ITU A|Z
VOL: 7 NO: 2, 21-34 2010-2

Potential landscape architecture contributions toward a more sustainable water management on the island of Gozo, Malta

Damian PEREZ BEVERINOTTI, Erich BUHMANN, Matthias PIETSCH
Anhalt University of Applied Sciences, Hochschule Anhalt, Bernburg, GERMANY.

Received: October 2010 Final Acceptance: November 2010

Abstract:
Intelligent water management was always the basis for settlement in the Mediterranean. Natural factors and cultural behavior have slowly shaped the Mediterranean islands' landscape through millennia. Island communities are especially sensitive to anthropogenic pressures. Accordingly, rapid population growth and related development over the 20th century have poised a great challenge to preserving landscape values of the islands. Recently, on the island of Gozo, part of the Maltese archipelago, great interest has been shown in the preservation of the rural landscape characteristics. Here, agriculture is a traditional aspect of the identity, which contributes greatly to the picturesque qualities of the countryside. Practices related to soil and water conservation, together with the island's geomorphologic characteristics, produce the unique scenery of the rural areas.

Agriculture has progressively diminished in importance as an economic activity in Malta, moreover urban developments have been constantly increasing at the expense of both cultivated land and natural countryside. Water management is one of the island's most critical issues. Rainfall is the only natural source of water while agriculture is the main single user. Local watershed characteristics are favorable for the storage of rainwater; nevertheless, groundwater depletion takes place. Gozo is already affected by an emerging need for sustainability and to face the challenge to adapt to climate change uncertainties. Adaptation is therefore necessary, in the short and longer term, to address the resulting impacts. The decline in agricultural use on the steeper slopes of the Gozo valleys has lead to the decline of rubble walls, the main structure of the terraced landscape. The disappearing rubble walls and changing agricultural practice are leading, together with increasing runoff caused by increased paving and building, to severe soil erosion during the rainy season.

The area addressed in this study has undergone major changes produced by tourism and development intensification in the last decades. Agricultural land-use comprises most of the area of the watershed whose outlet point is located in the village of Xlendi. The area is prone to flash flooding and therefore more sensitive to changes in the precipitation patterns and increase in the mean sea level.

A methodological approach is proposed to integrate the biotic, abiotic and cultural components of the landscape bringing forward the processes of importance for each one and also for water management.

Responses and adaptations of the cultural landscape to the aforementioned problems are discussed and the possible contributions of landscape architecture are shown. Landscape architects can contribute to the redesign of the catchment areas of the valleys on all level of planning and design. Landscape Architects could help to translating the ecological knowledge on rivers ecosystem to the civil engineer redesigning the roads in the valley in order to create adequate technical solutions using natural methods to its optimum. On the more detailed design level street scapes should be understood as part of the valley system with ecological and aesthetical needs for appreciation of cultural landscapes.

Keywords: *Cultural landscape, Run off Water management, Landscape Architecture in large and small scale, Mediterranean.*

Introduction

Landscape, considered as "...an area perceived by people whose character is the result of the action and interaction of natural and/or human factors" (ELC 2000) have, according to Drury (2002) an "...historic and a cultural dimension, the first consisting of the surviving physical impacts of people, and the second consisting on the intangible meanings, values, attributes and associations their people attach to its physical components...". Natural factors and cultural behaviors of past societies have slowly shaped the characteristic anthropogenic Mediterranean landscape through millennia (Makhzoumi 2000). People modified their habitat in order to obtain arable land, water or areas for shepherding; terraced slopes, cisterns, channels, windmills are only a few examples of the extensively modified Mediterranean landscape. European and particularly Mediterranean landscapes are increasingly changing, blurring the regional distinctiveness and consequently their particular heritage is being eroded (Drury 2002).

Island communities are particularly sensitive to anthropogenic pressures, experiencing challenges and vulnerabilities that arise from factors such as small populations and economies, weak institutional capacity, remoteness from international markets, susceptibility to natural disasters and climate change, fragility of land and marine ecosystems, high cost of transportation, limited diversification in production and exports and dependence on international markets among others. Traditional resource management and practices relevant to the sustainable use of island ecosystems are at risk of breaking down as a result of modern economic and social pressures, and require actions for revitalization and protection (COP 8 2006). The greatest asset of the Mediterranean islands is landscape, in which is embodied the basin's geomorphologic, biological and cultural diversity, and reflect the historical coexistence of people and environment (Makhzoumi & Pungetti 2008).

Landscape cultural values include both the inert and living infrastructures that form the rural landscapes as well as the collected knowledge on the use of resources (Gómez-Sal et al. 2003), by means of which that coexistence was possible. In the case of the Maltese archipelago, rapid population growth and related development over the 20th century poise a great challenge to preserving its landscape cultural values.

In the semi-arid climate of the insular area, water management is one of the most critical issues. Rainfall is the only natural source of water while agriculture is the main single user. Rainfall is mostly concentrated in winter when crops grow slowly and do not need as much water as in summer. Almost 85% of the annual rainfall falls between October and March. Local watershed characteristics would normally be favorable for the storage of rainwater, but a number of human interventions have lead to reduced withholding capacities as the following newspaper article shows.

> *"… Earlier today, the department had urged people not to travel, unless absolutely necessary, as heavy rain turned roads into rivers, dragging cars in several localities notably Balzan, Qormi, Birkirkara, Siggiewi and Msida. Several homes in low lying areas were also flooded, as was an undertaker's shop in Qormi, where coffins floated out with the water into the valley… Soldiers from 3 Regiment and workers from the Public Cleansing Department have started clearing the roads from debris, including stones from many rubble walls that collapsed … The overnight storm delayed the departure of at least nine flights as crew and passengers could not reach the airport on time … a reader said he had seen cars floating down the valley … the area near the roundabout opposite Mater Dei Hospital was flooded, making access to the hospital difficult … "*
>
> Times of Malta, Monday, October 25, 2010

Over a period of two weeks in October 2010, heavy rainfalls repeatedly turned the streets into rushing streams. All existing reservoirs had been filled during the first heavy rain, afterwards all water ran off into the sea.

Figure 1 shows Xlendi Bay as photographed on October 20, 2010. It is marked on the horizon with brown water caused by soils carried from the fields during the second week of the rainy season. In the 1960's, the mouth of the river in XLENDI was covered by a parking lot and by buildings. Within a few years this civil engineering intervention led to a nearly total disappearance of the pretty sand beach of Xlendi. All the water sweeping down the topsoil during the seasonal heavy rains as documented in this image was therefore floodwater on asphalt roads, and not likely helpful for building up the sand beach again.

On the most critical day of flooding on October 25, 2010, the media, such as Times of Malta, covered the severe logistical problems caused by this almost unimaginable dimension of run off problems. The media showed the roads converted to streams, showed the valleys converted into lakes and they discussed how to measure the amount of rain fall. However, even though washed-out gravel and soil was blocking roads and the streams were dark brown, we could not find any documentation on the huge amount of soil, which was washed out of Malta's fields.

The view from an airplane on the same day showed a ring of soil in the sea around Malta, which extended even further beyond the area of the bays, such as exhibited in Figure 1 taken a week before the most extreme rainstorm. It seems that the huge loss of the fine layer of topsoil is not in the public's awareness, as other casualties of rainstorms directly affecting daily life are.

As the reservoirs had been full for days and the mostly clay topsoil could no longer hold any rain, most of the 200 millimeters of rain of October 25, 2010, the second highest amount of rainfall since 1951, was washed directly into the sea. This extreme rainfall should raise the awareness that the natural systems should be reinforced by all possible means.

In the following text we focus on the situation of one of the critical catchment's areas, the valley of Xlendi on Gozo, the second largest island of Malta. The water regime of Xlendi is – to the knowledge of the authors – not a part of the first priorities of the long-planned National Flood Relief Project of Malta.

Figure 1. *Soil erosion monitored in Xlendi Bay, Gozo, Malta October 20, 2010. The doted line indicates the area until the soil is showing after one week of the rainy season with normal rainfall.*

Gozo island

On Gozo, preservation of the rural landscape characteristics has come to be considered of strategic importance (MEPA 2002). The traditional rural landscape of Gozo, as with all of Malta, is predominantly anthropogenic. The unique scenery of the rural areas on the island, because of the complexity and variation in the landscape, is produced by a combination of geomorphologic characteristics, agricultural practices and the multiple strategies used to address problems related to soil and water conservation (Buhmann et al. 2005) (MEPA 2004) (Jones & Hunt 1994).

While agriculture has progressively been diminishing in importance as an economic activity in Malta, tourism and service industries have been increasing (Government of Malta, 2002). Additionally, built up areas have been constantly increasing at the expense of both cultivated land and natural countryside in the last decades. Furthermore, soil erosion and succession are causing considerable changes in the vegetation in some areas. Modern agricultural practices have also introduced a number of elements which were not present in the traditional landscape such us greenhouses, tunnel cloches, pump rooms or agriculture stores among others (MEPA 2004).

In the semi-arid climate of the insular area, water management is one of the most critical issues. Rainfall is the only natural source of water while agriculture is the main single user. Rainfall is mostly concentrated in winter when crops grow slowly and do not need as much water as in summer. Almost 85% of the annual rainfall falls between October and March. Local watershed characteristics are favorable for the storage of rainwater; nevertheless, groundwater depletion takes place. Illegal wells account for a significant portion of the extracted ground water. Drinking water comes mostly from expensive desalination processing and unconfined aquifers, the most important of which is in contact with seawater. Groundwater doesn't have the required quality to be solely used as drinking water, mainly as a result of agricultural pollution and over-abstraction (Mangion & Sapiano 2003). Water scarcity along with high labor costs and cost of land are the major constraints facing agricultural activity (Government of Malta 2002).

Gozo is already affected by an emerging need for sustainability and to face the challenge to adapt to climate change uncertainties. Even though quantities can't be predicted, the likely direction of climate change over much of the Mediterranean basin has been estimated. The general tendency is decreasing rainfall with changes in the distribution patterns (Van Grunderbeeck & Tourre 2008) (Giannakopoulos et al. 2005). The predicted increase in the mean sea level would affect the availability of water from freshwater lens, the main source of water for agriculture. The impact in the very few local freshwater habitats will probably be quite severe (Axiak 1992). Adaptation is therefore necessary to address the resulting impact.

The particular area addressed by this study is a watershed comprising a steep valley of Gozo, on the edge of which lies a former fishing village. This site has undergone major changes as the result of tourism and development in the last decades. Agricultural land-use comprises most of the area of the watershed whose outlet point is located in the village, although the upper leveled areas are urbanized. Because of its location, and because of failure to recognize the impact of development, the village is prone to flash flooding. Changes in the precipitation patterns and increase in sea mean level have a great meaning here. The added uncertainties represent new challenges to landscape planning, which at the very least should translate into precautionary measures based on the knowledge about the increase of extreme weather events (Heiland & Demuth 2009)

A recent proposal for storm-water management in the Xlendi Valley put forward two alternatives to alleviate flooding problems, for public consideration. Although the general proposal considers the construction of several small dams in the Xlendi Basin for harvesting storm-water, both alternatives are structural measures. The first involved the construction of a 600m tunnel and the other a large culvert under the town's main street. (Water Services Corporation 2010).

Searching for an integrative methodological approach

Landscape planning and water management

The International Hydrological Program recognizes that water problems cannot be solved by quick technical solutions but rather they require the consideration of cultural, educational, communication and scientific aspects. Planning for water management has evolved from a paradigm of domination in the 19th century to one of sustainability in the 1990s with the introduction of approaches like the Integrated Water Resource Management (IWRM). In recent years, ecosystems management has been gradually incorporated into

IWRM as a way to truly attain sustainability. (Sousa Ferreira & Botequilha Leitão 2005)

An early integrative approach combining a planning methodology with the hydrological approach was developed by Van Buuren (1991). The methodology aimed mainly at the identification and understanding of problematic situations between land-use and water flow. It recognized the contribution of flowing surface water and ground water to the occurrence of landscape interactions. Taking the catchment area as the main spatial and functional unit, an analysis of the interaction of water flow in time and space revealed patterns of landscape units called "water-related landscape structure". These units helped later in formulating different zoning principles for allocation and relocation of land-use (Van Buuren 1991).

Sustainable landscape-planning (Botequilha Leitão & Ahern 2002), evolved from Jack Ahern's landscape ecological planning (Ahern 1999), proposes a set of principles and guidelines for integrating landscape ecology into planning. More recently, Sousa Ferreira & Botequilha Leitão (2005) proposed adapting the sustainable landscape-planning framework to include hydro-geological models describing water flow and water quality. On it, the landscape was to be analyzed for spatial and non-spatial relationships between landscape structures, associated human activities and the quantity of groundwater.

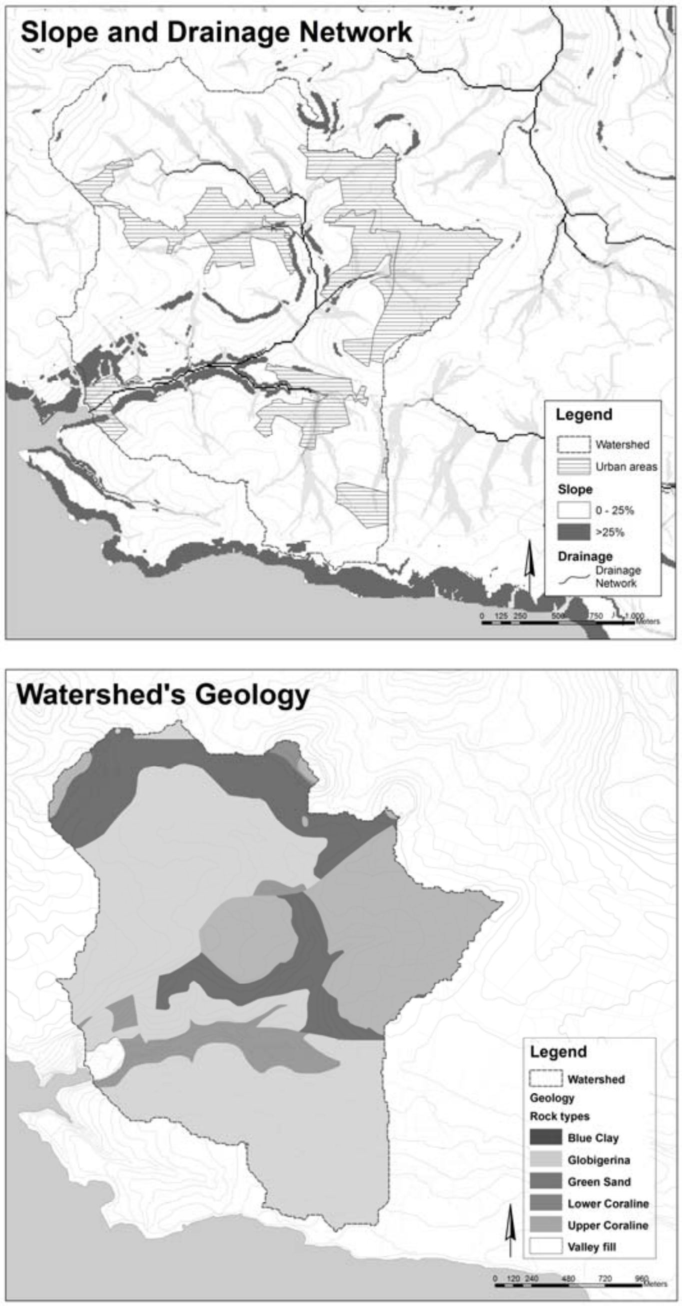
Landscape design, cultural landscape and sustainability

One proposed paradigm, aimed to integrate the natural and cultural evolutionary processes into a landscape design theory, is the ecological landscape design. In the methodology for ecological landscape design (Makhzoumi & Pungetti 1999) there are three suppositions on which the methodological framework is based: that "...landscape is a dynamic evolving system which has the ability to maintain structure" (e.g. change in the type of crop, keeping the structure); "that it has a characteristic complexity which arises from the interrelatedness of its abiotic, biotic and cultural components; and that understanding landscape stability and complexity dictates a temporal (evolutionary) and spatial (hierarchical) framework of evaluation" (page 216). These suppositions are particularly suitable for the distinctive Mediterranean cultural landscape. Moreover, in the Ecological Landscape Associations methodology, the ecological understanding of the landscape is an integral part of the design process through which the analytical capabilities of the ecological science are combined with the intuitive potentiality of design.

In water management, almost every decision taken would have an impact on the cultural, biotic and abiotic components of the landscape, thus the value of researching the relationship between water and these components.

Proposed integrative approach

Water may be regarded as a separate factor in order to stress its importance, and to bring out the processes of (re)generation and its role in the semi-arid climate. Building on both methodological approaches already presented, the methodology followed in the specific case of Xlendi watershed investigates the interactions into and between landscape and water flow in time and space to reveal significant patterns or structures, thus



a

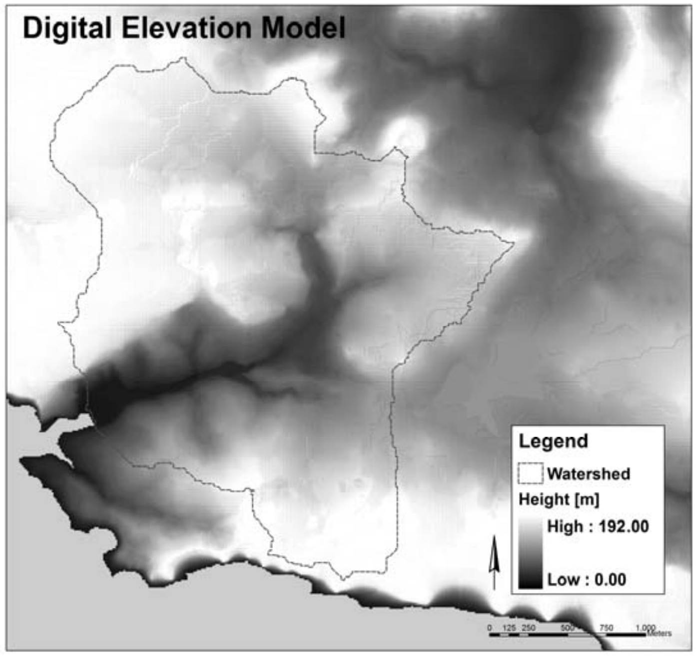
b

Figure 2 a-d. *Landscape physical characteristics and land-use. (Oil Exploration Directorate, 1993) (MEPA, 2003).*

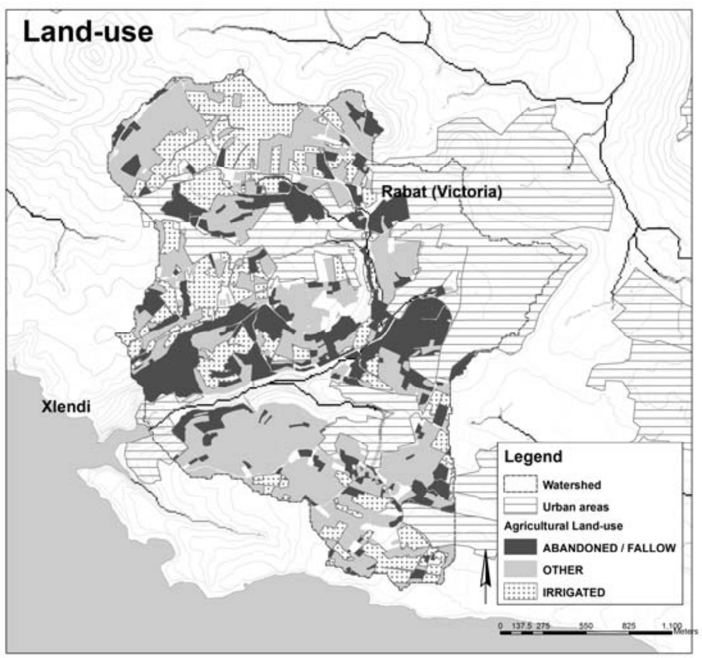
providing both a base for landscape planning and landscape design. Published literature was inquired, as well as existing surveys, statistics, and maps of physical and biological resources (Fig. 1). Informal interviews and field surveys were also made in the area. This knowledge base was later used as a base to determine management units emphasizing the relationship between water and landscape (Fig. 2). Studies show that abandonment of traditional cultivation in the Mediterranean area has different impacts, according to slope gradient, on soil sediment losses (Koulouri & Giourga 2007). Erosion is related to slope, soil, rainfall intensity and vegetation cover. Erosion is a significant hazard especially in areas where the soil layer is thin, so its risk may be a parameter for defining areas where it is of high importance to reduce or slow down runoff water.

Xlendi valley watershed

The watershed area of the Xlendi Basin is about 580 Ha, with the highest point located in the area of the city of Victoria, 176m above mean sea level, and its lowest point in the Xlendi Bay at sea level. 372 Ha (64%) of the land-use is rural, while 144 Ha (25%) is urban (MEPA 2003). The watershed's longest water course is 4.2 Km running from north-east to south-west. Xlendi Valley's discharge of storm-water runoff into the town's main street frequently results in inundation, a problem that will probably be aggravated, considering the likely changes to the climate. The distribution of plant communities in the landscape is closely related to topography, geology and soil availability. There are not special designated conservation areas in the watershed, furthermore, during this research no specific studies on the fauna and biota of the watershed had been found. The island's natural water resources depend entirely on rainwater percolating through the limestone rock and accumulating in aquifers. Studies have assessed the annual infiltrated rainfall between 16% and 25%. The island's largest aquifer is the Main Sea level Aquifer, a lens of freshwater floating on saline water on a matrix of limestone rock at sea level. Freshwater lens from the main sea level aquifer is contaminated with salt water due to over-extraction. Illegal wells account for a significant portion of the extracted ground water. Water scarcity along with high labor costs and opportunity cost of land are the major constraints facing agricultural activity. Other aquifers of importance are the Perched Aquifers, which consist of rainwater trapped in the permeable Upper Coralline Limestone due to the underlying layer of impermeable Blue Clay. High level springs exist wherever the Upper Coralline Limestone/Blue Clay interface is exposed, water flowing from them feeds the river valleys, however, mostly during the wet period (Schembri 1993).



c



d

Figure 2 a-d. *Continued*

Planning / design units

Following the analysis, six landscape units have been found in the area, in which biotic, abiotic and cultural aspects have been considered, together with the processes related with water flow:

(1) *Upper urban areas/ impervious soils / exotic species / runoff*

The upper part of the watershed is occupied by the totality of urban areas of Fontana, Kercem and Munxar councils, as well as part of Sannat and almost half of Victoria, the largest locality in Gozo. Victoria's archaeological and architectural heritage is one of the attractions of the Island. Urbanization is one of the most significant pressures on the Maltese countryside, moreover urban areas are visible from most of the area except from the lower part of the watershed. This unit's soils are mostly sealed having the hydrological characteristics of urban areas, namely: increased peak runoff, volume, frequency of runoff and flow duration. Water runoff in the city flows to sewers or stream down-slope through the streets. The upper coralline limestone rock type contains the perched aquifer, which generates springs, although most of the urban area lies over it, thus preventing infiltration. Water pollution is a very problematic issue, since most of pollution comes from non-point sources and is therefore difficult to control. Vegetation in this area is mostly exotic, related to gardens, although ruderal vegetation grows in abandoned plots

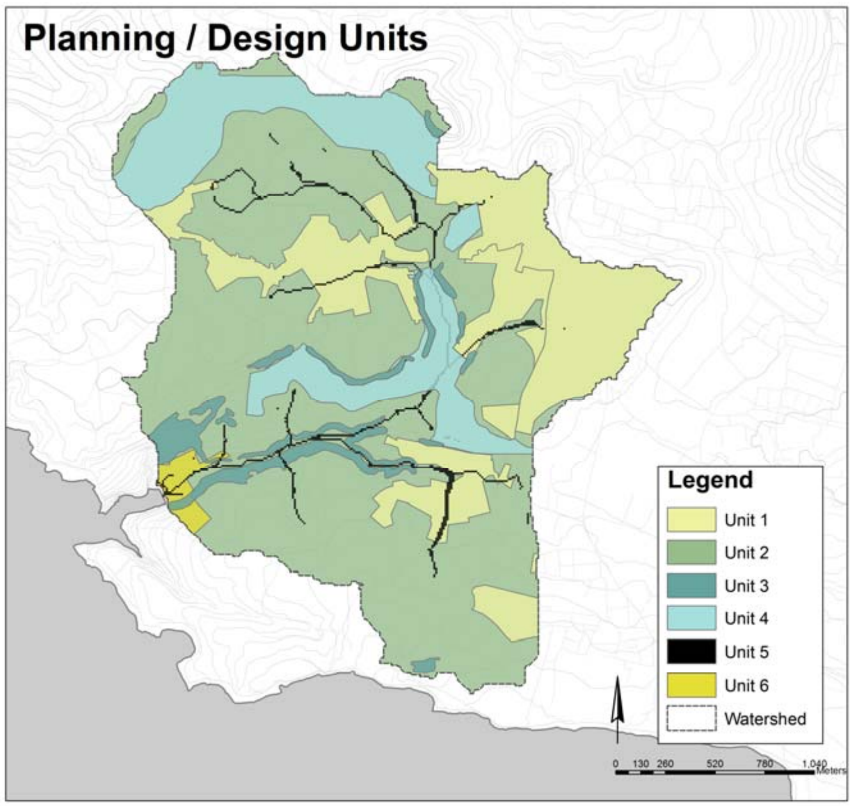


Figure 3. *Watershed's management units.*

(2) *Walled terraces / Coralline Limestone – Globigerina / outcrops / runoff – erosion - sedimentation*

Agriculture is the main land-use in this unit. Rock types are Upper - Lower Coralline Limestone and Globigerina. The area is extensively terraced allowing it to be cultivated. The retaining terrace walls are the most striking visual aspect of the Gozitan landscape, however due to the increasing rejection of traditional cultivation over the last decades, many dry stone walls have fallen into disrepair. Therefore soil erosion has increased. Although erosion is a problem, it has historically helped form the soil in the terraces. Rainwater and runoff eroded and transported material which later sedimented near the rubble walls. These dry stone walls, considered along with water-mills to be one of the particular visual features of Gozo, have also functions as bench terrace retaining walls, check-dams, boundary walls, route side walls, conduit durable walls, river erosion control walls, river diversion walls, damps for water and sediment retention, field clearance and, although rare and abandoned, water harvesting walls (Jones & Hunt 1994). Almost half of this unit area's (102 Ha) fields are irrigated, mostly with groundwater. Irrigated and semi-irrigated fields form clusters, which respond to the way irrigation water is distributed between farmers. Traditionally, farmers on whose land lay springs shared water with his neighbors, who were allowed to use the irrigation water to fill-up their cisterns in a 'turn' basis. The extraction of groundwater is currently regulated by extraction licenses. Most of the agricultural land that is not irrigated remains bare of vegetation, leading to accelerated erosion. Roads accelerate the soil loss because they provide an unimpeded channel for storm water. Modern agricultural practices have a high visual impact, especially greenhouses and tunnel cloches.

(3) *Walled terraces / Globigerina - Coralline / outcrops-bare rock / erosion - runoff*
This unit forms a narrow area following the stream valley and plateau borders. The risk of erosion in this unit is very high due to the high slope, moreover, most terraced fields adjoining this unit are abandoned which increases the runoff volume and speed. It is, therefore, crucial to maintain this area's terraced fields.

(4) *Walled terraces / blue clay / outcrops / erosion - runoff*
This unit is similar to the previous ones named, however the high erosion risk of this area lays in the nature of the soil. Studies carried out on the north-west area of Malta have demonstrated that the areas with the highest risk of soil erosion are rain-fed terrace slopes on underlying clay. In this area the runoff water is particularly high since the clay-rich soils inhibit absorption. Furthermore, dry-stone walls cannot be adequately constructed in these areas because clay is not a suitable foundation. (Rolé 2007)

(5) *Stream valley / lower coralline Limestone – valley fill / widien vegetation / runoff - sedimentation*
The stream valley is a corridor of exceptional importance, linking different patches and allowing for the movement of species. It carries most of the runoff, and after heavy rains produces flooding in the watershed outlet. It also carries sediment, which causes the dams on it to become silted containing dissolved substances, mainly nitrogen and phosphorus from agricultural fertilizers. Stream valleys are one of the richest habitats on the island because of the wet soils and richness in sediment soils. They are farmed where the slope allows. Small dams reduce the water flow and retain it for longer periods, enabling increased infiltration. They may also be a source of water for irrigation.

(6) *Lower urban area / valley fill / sedimentation*
Uncontrolled development in the town has lead to the construction of buildings on the waterfront, right in the watershed outlet point. This area itself sits on valley fill, material, which has been eroded and transported downhill by runoff water. The town blocks the natural runoff flowing, thus it is prone to flash flooding.

Planning and designing for water management in Xlendi valley

Terrace cultivation has been found to be a strikingly important feature of the landscape, both considering cultural values as well as ecological and aesthetic, therefore its conservation should be a priority. Small-scale high value agricultural activities such us horticulture, viticulture and olive cultivation may be a solution to this problem. Priorities for conservation can be set up considering the risk of erosion. Interventions aimed at runoff water harvesting may be done in the streams, however sedimentation and the ecological functions of the stream should be taken into consideration. A buffer zone surrounding the stream, where fertilizers and agrochemicals should not be used, may help reduce the water pollution.

Water-management best management practices to reduce runoff water and non-point pollution may be applied to upper urban areas.

Summarizing, the Xlendi watershed has an extremely varied landscape, which combines natural, semi-natural and cultural features. This diversity is typical of the Mediterranean rural areas, reflecting both natural and cultural processes. The methodological approach used to discern the units leads the landscape architect to consider these processes when designing, which may allow for more sustainable solutions to the problems faced by Gozo regarding water-management.

Conclusion

The analysis of the six different landscape units shows that specific and differentiated management of the units could lead to reduced soil erosion for each of them. The traditionally developed forms of the open landscape are part of a terraced landscape with rubble walls, which characterize Gozo. The differently defined 6 units reflect the different ecological situations. The unique management of them reduced soil erosion in the past. A very elaborate catchment and distribution system provided water to all farmers. Strategies to stabilize the historic systems of landscape terraces have to be found and implemented. The restoring of the system for different parts of the landscape terraces would also reactivate the historically valuable structures and their function of providing habitats to a great variety of species. In now abandoned sloped agricultural areas where rubble walls cannot be restored immediate forestation should be implemented.

In the settlements, technical solutions for reduction of run-off have to be found. Only the combination of natural measures, including all kinds of retention methods for restabilising the natural dynamic of the water flow of the valley, technical structures to reduce the amount of sealed areas, and a large amount of local cisterns, will meet economic and ecological requirements. Top soils once lost are lost forever.

Outlook

Drawing up of a Bill on sustainable development and the drafting of a national environment policy are a testimony of the government's commitment to strengthen the environmental aspect and protect the environment (Borg, 2010). This bill is a clear indication that the Maltese government is aware of the general need for a more sustainable handling of Maltese environmental resources. This Bill on sustainable development could lead the government to actively operate sustainably in all its actions and in this way stimulate the public to think and act more sustainably.

In terms of a more sustainable water management, there should be a policy, which calls for the direct and local harvesting of run-off water at all sealed areas, such as water cisterns in private houses, as practiced, in ancient Malta. The natural river systems, widely disturbed by building interventions, have to be reestablished with the highest possible amount of retention areas.

The soil erosion from abandoned agricultural land can be only stopped by immediate and substantial forestation. These four objectives; the overall water management plan, the reestablishing of the river ecosystem, the need for water harvesting and the urgent need for large scale forestation of endangered topsoil are only examples for the need for the instrumentation of landscape planning, as introduced to the public during the International Conference "Ecological Landscape Modeling and Management for Mediterranean Islands" 21- 23 October 2010 in Gozo, Malta (Borg 2010, Buhmann 2010). The landscape plan covers the potentials and restrictions of the entire non-built landscape and is a must in order to complement sectorial planning such as road planning. The landscape plan complements the structural plan of the built landscape and should be the basis of Environmental Impact Assessments. The discipline of Landscape Architects is trained in the necessary interdisciplinary work of landscape planning which is also the basis for proper landscape design for more detailed implementation.

ACKNOWLEDGEMENTS
Authors wish to acknowledge Alßan (Programa de becas de alto nivel de la Unión Europea para América Latina) which has funded this research through the Master's grant E07M403338AR (Damian Perez Beverinotti). We further thank the German Research Foundation DFG for funding the International Conference "Ecological Landscape Modeling and Management for Mediterranean Islands" 21- 23 October 2010 in Gozo, Malta there this paper had been submitted (grant BU 2105/3-1).

References

Rolé A., (2007). *The Terraced landscapes of the Maltese Islands,* **Landscape Europe**, 405-420.

Ahern, J., (1999). *Spatial Concepts, Planning Strategies, and Future Scenarios: A Framework Method for Integrating Landscape Ecology and Landscape Planning,* In **Landscape ecological analysis: issues and applications**, New York: Springer, pp. 175-204.

Axiak, V., (1992). **Implications of Expected Climatic Changes on the Island of Malta. Identification and Assessment of Possible Climatic Change on Marine and Freshwater Ecosystems**.

Botequilha Leitão, A. & Ahern, J., (2002). *Applying landscape ecological concepts and metrics in sustainable landscape planning*, **Landscape and Urban Planning**, 59(2), 65–93.

Buhmann, E. (Eds.) (2010) **Ecological Landscape Modeling and Management for Mediterranean Islands**, Bernburg, Germany: Anhalt University of Applied Sciences (in print).

Buhmann, E., Beck-Koh, A. & Kircher, W. (Eds.), (2005). **Landscape Architecture Proposals for Gozo Island,** Bernburg, Germany: Anhalt University of Applied Sciences.

Borg, A. (2010). *Sustainable development policies should exceed EU minimum requisites*. In **The Malta Independent**, October 23, 2010

COP 8 (ed.), (2006). **COP Decision VIII/1 Island Biodiversity**.

Drury, P., (2002). *The historic and cultural dimensions of landscape*. **NATUROPA**, 12–13.

ELC, (2000). **Council of Europe - ETS No. 176** - European Landscape Convention.

Giannakopoulos, C. et al., (2005). **Climate change impacts in the Mediterranean resulting from a 2°C global temperature rise**, WWF.

Gómez-Sal, A., Belmontes,, J. & Nicolau, J., (2003). *Assessing landscape values: a proposal for a multidimensional conceptual model,* **Ecological Modeling**, 168, 319-341.

Government of Malta, (2002). **Malta National Report Submitted to the World Summit on Sustainable Development**.

Heiland, S. & Demuth, B., (2009). *Climate Change - Requirements for Environmental Planning.,* In **3rd International Congress on Environmental Planning and Management**, Seoul: Institute for Eco-Plan, University of Seoul, pp. 244-246.

Jones, A. & Hunt, C., (1994). *Walls, wells and water supply: aspects of the cultural landscape of Gozo, Maltese Islands*, **Landscape Issues**, 11, 24-29.

Koulouri, M. & Giourga, C., (2007). *Land abandonment and slope gradient as key factors of soil erosion in Mediterranean terraced lands*, **Catena**, 69(3), 274–281.

Makhzoumi, J. & Pungetti, G., (1999). **Ecological landscape design and planning: The Mediterranean Context**, London: E& FN Spon.

Makhzoumi, J.M., (2000). *Landscape Ecology as a foundation for landscape architectures: application in Malta*, **Landscape and Urban Planning**, 50, 167-177.

Makhzoumi, J. & Pungetti, G., (2008). *Landscape Strategies*. In **Mediterranean Island Landscapes**, **Landscape Series**. Netherlands, pp. 325-348.

Mangion, J. & Sapiano, M., (2003). *Meeting the Demand.–Enhancing the Availability of Water Supplies in Malta*. In **International Conference of the LIFE – 3rd Countries Project: "Development and implementation of an integrated system for the control and monitoring of the urban wastewater treatment plants in Cyprus**" (COMWATER). Cyprus.

Malta Environment Planning Authority (MEPA), (2002). **Gozo and Comino Local Plan** - Inception Report - Approved Draft.

Malta Environment Planning Authority (MEPA). (2003). **Gozo and Comino Topographic Map. Scale 1:25.000.**

Malta Environment Planning Authority (MEPA), (2003). **GIS Dataset: land-use, streets and development areas.**

Malta Environment Planning Authority (MEPA), (2004). **Landscape Assessment Study of the Maltese Islands.**

Perez, D.A.; Buhmann, E. & Pietsch, M. (2010). *Landscape Architecture Contributions Toward Sustainable Water Management on the Island Of Gozo, Malta,* In **Cultural Landscape, ECLAS 2010 Istanbul Proceedings**, Istanbul Technical University, 171-181

Oil Exploration Directorate, (1993). **Geological Map of the Maltese Islands, Sheet 2. Scale 1:25,000**, Office of the Prime Minister, Malta

Schembri, P.J., (1993). *Physical geography and ecology of the Maltese Islands: a brief overview*, **Malta: food, agriculture, fisheries and**

the environment. [Options Méditerranéennes ser. B: Etudes et Recherches 7], (7), 27–39.

Sousa Ferreira, H. & Botequilha Leitão, A., (2005). *Integrating landscape and water-resources planning with focus on sustainability*, In **From landscape research to landscape planning: aspects of integration, Education and Applications**, Wageningen UR Frontis Series. Netherlands: Springer, pp. 143-159.

Times of Malta, Monday, (October 25, 2010). (online) **Update 7: CPD says situation on the roads returning to normality**.

Times of Malta, Monday, (October 27, 2010), **Flood relief: Not a moment too soon**.

Van Buuren, M., (1991). *A hydrological approach to landscape planning: the framework concept elaborated from a hydrological perspective*, **Landscape and Urban Planning**, 21(1-2), 91–107.

Van Grunderbeeck, P. & Tourre, Y.M., (2008). *Mediterranean Basin: Climate Change and Impacts during the 21st Century*, In **Climate Change and Energy in the Mediterranean**. Plan Bleu, pp. 8-59.

Water Services Corporation, (2010). **Strategic Environmental Assessment (SEA) of the Storm Water Master Plan for the Maltese Islands** - Draft Environmental Report.