10 Nature-based solutions in the teaching of landscape design by Manuel de Sousa da Câmara

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Introduction

Since the introduction of the Landscape Architecture degree in the Portuguese academic circuit by Francisco Caldeira Cabral in 1942, teaching and learning in this area of knowledge have been structured by a combination of ecological, technical, and artistic concepts. Such synthesis has been most relevant in the core subjects of the discipline such as design, planning, and management of the outdoor space and the entire landscape. In these, the guiding principles of the intervention adopt a systemic vision based on the understanding and implementation of the functioning and dynamics of the ecosystems.

Manuel de Sousa da Câmara (1929–1992), agronomist and Landscape Architect, was one of the most remarkable disciples of Cabral. In 1981–1982, he was the person that led the implementation of the five-year full-time programme in Landscape Architecture at the High Institute of Agronomy, University of Lisbon. This was the beginning of an independent degree in the discipline, following the bright steps of the founder, which he conducted for eight years with distinctive ingenuity and innovation.

He advocated that the organisation and design of outdoor spaces should be based on the suitable location and integration of human activities into existing ecosystems, rigorously observing their microclimate, terrain landform, geological substrate, water resources, biological communities, and cultural values.

Notions such as *carrying capacity*, *substitute ecosystem*, *minimised disorder*, *viability*, and *durability* of the intervened spaces oriented the design concepts and the overall detailing. Specifically, these ideas were accomplished in proposals comprising 1) spatial models harmonizing ecological values (diversity), human use (functionality), and aesthetic performance (e.g., mosaic landscapes/clearing-edge-woodland spatial model); 2) in-depth knowledge and handling of vegetation; 3) multi-layered compositions, etc.; 4) adequate water management infrastructure (irrigation, drainage, and impoundment); 5) spatial design that facilitates mechanised maintenance.

The conception of this chapter was based on the reading and selection of information registered in notebooks during the classes of the curricular unit Green

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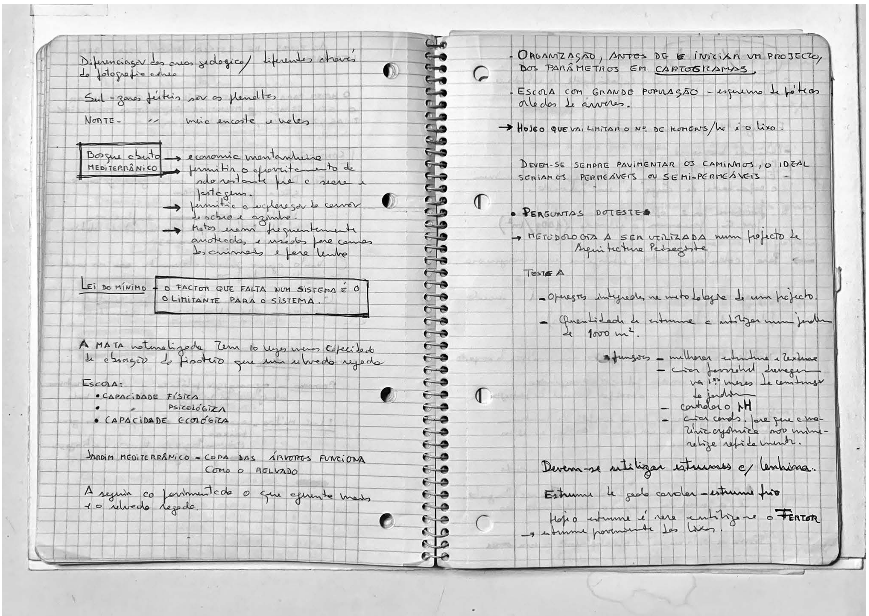

Figure 10.1 Photo of a student's notebook.

Space Construction II (Construção de Zonas Verdes II), taught by Manuel de Sousa da Câmara, during the 4th year of the Landscape Architecture degree, 1985–1986.

Handwritten notes were then organized, interpreted, and rewritten in a new joint text that proposes a single narrative, integrating some of the concepts presented in the classes, all grounded on the interpretation of the functioning of natural-based systems.

Special attention was given to my notebook, which I intensively explored, recalling very relevant and inspiring moments of fundamental learning of Landscape Architecture.

Principles: Carrying capacity and substitute ecosystem

The problem of the carrying capacity of the Portuguese territory is directly linked to the close relationship between rainfall and biomass, in which there are great asymmetries. A rainy northwest (1000–1500 mm/year), temperate and green almost all year round, contrasts with a semi-arid southeast (300–400 mm/year), dry, yellow, progressively closer to a desert situation. An easily communicable ecological indicator can be used in this context, such as a cow. Generally speaking, while in Minho ½ ha of local resources are necessary to sustain a cow, in Alentejo 10 ha are sometimes necessary to achieve this end (20 times more). It is immediately apparent that the viability and even the wealth of a region are directly linked to its ability to generate biomass, and this capacity defines its ability to sustain demanding consumers, such as large herbivores.

As a fundamental principle, the landscape architect plans and designs in harmony with the natural and cultural conditions of the space where he intervenes; for this, he must observe and fully understand its systemic and metabolic context and draw inspiration from it to generate integrated, sustainable, and long-lasting solutions. This knowledge allows us, above all, to take advantage of the functioning of natural systems in favour of human populations and consequently to propose consonant interventions that simultaneously enable human use and maintain the intrinsic qualities and values present.

In this sense, the landscape architect is impelled to adapt the existing situation to a new one that can better support human pressure without degrading it. This adaptation or adjustment can, for example, involve interventions that occasionally influence or modify the microclimate and the topography of the site, the quality of the soil, the circulation of water and the permeability of the substrate, and the type of vegetation cover.

This means that, in most circumstances, humans in high density cannot use intensively and directly the natural ecosystems (or those dominated by living elements); to avoid ecosystem degradation, it is necessary to adapt its spatial organisation and land cover to such pressure in order to guarantee the viability of the living systems.

The pressure of high human density requires the "hardening" of the land, which allows for an increase in the carrying capacity of the spaces; this hardening can be achieved by covering the ground with inert materials (e.g., built structures or paving) or by maintaining a vegetation cover that is resistant to trampling. This requires the practice of irrigation and frequent cutting of the aerial part of the plants, combined with regular fertilisation, reduction of soil compaction, and root pruning (scarification). In addition to these actions, there is also the selection of the most favourable species and the prevention of antagonistic species, the eradication of infesting or invasive species (e.g., some ruderal plants), the removal of waste and general cleaning of the spaces, and the elimination or minimisation of situations that indicate a lack of spatial order.

Carrying capacity is generally a function of the type of ground cover, rainfall and irrigation, and the type of maintenance. It varies as follows: 1) it is higher on paved land than on vegetated land; 2) it is higher on regularly mown and irrigated grassland than on similar non-irrigated land; 3) it is higher on regularly mown grassland than on non-irrigated natural woodland.

This is when the concept of substitute ecosystem arises, which, according to Sousa da Câmara, is an ecosystem modified by human intervention; it adapts the existing ecosystem to increase its carrying capacity so that it can support human use without being degraded, maintaining its most important characteristics such as soil fertility, permeability and aquifer recharge, and long-lasting vegetation cover.

This substitute ecosystem requires a set of characteristics and adaptations to best meet its design as follows: 1) the organisation and zoning of the space, adapting the biophysical suitability of each unit to the proposed activities; 2) a woody and perennial vegetation cover, undemanding in terms of installation and maintenance conditions, easily adaptable, stable, combining fast-growing species (pioneers) and long-lasting species (climax); 3) a space design that facilitates the mechanisation of maintenance operations; and 4) a careful selection of areas to be irrigated to ensure that those of greater intensity of use are the most efficiently irrigated.

Within the scope of this reflection, it is assumed that all ecosystems have a limited carrying capacity; when this is exceeded, their regeneration is compromised, resulting in biological impoverishment and degradation. This physical, ecological, and physiological capacity, especially of green spaces, tends to increase with latitude, with rainfall more evenly distributed throughout the year, and with the possibility of organic matter recharging on the soil surface.

Guidelines for project development

Main principles

Based on functional, aesthetic, and economic objectives, a landscape designer develops clear, simple, and congruent proposals suitable to the site's environmental context. The functional objectives assume the use of vegetation, paving, and equipment is appropriate for human use, always considering the durability of the materials and the problems arising from misuse, such as vandalism. The aesthetic objectives focus on the enhancement of views of special interest, on distinctive aspects of the place, and on philosophical issues that inspire the design. The economic objectives ensure the viability of the idea and its perpetuation, through a correct management strategy that relies mainly on mechanisation and automation.

In terms of the spatial overall composition, the design of parks and gardens should follow an aesthetic philosophy that affirms a simple and uncluttered layout, based on the appropriateness to the topographical conditions and rational use of other natural and cultural resources, which promotes the proper functioning and expression of the natural systems.

Such an approach can be inspired by naturalistic climax landscapes and pre-industrial rural landscapes adapted to human use and optimized management.

Composition and vegetation

The composition defines structuring spatial units whose presence and articulation guarantee a fundamental diversity important for the multifunctionality and viability of the whole. These spatial units are the clearing, the edge, and the woodland. The clearing constitutes the open, illuminated, and sunny space, being essential for extended views and activities of movement. The woodland is the place of intense woody covering, shade, recharge, and conservation of resources. The edge is the transitional space between the two previous ones, the most biodiverse and aesthetically stimulating.

Awareness of the need for sunbathing gave urban green spaces a different opportunity for use than they had had until the 19th century. Shade and paleness were replaced by tanned bodies and a new culture of outdoor health, motivated by the need for vitamin D and physical exercise for all social and age groups. The clearing, wide, unobstructed, and preferably flat becomes an indispensable spatial element in any modern park or garden. The clearing can easily be obtained with the creation of a meadow, a lawn, or a lake, all of which are favourable to mitigate the negative effect of the albedo.

In each case, the recreation opportunities are very different; clearings, with regularly mowed and watered grass cover (e.g., meadows or lawns) create better opportunities for active recreation (movement activities), are more easily accessible to a greater and more diverse number of users and allow for more easily mechanised maintenance (higher carrying capacity).

Clearings with high radiation are complemented by dense woods with a strong shading and soil protection effect; this shading effect is also important in deterring the growth of weeds under their canopies, contributing to greater stability and order in the space. An example of this is the clusters and small stone pine woods used in the urban development of Olivais Sul, northeast of Lisbon.

The transition between the clearing and the woodland is made by a spatial unit of enormous importance, the edge of the woodland. The main advantages of the edge can be summarised as follows: 1) it is an area with favourable solar radiation and a good shadow-sun balance; 2) it is an area of shelter and refuge, where one can see without being seen; 3) it is an area which also offers selective protection against winds, undesirable views, predators, pollution, etc.; 4) it is an area with high biological and sensory diversity (e.g., the area with the highest diversity of blooms). For these reasons, the layout of the paths and the location of the resting areas (sitting areas) or viewpoints should be associated with the edge of the woodland.

The interventions with vegetation should make the best use of the various floristic strata available, proposing multi-stratified compositions that guarantee the simultaneous presence of trees, shrubs, and herbaceous plants. In woodland areas and at the edge (border), three main strata should always be considered, with the perennial flowering herbaceous plants having a special visual and ecological importance, in covering, finishing, and redoing the border, preventing the garden spaces from being invaded by undesirable plants, such as ruderal plants.

The use of isolated trees and shrubs is of little interest due to the difficulty they create for mechanised maintenance, as well as the low ecological and aesthetic performance they confer to the compositions. In the Portuguese climatic situation, with relatively long, dry, and hot summer periods, the use of isolated trees or shrubs does not produce sufficient shade or soil protection. As an alternative, denser multi-stratified woody clumps should be designed, consisting of several individuals and several species, planted at close spacing so that they can quickly intertwine their crowns and create a relevant and conspicuous green mass in the landscape.

Water, landform, and soil

The clearings with permanent water bodies, forming lakes or ponds, are more restrictive to direct human use but greatly contribute to the ecological and aesthetic diversification of the spaces, still maintaining the possibility of certain types of active recreation (e.g., boats, bathing/swimming). Alternatively, if the presence of water bodies is not permanent, the clearings can function as seasonal retention basins of peak flows from torrential rains, which are directed there, constituting "stormwater basins", especially in the autumn-winter period; in the dry months, when precipitation is rare, they can be used as meadows or lawns for recreation.

These temporary water reservoirs are of enormous importance, especially in the hotter and drier areas where the irrigation of green spaces is crucial during the summer. This use of rainwater can also be done more efficiently and for many purposes, through the cistern system linked to the collection of less polluted water from roofs.

In this sense, it is very important to maximise the permeability of the catchments including urban areas, especially in the headwaters, ensuring that natural drainage lines dissipate run-off velocity, increase temporary retention capacity (i.e., increase the time of concentration of flows), and promote infiltration and storage. Low-lying areas must be transformed into green spaces that dissipate and accommodate flood waters.

From the point of view of management and maintenance, the project should integrate these aspects from the initial phases of its design. Thus, it is necessary to overcome constraints that prevent or hinder mechanisation and automation, promoting 1) the definition of homogeneous areas that relate suitability, activity, and maintenance; 2) the creation of gentler slopes, favourable for the operation of machines, irrigation, and drainage; 3) the increase of mechanisable areas (e.g., larger and wider clearings make mechanical cutting and automatic irrigation of

Figure 10.2 Influence of Sousa da Câmara's teaching in one of his students' landscape design interventions (clearing-edge-woodland spatial model): the path along the edge; subtle terrain grading for stormwater retention—Parques da Asprela, Porto.

vegetation more efficient); and 4) the selection of materials more resistant to the weather and human use and less demanding in resources in their maintenance processes.

Sloping areas make it difficult for machinery to operate; this can be significantly improved by grading the land to increase the flatter areas that are more suitable for mechanical maintenance, particularly of the vegetation cover (e.g., lawns, meadows, or grasslands); sloping areas, which are less accessible, can only be made possible with a free-growing shrub and tree cover that is less demanding on maintenance and consequent mechanisation.

In this context, it is also essential to exercise topographic concordance, ensuring continuity of access between all spaces, even adopting sigmoidal slopes, if necessary.

The limitations introduced by the slopes are also reflected in the opportunity for automatic irrigation systems, with the distribution of water under pressure, namely sprinkling and spraying. To optimise automatic irrigation, it is necessary to locate the clearings in areas with low gradients (0–5%) and design them free from obstacles and with dimensions following the range of the irrigation nozzles.

In turn, its flow rate must be in accordance with the permeability of the soil. In general, the water infiltration rate in most Portuguese soils is low, which means that a significant part of the distributed water does not infiltrate, but runs off on the surface, therefore not meeting local needs. This means that the water supply must be slow, making use of low precipitation rates distributed throughout the day, avoiding unnecessary losses by surface run-off, evaporation, or accumulation on the surface (formation of mudflats). Irrigation is the most important factor in the creation and management of green space and a key factor in its viability.

Sustainability in the urban context

It is important to highlight that the effect and success of green spaces in highly artificialized cities and industrial areas depend on urban planning. Fundamentally, this planning foresees the creation of connected green spaces with a homogeneous and balanced distribution in the urban network (*continuum naturale*). This connectivity network should be based primarily on natural drainage lines operating in the open air, which can sustain riparian woodland, an essential element for the existence of robust and efficient green corridors.

The sustainability of the green structure in the urban ecosystem depends on five main aspects: 1) adequate location; 2) precise suitability to the purpose for which they are intended; 3) integration of well-dimensioned irrigation and drainage systems; 4) selection of species well adapted to the ecological and social conditions of the site; and 5) possibility of mechanisation of the main maintenance operations.

This means that, in the medium and long-term, the organisation and conception of green spaces articulate and optimise functional needs, ecological and aesthetic qualities, and socio-economic aspects.

Conclusion

The text presented earlier highlights some of the concepts and solutions professed in Manuel de Sousa da Câmara's course unit Green Space Construction II, 1985–86 (Construção de Zonas Verdes II). It aims at systematizing and disseminating his lucid and sharp approach on the subject of green space design within the scope of Landscape Architecture.

The understanding of the natural systems' metabolism and the necessary change of spaces to accommodate human use through an appropriate spatial organisation and design, in a context of viability and durability (sustainability) underpins the learning of landscape design practice.

For Sousa da Câmara, design solutions must be based on knowledge, rationality, critical thinking, and the aesthetics of simplicity; they are intended for all, universalistic and inclusive, manifesting themselves frontally through objectivity, utility, quantification, promptness, and functionality.

There is still much to explore in Manuel de Sousa da Câmara's class notebooks. At the time, students recorded this information, sometimes without fully understanding its scope, but often feeling its importance and awakening a desire to know more.

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