local Knowledge. The project gathers and protects historical knowledge and promotes and certifies innovative practices based on the modern re-proposal of tradition as well. The main targets are the firms, the natural areas, and the historical centres which will be assigned quality trademarks and acknowledgements of international excellence in production or use of good practices and innovative solutions. Each technology, proposition and experience achieved will provide a spin-off on an international scale and each good practice will contribute to safeguarding the whole planet.

Keywords Cultural landscape; ecosystems management; traditional knowledge; water harvesting

Water Science & Technology: Water Supply **Vol 7 No 1 pp 237–244** © IWA Publishing 2007

Water harvesting techniques in the Mediterranean area

Three sides of the Mediterranean Basin are connected with areas where humankind had to cope with dry land areas; its isles are completely lacking in underground or ground water sources, where complex civilizations developed and even in its more northern areas it undergoes a changing and catastrophic environment. Therefore, most of traditional techniques for water harvesting, conservation and diversion are widespread as well as the systems of slope protection and the creation of soil that have different characteristics according to the environment.

The several water saving techniques used by the Nabatean agriculture, the condensation caves and pits, the stone arrangement for rainfall harvesting, the underground dams are not only widespread in the Negev desert (Evenari *et al.*, 1982) but also in the whole Mediterranean area. In Petra (Jordan) they present their urban ecosystem synthesis (Zaydine, 1991) but they can be also found in Tunisia, in Libya and in southern Italy and in particular in the isles thanks to the influence of prehistoric times or widespread traditions imported by current exchanges. The techniques of Andalusia agriculture in Spain are widely represented. In the isle of Ibiza there is a irrigation practice called feixes designed according to an ingenious hydraulic organization (Laureano, 2005). The fields are divided into long and narrow rectangular plots by means of a network of canals having the twofold function of draining the water in excess, thus collecting and saving it and of irrigating the fields during drought seasons. In fact, if these works were not carried out it would be a swampy area in some seasons and arid or flooded by seawater in other seasons. In this way, it is possible to carry out a self-regulating process which allows the practice of intensive cultivations of both marshlands and arid lands. Open canals are about 1 m deep and flow at a lower level than the plots of land thus keeping them dry.

doi: 10.2166/ws.2007.027

The land excavated for building the canals is used to raise the level of the cultivated land. During hot seasons when the land undergoes high evaporation, the plots absorb the necessary quantity of moisture directly from the subsoil and from the walls of the canals by osmosis and capillarity. The process is then fostered by further underground canalisations excavated in the plots. These underground canals are built with porous stones and pine-tree branches covered with a layer of Posidonia algae collected along the coast. This method ensures the good running water pipings and at the same time it allows to obtain a certain level of permeability in order to give the land the quantity of water necessary to keep it humid. Therefore, the irrigation is carried out from the subsoil directly to the plant roots. This technique enables to save water that would be lost because of evaporation by using open irrigation methods.

Traditional techniques can be found not only on southern Mediterranean shores and in southern areas of Europe but also in northern France and even in the Swiss mountains, where specific geomorphologic conditions cause aridity. The most widespread system that can be defined as one of the typical features of the Mediterranean area is the terracing which can be found from the Middle East to Greece and from Italy to Portugal. Terracing associated with olive and wine growing actually contributes to shaping the landscape. The slopes and hills in the northern Mediterranean have stood up to erosion over time and their present shape is the result of that long-lasting titanic action. Along with the dry stone walls, the stone barrows (specchie) and the tholos constructions (trulli), terracing is typical of the Apulian region in the south of Italy. Here, the terraced slopes of Amalfi and in the north of Italy, the Cinque Terre in Liguria, create fascinating and traditional urban ecosystems. In Sardinia and in the isle of Ibiza there are systems of fields surrounded by dry stone walls called tanka, which is a term deriving from an ancient Mediterranean toponym.

The majority of the ancient Mediterranean sites follow the layout of the terracing and the water systems network. These sites adopt the techniques of rainfall harvesting, protected vegetable gardens, the use of organic waste for the creation of humus, the methods of passive architecture and of climate control for food storage and for energy saving as well as the practices of recycling productive and food residues. The aesthetic qualities, the beauty of natural materials, the comfort of architecture and spaces, and the organic relationship with the landscape that these ancient towns boast are especially due to the intrinsic qualities of traditional techniques and to the search for symbiosis and harmony intrinsic to local knowledge. In the Mediterranean area each part of the environment is not only the result of natural process, but rather represents a cultural landscape where historical centres are the crystallization of knowledge appropriate to the correct environmental management and maintenance (Laureano, 1998).

The case study of Matera, Southern Italy

The Sassi of Matera represents a typical example of traditional use of water resources in the Mediterranean. The local knowledge system adopted is found in a wide set of situations ranging from the troglodyte dwellings of the Loire valley, in France, to Petra, in Jordan, to the towns carved out of the calcareous rock in Cappadocia, in Turkey, to the underground settlements of Matmata in Tunisia, to the villages along the canyons in Algeria and in Morocco up to Andalusia and Nabatean water farming techniques. The towns are built along the borders of deep valleys, the Gravine, that have a small water carrying capacity or do not have any. The settlements are not placed on the bottom of the canyon like one could expect if it were to provide water, but on the upper part, along the plateau and its steep slopes. In fact, the resources of the maze-like troglodyte dwellings of the Sassi of Matera and of the other stone towns of the Gravine are the rain and

the dew that are harvested in drains and in cave-dwellings (Laureano, 1997). The time stratification of traditional knowledge according to the classification adopted for social groupings, hunter-gatherers, farmer-breeders, agropastoralists shows the progressive determination of a complex system of knowledge and appropriate use of resources until the creation of stone oasis and of the urban ecosystem.

Hunter-gatherers

Human beings have settled the area from the Palaeolithic onwards, as evidenced by a number of stone findings in the Grotta dei Pipistrelli (The Cave of Bats) and by an intact skeleton of a hominoid found in a karst pit near Altamura which has been dated at about 250,000 years old. The Grotta dei Pipistrelli is a natural formation but its structure is made up of a passageway, the entrance of which gives out onto the slope and the other end of which emerges through a karst sink hole onto the plain and is a model for later artificial constructions.

Farmer-breeders

During the Neolithic age, a number of techniques were developed for digging in the calcareous highland and for harvesting water. Bell-shaped cisterns, huts and small canals were enclosed in deep ditches, forming circles and ellipses and were therefore called entrenched villages (Tiné, 1967; 1983). It is nonetheless likely that the ditches were not used for defensive purposes, but rather they were used in Neolithic practices of animal husbandry and farming. An analysis of aerial photographs showing where vegetation grew more thickly also show drainage systems used for water harvesting or humus collection, and the maze-like systems called corral that were necessary for agricultural and animal grazing. The recent excavation of the Neolithic complex of Casale del Dolce near Anagni underpins this hypothesis.

Agro-pastoralists

The Age of Metals provided new tools which made it easier to excavate caves and pits. As the environment deteriorated, these caves became ever more attractive as human dwellings. In fact, the progressive loss of the vegetation cover left the surface villages without shelter, left the land unprotected, thus causing a shortage of wood for building and heating purposes. The climate ranged from freezing winters to broiling summers. The absolute lack in water in the rivers or on the slope made it necessary to harvest meteoric water in underground cisterns. An increasing popular form of dwelling was the pit courtyard which had been developed during the Neolithic age subsequent to the development of excavation techniques where tunnels radiated out from a central shaft.

This dwelling model also arose in remote areas such as Matmata, in Tunisia and on the dry plains of China and was the origin of the courtyard dwelling used by the Sumerians, both in antiquity and during the Islamic era. An excavated house near the Neolithic site of Murgia Timone, across from the Sassi of Matera, proves just how effective this type of construction is. The house is rectangular in shape like the megaron of Crete and is divided into three spaces made up of two open rooms and a third underground room. The courtyard is used as a water reservoir, it is an open and sunny space, which is protected by its walls and which can be used for the preparation of the food. At the opposite end is a garden that is used for waste and as a compost heap, which has been carved out of the rock. The garden is absolutely necessary given the poor soil and the need to protect plants. The caves keep a constant temperature throughout the whole year and are ideal shelters for men and animals, for the storage of grains and water conservation.

It is interesting to remark that after the structure was discovered and freed of sediments, the underground part of the cistern soon filled up with water, even though there had been no rainfall. Therefore, the system started working again using capillary infiltration and condensation. Even the barrows of the Bronze Age took their shape from water harvesting practices, both functionally and ritually. The barrows consisted of a double circle through which ran a corridor with a room excavated down the centre. What is interesting to notice is that these structures were introduced along the excavation of the archaic Neolithic walls, which had been abandoned when the buildings were constructed but which can still be used as moisture diversion systems. What has been found in Matera is quite similar to prehistoric structures made up of barrows and underground rooms in the Sahara desert (Laureano, 1989). They could be ancient methods for the collection of moisture and dew and could belong to cults devoted to the practice of water harvesting (Pirenne, 1977, 1990).

Similar interpretations could be made of the dry stone structures spread throughout the dry lands of Apulia where stone mounds harvest the night dew thus replenishing the soil with moisture (Nebbia, 1961). Indeed, the roots of centuries-old olive trees all point to the low walls that are a staple of the farmland. The walls, the barrows, the trulli and the mounds of calcareous rock called specchie are all structures of water condensation and conservation (Cantelli, 1994). These structures carry out their tasks during the day and at night. In the broiling sun, the wind carries traces of moisture which seep into the interstices of the stone mounds, whose internal temperature is lower than the outside temperature because it is not exposed to the sun and it has an underground chamber. The decrease in temperature causes the condensation of drops that fall into the cavity. The same water accumulates and provides further moisture and coolness by amplifying the efficiency of the condensation chamber. Overnight, the process is reversed and condensation occurs externally so that dew settles on the surface; the dew slides into the interstices and is harvested in the underground chamber.

Stone oases

By developing the original prehistoric techniques, an adapted habitat system that uses the combination of different water production techniques: catchment, distillation, and condensation are carried out in the Sassi of Matera. During the torrential rainfalls, the terracing and the water collection systems protect the slopes from erosion and gravity pulls the water down towards the cisterns in the caves. During dry spells, the dug out caves suck out the moisture in the air at night: the moisture condenses in the final underground cistern, which is always full even if it is not connected to outside canals or ducts. The result is a multitude of underground storeys topped by long tunnels leading downward underground. Their slope allows the sun's rays to penetrate down to the bottom when heat is most necessary. In winter, the sun's rays are more oblique and can penetrate the underground areas. During the warm season, when the sun is at its zenith, it shines only on the entrance to the underground caves, which thus remain fresh and humid.

We know up to ten storeys of caves one atop the other, with dozens of bell-shaped cisterns all connected to each other by means of canals and water filter systems. Like in the Sahara oasis the system of local knowledge enables, in a situation without water resources, to realize good living conditions thanks to the appropriate use of techniques and to their perfect interaction with the environment.

Urban ecosystem

The Medieval monasticism contributed to this archaic texture. The hermitages, the parish churches, the farmhouses that are located in checkpoints of hydraulic works represent the

poles of the urban growth process. The two main drainage systems called "grabiglioni" that provide tillable land and humus by sewage collection are surrounded by two urban sections called Sasso Caveoso and Sasso Barisano. In the middle there is the Civita, the fortified acropolis that represents the ancient shelter in case of danger where the Cathedral was built. Along the boundaries of the highland where there are the large cisterns and the ditches, the cave silos for grain storage and the craftsmen's workshops.

The vertical structure of the town allows the use of gravity for water distribution and protects from wind blowing on the plateau. Matera boasts hundreds of rock-hewn churches painted with beautiful Byzantine frescoes or built on the plateau and bearing monumental facades carved out of the tufa according to the architectural style of the period of construction: medieval, classic or baroque. However, the maze of small streets, stairs and underground passageways continues to follow the ancient hydraulic structure.

Collapse and rebirth

During the 1950s The Sassi of Matera were closed due to their neglected condition, and 20,000 inhabitants were moved to other neighbourhoods. The abandoned houses became property of the state and a wall was erected to prevent them from being occupied. The Sassi of Matera were transformed into a ghost town, the greatest troglodyte centre in the whole of Europe was completely abandoned.

In 1986, largely thanks to the motivation of individuals involved in cultural activities, the Italian Government allocated 100 billion liras to restore the Sassi and undertake the work necessary to improve its sanitary conditions and urbanization, and to encourage private individuals to take up residence there. All the state properties were entrusted to the Mayor of Matera, responsible for financing the project. The turning point in the management of the Sassi came about with their inscription in 1993 as an UNESCO World Heritage Site. Matera became a destination for both national and international tourists and the individual requests to return and live in the Sassi multiplied. Around 3,000 people now live in the typical cave-homes, half-built, half hallowed out. The restoration of traditional systems of water collection experiment in Matera could be adopted in other urban Mediterranean centers. In these countries, the progress of modernization often destroys traditional methods of managing space and threatens the ecological equilibrium of the whole region. Only by demonstrating the success of rich industrialized countries, like Italy, to restore traditional systems can countries that are less industrialized, be persuaded to do the same.

Ancient water techniques for a sustainable future

Using traditional knowledge does not mean to reapply directly the techniques of the past, but rather to understand the logic of this model of knowledge. It allowed societies, in the past, to manage ecosystems in balance, to carry out outstanding technical, artistic and architectonic work which are universally admired and has always been able to renew and adapt itself. Traditional knowledge is a dynamic system able to incorporate innovation subjected to the test of the long term and thus achieves local and environmental sustainability.

Traditional knowledge consists of practical (instrumental) and normative knowledge concerning the ecological, socio-economic and cultural environment. Traditional knowledge originates from people and is transmitted to people by recognizable and experienced actors. It is systemic (inter-sectorial and holistic), experimental (empirical and practical), handed down from generation to generation and culturally enhanced. Such a kind of knowledge supports diversity and enhances and reproduces local resources (UNCCD, 1999a, b, c).

Traditional knowledge is to be considered as part of an extensive system which hands down and accumulates shared knowledge whose proficiency and evolution is appreciable over long and very long periods. The functioning principle of the traditional systems is based on a strong cohesion between society, culture and the economy. Their efficacy depends on the interaction between several factors which should be carefully considered: aesthetic and ethical values complete the interaction between environmental, productive, technological and social aspects. Traditional techniques, therefore, cannot be reduced to a list of mere isolated technical solutions able to solve a specific problem. To catch the full meaning and importance of traditional techniques they must be always highly contextualised, not only into the local environmental situation, but to a precise historical moment and the complex social construction which originated them. The understanding of the logic of traditional techniques' use and of their success in terms of environmental sustainability and efficacy over long periods is fundamental not only to safeguard a vast cultural heritage but as a new paradigm on which the modern re-proposition of traditional techniques must be founded.

Innovative use of ancient water techniques in agriculture

Prehistoric traditional techniques, which were used to build the Italian agricultural landscape, are today re-proposed in agriculture as the best practices to replenish soils, save water and combat hydrogeological instability and desertification. The technique of the drainage ditches spread in the Apulia district of Daunia 6,000 years ago when Neolithic communities built more than 3,000 villages surrounded by trenches in the shape of a crescent. The ditches met environmental needs by draining water and drying some areas to be tilled during the humid season and by working as drinking troughs for cattle, humus collection and water reserves during dry season. After this practice has been replaced by mechanized agriculture, today these places are suffering terrible inundations in winter and extreme drought in summer. On the Ethiopian highlands, on the slopes of the Rift Valley ridges, there are many villages where multipurpose ditches systems are still used to store and manage water resources, gather sewage and produce fertilizers.

The atmospheric water condensed inside caves or mounds of stones and the dry limestone walls are used by all the ancient societies in arid areas. Today, authentic aerial wells, atmospheric condensers producing water from vapour, are used in the desert. They produce water from atmospheric moisture according to the principles and resources of very ancient techniques. The practice of setting cistern-jars full of water or calcareous masses close to the plants to provide irrigation is today re-proposed with innovative techniques which enable to overcome constraints in ancient systems through modern drop irrigation. These traditional innovative techniques are used, for example, during the processes of reforestation of arid areas, thus allowing each single shrub to be supplied with the quantity of water it needs during the phases of growing as long as the plant will get independent vegetative power. Within the framework of this family of techniques a big company elaborated an enzymatically degradable product called dry water which, set into the soil close to the roots, progressively transforms into the necessary water supply.

The drainage tunnels are underground tunnels spread over arid areas since 3,000 years and which are still working today in the Sahara Desert, in China and in Iran to supply the oases with water resources. They allow absorbing the right quantity of water for the replenishment of the environment itself. This solution could be re-proposed, also in Italy, as an alternative to the excavation of wells which lower the groundwater and deeply perforate the soil, thus causing pollution and the salinisation on the surface. In the Sahara Desert, people are experimenting the use of techniques to relieve the hard excavation work by introducing small machines planned for the purpose. This innovative category

includes the whole of mechanical adapted tools which range from mini-tractors for the excavation of lunettes for water harvesting to new machines for sustainable agriculture.

The re-proposition in this field of ancient techniques enables to get important successes to combat erosion and soil degradation. In southern Italy there is successful experimentation with practices such as the grassing and sowing on "hard soil". The first consists in making the grass grow under the orchards and in the olive groves, thus it forms a protective cover to avoid ploughing which causes erosion. The second consists in sowing wheat over unploughed soils. This technique enables to protect soils, to reduce costs and to have better results than by ploughing. This practice is most advantageous during drought periods because ears of wheat grow less high and need a lesser quantity of water and chemical fertilizers.

Innovative use of ancient water techniques in settlement and architecture

Several innovative techniques coming from tradition are being experimented in urban fields. The building of most of the ancient centres followed the layout of the terracing and the water systems network. As a matter of fact, the rainwater harvesting techniques, the areas with the walled gardens, the use of organic remains for the production of humus, the passive architecture methods and climate control for food conservation and for energy saving and the practices of recycling production and food residues have been integrated and perpetuated in the very structure of the ancient centres. This category includes all innovative techniques in the photovoltaic, sun warming, water catchment, composting, and waste recycling fields. In some advanced contexts e.g. in Tokyo, a number of industries are now proposing by law the roofed-garden technique in new houses where the vegetable covering on the terraces of the modern buildings, which brings to mind the hanging-gardens in Babylonia. This keeps optimal climatic conditions inside the houses, harvests water and becomes an area for entertainment and contemplation. The micro-solutions for city quarters and houses represent a large innovative sector in the waste recycling field. Several mini-compost machines to be placed inside the gardens or in common areas of the quarters have been realized to directly absorb organic waste and supply the gardens with humus. A water compost machine is a device set beneath the toilet bowl, which directly transforms waste into compost. Biomass mini-reactors which transform waste into kitchen gases as well as greater plants for heating the whole house have been also realized. Also small and large-scale solutions for sewage water have been found. In Germany, modern houses have been equipped with a vertical marsh, a device which reproduces the processes of water decantation and filtration still existing naturally in marshlands. The process is reproduced along the wall of the building in glass interspaces where sewage waters seep into, infiltrate and constantly recycle themselves by gravity. In Calcutta, an innovative traditional technique used on a very large scale solved the serious problem of used waters. Sewage waters, traditionally re-used in rice-fields, are today turned into a resource for irrigating and fertilising rice fields by using proper innovative systems of sewage waters filtration and sterilization.

Conclusion: the actuality of the past

With emigration and the dramatic transfer from traditional habitats into new urban agglomerations, the rapid abandonment of the agricultural sector by large segments of the population and with the superficial suggestion of the absolute superiority of modern technology, the process of conservation and dissemination of knowledge is interrupted and lost. On the contrary, the good welfare conditions of people favour social cohesion, confidence within cultural identity and enable the safeguarding of traditional systems through the guarantee of a high remuneration of the work necessary to maintain them.

It explains the apparent paradox of those rich countries which were able to maintain high levels of traditional techniques, and succeeded in paying for the necessary efforts with a great increase in product value. Thus, we can state that tradition is a feature of 'successful modernity', capable of getting benefits and values from it. To re-propose tradition by resuming its historical relationship with people's innovative and creative power is decisive to safeguard landscape and realize sustainable futures.

Acknowledgements

The author thanks the European Commission for the financial support given under Contracts INCO Foggara and Shaduf.

References

Cantelli, C. (1994). *Misconosciute Funzioni dei Muretti a Secco*. In: *Umanesimo della Pietra*, No 9, Martina Franca, Italy.

Evenari, M., Shanan, L. and Tadmor, N. (1982). *The Negev the Challenge of a Desert*, Harvard University Press, Cambridge Mass., London, UK.

Laureano, P. (1989). *Sahara, Giardino Sconosciuto*. II edizione, Giunti, Firenze, Italy.

Laureano, P. (1997). *Giardini di Pietra, i Sassi di Matera e la civiltà Mediterranea*. II edizione, Bollati Boringhieri, Torino, Italy.

Laureano, P. (1998). *La Piramide Rovesciata, il Modello dell'Oasi per il Pianeta Terra*. II edizione, Bollati Boringhieri, Torino, Italy.

Laureano, P. (2005). *The Water Atlas*. Traditional knowledge to combat desertification, Laia Libros, Barcelona, Spain.

Nebbia, G. (1961). Il problema dell'acqua nelle zone aride: l'estrazione dell'acqua dall'atmosfera. In: *Annali della Facoltà di Economia e Commercio*, Nuova serie, XVII, Bari, Italy.

Pirenne, J. (1977). *La Maîtrise de l'Eau En Arabie du sud Antique*. Geuthner, Paris, France.

Pirenne, J. (1990). *Fouilles de Shabwa*. Geuthner, Paris, France.

Tinè, S (1967). Alcuni dati circa il sistema di raccolta idrica nei villaggi neolitici del foggiano. In: *Atti della XI e XII Riunione scientifica*, dell'Istituto Italiano di Preistoria e di Protostoria, Firenze, Italy.

Tinè, S. (1983). *Passo di Corvo e la Civiltà Neolitica del Tavoliere*. Genova, Italy.

UNCCD (1999a). *Traditional Knowledge, Report of the Ad Hoc Panel*. ICCD/COP(3)/CST/3, Paris, France.

UNCCD (1999b). *Building Linkage between Environmental Conventions and Initiatives*, Paris, France.

UNCCD (1999c). *Synthesis on Important and Widely Applied Traditional Knowledge on a Sub-Regional and Regional Basis and on Traditional Scale*. ICCD/COP(3)/CST/3, Paris, France.

Zaydine, F. (1991). Le royaume des Nabatéens. *Le Dossiers d'Archéologie*, **163**.