The Water that Passes Through Alcoa and Baça: The Hydraulic System of the Monastery of Alcobaça

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Abstract

This monastery, with its presence effectively defining the town of Alcobaça, provides an exemplary case of the Portuguese territorial layout, both in its balance and in the relationship between the genius loci that the local territory offers and the new, human-constructed landscape. Adopting water as the key natural resource, the monks of Alcobaça applied its use with wisdom and mastery in the most diverse fashions. Water not only becomes a frequent presence on the macro-agricultural scale of the *Couto Alcobacense*, but also appears in places of symbolic meaning, such as the cloister's *lavatorium*. The members of the religious community were referred to as farmer-monks, also deriving from the core Benedictine principle of "*Ora et Labora*" that was in effect at this Cistercian monastery; furthermore, they applied the empirical knowledge of agronomic science and improved the techniques that would subsequently change the territories of their application.

1 Introduction

The English aristocrat, politician and travel writer William Beckford gave a clear description of the beauty and excellence of the Alcobaça environment, alongside the prominence of water as an intrinsic factor:

> Here every object smiled; here every rood of land was employed to advantage, the Lombard system of irrigation being perfectly understood and practiced. Every cottage, apparently the abode of industrious contentment, had its well-fenced garden richly embossed with gourds

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> and melons, its abundant waterspout, its vine, its fig-tree, and its espalier of pomegranate. (Beckford 1835: 164)

Although not unique in Portugal, Alcobaça represents one of the most relevant examples of national monastic heritage and, perhaps, also the best expression of its centuries-long relationship with its surrounding territory and its symbiosis with the natural resources contained in this landscape.

The Monastery of Alcobaça thus represents a relevant case study on Cistercian communities within the scope of Portuguese history. This especially arises due to a prevailing series of atypical factors interrelated with its topography, its vulnerability to floods, especially the great flood of 1772 (Tavares 2003), and the sediment-alluvial deposits and landfills created by the monks that also altered the river's course. All of these changes in the landscape brought about episodes in the monastic complex settlements that were not intentional. The recourse to irrigation processes and the hydraulic energy used in the mills during the Cistercian and post-Cistercian periods derived from adapting the hydraulic knowledge applied to changing the territory that determined the prevailing structure of Alcobaça in an inheritable way. Hence, from around the end of the seventeenth century and throughout the following century, a period that characterized the Modern Age, the Cistercian monks embarked on this genuine transformation of the landscape in adapting it to human permanence. They transformed unproductive lands into remarkably productive agricultural fields. This regenerative capacity of the agronomist monks achieved notice and recognition by the order's chroniclers, who proposed it as an example of excellence, as opposed to the generalized state of abandonment that then afflicted the country.

The history of the Monastery of Alcobaça was initially written by two leading protagonists. Firstly, Afonso Henriques, who led the armies at the Battle of Ourique in 1137, had also recently conquered the cities of Santarém and Lisbon (1147), and, in 1143, with the Treaty of Zamora, gained recognition of its independence from the Kingdom of Leon and Castile before then seeking papal recognition. Secondly came Bernard de Clairvaux, the French abbot and great reformist leader of the Cistercian order, who held remarkable power in the Christian world at the time of the monastery's foundation. The historic coincidence stemmed from the Duchy of Burgundy, the birthplace of the paternal ancestors of Afonso Henriques, being interlinked with the founding of the order.

The Alcobaça complex was established in the coastal zone of central Portugal, more specifically, in the district of Leiria, located about 110 km from Lisbon, in the Lusitanian Basin, a sedimentary basin of clays, limestone and sand (Rebelo and Cunha 1991).

The building of the monastery and all of its other secondary support structures duly took into account the existing territory. Examples of such planning include the Quinta da Chiqueda, planted with oaks and cork oaks and with the presence of water then enabling the installation of gardens, workshops and mills and the monastic fences (in the fourteenth century, there were two, the interior and exterior walls) that provided access for the monks to enjoy the waters along the course of the irrigation channel on the south and west sides of the river, which later came to be called Baça.

Fig. 1 Main Facade of the Monastery of Alcobaça. Photos by the Author, 2016

1153 marks the beginning of this Couto, with the construction of its abbey occurring a quarter of a century later, in 1178, prior to an existence marked by extreme natural phenomena over the course of centuries. Such examples would include the 1329 earthquake that caused the partial destruction of the monastery, especially the kitchen and dining room. However, the eighteenth century saw the two events that had the greatest impact on this region: the 1755 earthquake that "… manifested itself in all the lands of Alcobaça and especially in Chiqueda, where the sources of the Alcoa River and beautiful Poçoão were completely dry." Secondly, the great flood of 1774, which, in his contemporary description, Friar Viterbo portrays as follows: "… a memory of the breathtaking inhabitants and never forgotten: it has done terrible damage to men, animals, walls, bridges and paths. In fact, this flood was responsible for the disappearance of many of the remains of the Roman settlement of Helcobatice" (Fig. 1).

2 Hydrography

The geography of this municipality is defined by its enormous hydrographic network, with numerous crisscrossing water lines, rivers and streams flowing down to the Atlantic Ocean, especially the Alcoa and Baça rivers, the two main rivers of this region. The first is characterized by its source, which varies across different

locations in narrow and deep valleys (Tomé 2016), while the Baça River, smaller in scale, flows in the opposite direction to the Alcoa.

It is therefore not surprising that, at the time of its founding, the *Couto de Alcobaça* operated four seaports, which later disappeared due to the retreat of the Atlantic that consequently brought about the end of these shipping channels.

The routes of the rivers in contemporary Alcobaça differ from those of the medieval period. On the one hand, the Alcoa River was deviated in the seventeenth century to allow for the construction of the Cardinal's Cloisters and the Rachadouro, with an abrupt change in the river's direction when it arrived at the present district of the Lameirão, taking a 90° turn, with the river having since adopted a straight course, as opposed to its irregular layout elsewhere. The Baça River is also believed to have been diverted to its present course, leaving the left bank running in parallel with the Monastery facade. As we look closer, we become more aware of the confluence between these two rivers. On the eastern side of the monastery, the Alcôa River joins the Baça River on the western side, ultimately meeting and merging into the Alcobaça River, which crosses its path on route to the Atlantic coast.

The extent of the Alcôa River, within the scope of the Pederneira Lagoon, once played a much more extensive role in the landscape than that which we observe today. It ran through the territory for a few kilometres, almost reaching the Maiorga area.

In order to minimize the effects of flooding, downstream work took place to regularize the river flows, alongside controlling irrigation processes, particularly in the extensive Campo do Valado fields.

New watercourses were established, particularly in the sixteenth century, with the movement and containment of the Alcoa River and, in all likelihood, the Baça River as well.

This extensive and dedicated work was implemented in the eighteenth century with knowledge from the field of hydraulics, its applicability resulting in the conversion of coastal areas and wetlands into highly productive agricultural farmland.

3 The Monks of Alcobaça

Also known as agronomist monks, they performed remarkable work that had first started out in close collaboration with King D. Dinis in the last quarter of the thirteenth century within the framework of his agrarian policy (Gonçalves 1997).

This collaboration between the Cistercian community and the king was an effort to claim dominion over the formerly inhabited territories of the region of Extremadura, developing them in both agrarian and economic terms, with the establishment of villages and with the associated objective of highlighting the presence of the Portuguese Kingdom in lands that had, in the past, been occupied and dominated by different enemies. The Alcobaça monks initially began to implement

the settlement, with the help of Letters of Population issued by King Dinis, in Extremadura, hitherto a region of polycultures, and particularly in the Couto de Alcobaça domains. The monks, with the help of the new settlers of Alcobaça, thus contributed to implementing and improving the cultivation of vines in conjunction with olive trees (Natividade 1942).

The monks also defined which crops would be grown and where, recording them on settlement maps. Furthermore, whenever these places did not feature on the Couto Charter, the monks would study the soils and their qualities to decide as to whether they were better suited to vines or cereals, with the latter being a tradition that dated back to Roman times, in this case, wheat and barley (Caldas 1998).

For all such reasons, the monks of Alcobaça played a highly important role in regional development through their way of life and their interactions with their lands in agronomic and agricultural terms, as well as their capacity to convey all of this knowledge, in terms of cultivation techniques, to the settlers of this region (Fig. 2).

Fig. 2 Cistercian monks mowing the field under the protection of the Virgin and St. Bernard. Detail (Painting—Portuguese School, 1620; Authors: Domingos Vieira Serrão & Simão Rodrigues)

All of the aforementioned qualities of the Cistercian monk prevailed in their choice of location and the setting up of the extensively built structures of the Couto of Alcobaça.

According to the Order's constitution, in its definitive version issued in 1119 at the assembly denominated the First General Chapter of Cister (Martins 2011), the monastery was to be built in such a manner that its internal organic structure was to contain everything necessary to their existence, specifically: water, mills, orchards and gardens, and workshops for the respective trades, in order to ensure that the monks did not need to emerge from their domains.

From the perspective of Ellen Arnold, "the desire to encounter an isolated landscape was accompanied by a sense of importance around converting that desert so as to ensure it was apt for human purposes." Additionally, these premises that guided the Order, as well as the desire to build a system of resources that would enable the monks to be autonomous in accordance with these basic guidelines, required solid and widespread technical support from many fields of knowledge.

Furthermore, in order to put all of this knowledge into practice, the common sense or accumulated experience of a particular group of monks would not be enough. There would also be a need to attain scientific knowledge beyond that which was passed down orally, making recourse to the specific scientific literature that had been acquired over decades to enrich the collections of its libraries. While the most notable students of the Franciscans, Dominicans and Augustinian hermits were able to continue their studies at universities outside of the country, in particular, in Oxford and Cambridge, the Cistercians of Alcobaça and other monasteries, by determination of the Order's General Chapter, went to Paris and Salamanca. Alcobaça was to become the center of education for all Portuguese Cistercian monks. In 1458, a studium was founded for the teaching of Grammar and Logic. However, it has since been verified that the Cistercian monks dominated other areas of knowledge as well, in particular, agronomy, architecture and hydraulic engineering, with this latter field being reflected in the drainage and drying works of Paul de Ulmar in Leiria, supervised by Friar Martinho, the king's deacon, in 1291 (Gomes, 2000). In the tradition of Lombardian irrigation practices, this system consisted of the drainage of previously occupied areas by rivers that, through a system of dams and channels, allowed for the exploitation of these lands for agriculture. Beginning in Italy in the twelfth century with works on the River Ticino, these irrigation schemes gradually extended to other rivers that drained into the Po from the northern lakes (Smith 1976).

There is no clear current recognition of the rules, statutes and instructions necessary for the execution of such complex works alongside all of the technical procedures deployed that incorporate the field of hydraulics for its in praxis application. Furthermore, without the application of arithmetic and geometry (belonging to the Quadrivium), undertaking such technical exploits would never have been possible. Furthermore, understanding how the knowledge that circulated orally among the craftsmen involved in the construction of these monastic complexes took place would lead us to a better perception of all of these dynamics.

These doubts around the dissemination of the knowledge acquired by Cistercian monks led Joaquim Vieira Natividade to posit one possible hypothesis as being the oral diffusion of knowledge among the pilgrims or monks from different European countries or on pilgrimages to Rome. This may represent the most consensual hypothesis in which the empirical knowledge of the monks was not only disseminated as a result of their pilgrimages between monasteries and convents across Europe, but also because of their knowledge of the works that existed in their bibliographic collections. Translations of works by Democritus, Xenophon and Theophrastus or the treatises of authors such as Cato, Varro, Columella, Palladio and Vergilus contained the knowledge necessary for the application and development of the agricultural techniques applied by the monks (Caldas 1998). Such is the example of the "Agriculture Treaty" of Abu Zacaria-Iahia, known as Ibn al-Awwam (twelfth century), which would become one of the fundamental works for the development of many agricultural techniques due to its richness and diversity of content. According to Eugenio de Castro Caldas, "Abu Zacaria, to elaborate his treaty, according to declarations, drew from texts by more than thirty authors from the Middle East, Greeks, Romans and Arabs…".

On the one hand, the Arab tradition reveals a new scientific perspective. In the field of hydraulics, it discloses innovative solutions, in particular, the devices powered by animal traction, the wind-powered water pumps, storage in reservoirs, and the establishment of irrigation channels with their consequent diversion of flows for irrigation, in addition to the application of the cogwheel in the milling systems that functioned in the factories located alongside the watercourses.

On the other hand, the scientific knowledge developed initially by the Romans was fundamental to the extraordinary levels of agricultural productivity achieved by the farms belonging to the "Couto" of Alcobaça. This incorporated theoretical agronomic knowledge into the practical actions that included: soil preparation being considered and segmented in several phases, including breaking the soil up and sanitizing it, the systematization of solar observation practices and the successive distribution of crops. With the rise of the Cistercian Order, as a consequence of the counter-reform of the Benedictine Order, their monks began to specialize and diversify, especially in the agronomic field. All of this knowledge drove the initiative of the monks who settled in contemporary Portugal, firstly, in the monastery of Tarouca, then in Salzedas and Lafões, Aguiar, Fiães, Ermelo, Bouro and Júnias, thus establishing the farms that attained the highest rates of productivity among all of those in the Alcobaça region. These same farms also functioned as general agricultural schools, perfecting all of the activities that then underwent application. Through wisdom and the mastery of the existing water resources, they were able to fully apply their knowledge to the most diverse aspects. Such knowledge became a frequent presence in the macro-agricultural scope of the Couto of Alcobaça, as well as in places of predominantly symbolic meaning, for example, in the cloister lavatory. These were the "agronomist monks," applying the core Cistercian principle of "Ora et Labora" alongside unprecedented recourse to the empirical knowledge of science applied to transforming the landscape, and consequently improving the techniques that were in effect, which would then change the

territories of their application. It thus proved possible to tangibly implement the knowledge learned from agricultural or hydraulic treaties, giving rise to a very late historical period when the productive capacity surpassed expectations, the fruit of the work of both these dedicated monks and the surrounding community that adapted to their management becoming an exemplary case of sustainability and autonomy.

4 The Structure of Couto of Alcobaça

The Couto de Alcobaça had a well-defined functional structure (Fig. 1). As a macrostructure, it first extended across the so-called Couto[1] (Enclosure), which contained other substructures that constituted part of its functioning and sustainability. Considering that most of this territory was initially occupied by forested areas, these agricultural farms were only created gradually, functional units that allowed for administering the entire monastery complex. Contained within this initial structure, there later appeared a monastic fence, composed of a larger exterior and then an interior, the latter in greater proximity to the buildings adjoining the gardens. Finally, there was the complex nucleus that contained the main structures (monastery and church) (Fig. 3).

Fig. 3 Categorization of Monastic Domain Spaces. Infographics by the author, 2016

[1]The word "Couto" defines the perimeter that contains all of the lands of the monastic territory under study and that we here refer to as the monastic enclosure.

Having been signed by Afonso Henriques in 1153, the Couto Charter formalized the donation of its territorial boundaries, delineated to the north by Leiria, to the south by Óbidos and to the west by the Serra dos Candeeiros, spanning an area of 108,680 acres (44,000 ha).

The diversity of activities within the Couto would allow for the range of production that contributed to its quasi-self-sustainability. The proximity of the Atlantic Coast, through the Pederneira Lagoon, gave rise to structures that were directly linked to the sea. Examples include the seaports that ensured the shipment of products or the landing of certain otherwise unattainable raw materials. Naval yards were also set up for the construction or repair of ships and salt production. As a result of these dynamics, the landscape was bountiful. The olive trees provided the olives that, through their transformation in the mills, gave rise to excellent quality olive oil. The production of large quantities of wine led to the construction of cellars to provide storage and the abundant cereal crops gave rise to thirty-seven barns. In addition, the mills, known as "booms," were used to give greater consistency to fabrics or tanneries. There were also the lime kilns, the kilns that produced tiles for the construction of the buildings, the metallurgical units for producing tools and, finally, the pottery production facilities. Joaquim Vieira Natividade drew a map featuring a total of 14 farms in the municipality of Alcobaça (Natividade 1885).

The agronomic sciences applied on these farms derived from the deep knowledge of the classical and modern treatises of agronomy associated with a network of information exchanged among both the Order's abbeys in Portugal and at the European level. This enabled the fostering of excellence and innovation throughout this area. This knowledge was reflected in improvements to the techniques for working the earth and the introduction of new species of cultivation that generated significantly increased harvests (Natividade 1922). This was then complemented by the plantation of olive groves of such importance that the 1314 letter of settlement of Turquel contained specific guidance on them.

The parish of Vallado dos Frades hosted one of the best agricultural schools, and its population was almost entirely dedicated to working the land. With the abolition of the religious orders in 1834, this was then transferred to the Royal Estate.

Located in Évora de Alcobaça, one of the first agricultural schools was set up to meet the initial needs of the Couto of Alcobaça, even though it only existed for a short period of time.

Ataíja de Cima and Ataíja de Baixo delimited the great olive grove of the monks and Cella, one of the extinct villages of Couto, had, in the early days, hosted its own agricultural school.

In the parish of Maiorga, next to the St. Vicente hermitage, there was a fountain "…whose waters were effective in eye diseases, specializing in ophthalmic conditions."

In turn, Fervença parish stood out for the quality of its waters, not only in their agricultural applications, but also at the medicinal level, especially in regard to treating herpes infections to the detriment of the hot springs in Caldas da Rainha.

Quinta do Vimeiro, located in the parish of the same name, included an extensive forest of oaks (Matta Coutada), and the Granja de Turquel, on a larger scale, was described as having woods, vineyards, olive groves, orchards and fields.

Located near the source of the Alcoa, the population of Chiqueda was especially dedicated to milling, taking advantage of the river's water, which was subdivided in order to power the water mills.

In this parish, the estate spans an extensive forest of cork oaks, which was a dependence of Quinta do Vimeiro that belonged exclusively to the monastery of Alcobaça.

The Granja de Turquel was greatly renowned for its vineyards, olive groves, orchards, fruit farms and, especially, for Quinta do Orjo, with its lands returning generous harvests of cereals.

5 The Monastic Fence[2]

In the fourteenth century, there was both an outer fence and an inner fence. The alteration in the location of the Santa Maria de Alcobaça Monastery came about due to the increasing presence of fugitives from justice in the vicinity of the fifteenth century monument. In 1506, King Manuel I passed a decree authorizing these fugitives to go to the parish of Vestiaria while still under the same legal protection. However, either because they distrusted the validity of this guarantee or because they benefited from the resources of the bakery (eating the bread that they produced), as well as the opportunity to visit the monastery pharmacy to cure any illnesses that they may have contracted, the fact is that the fugitives did not leave this site. Out of desperation, and already into the seventeenth century, King Afonso VI decided to re-implement the fence, giving rise to the city of Alcobaça, with some vestiges of the original fence still being observable today. These provide examples of what remains of the Obelisco and Murtas gardens. The installation of these monastic fences allowed the monks to draw water from the course of the irrigation channel running to the south and west sides of the river, which later came to be called the Baça.

The monastic fence, despite its supposed monumentality, did not escape changes over the course of time, both in terms of its area and its uses. Everything becomes even more complex at this point, due to the difficulty of obtaining documentation from this time that is capable of transmitting information about the organization of this monastic space in Alcobaça. However, in keeping with better preserved models, such as the Clairvaux Abbey in France, it is possible to ascertain an approximate working model of the historical past of the Monastery of Alcobaça.

[2]The landscape feature denominated in Portuguese as the "*Cerca Monástica*."

6 The Main Building

The Mother House of the Cistercian Order in Portugal, this huge building, with 47,000 m^2, is one of the largest Portuguese monastic complexes. Its construction began in 1178 and continued for several decades, with monks moving into the building in 1223.

This structure contains the most extensive Gothic church in Portugal, running 100 m in length and with its layout taking the form of a Latin cross. The chapter room, the refectory, the monks' rooms and the dormitory date from the thirteenth and fourteenth centuries, while the famous kitchen was built at a later date, in 1752. Classified as a UNESCO World Heritage site since 1989, Alcobaça is a structure that now displays a different configuration to that initially constructed, having undergone numerous modifications throughout its existence, especially in the sixteenth and seventeenth centuries. Firstly, the sixteenth century saw the expansion of the monastery eastwards, while the complete reform of the west wing took place in the late sixteenth and early seventeenth centuries with the transformation of the converts' wing and the completion of the church's frontispiece in 1725. This latter set of significant changes was only completed in the second half of the eighteenth century with the construction of apartments for the Abbot General of the Congregation of Alcobaça, located in the Southwest section (Maduro 2015).

Furthermore, a set of vicissitudes occurred over time and served to profoundly alter the monastery's existence. The earthquake of 1755 caused severe damage to the monastic complex, before the already mentioned great floods of 1772. No less serious was the destruction brought about by the French invasions in 1811, which consequently led to a financial crisis from which there was no return. The culmination of all of these ruinous events came in 1834 with the abolition of religious orders in Portugal that first triggered the looting of its collections by the inhabitants of Alcobaça, before its subsequent conversion, firstly into a prison, then into barracks, before finally into administrative offices.

7 The Monastic Garden

The gardens constitute an integral component of any monastic complex while being categorized into two distinct types. On the one hand, there are gardens circumscribed within built spaces, the so-called garden cloister, with a central focus, generally a fountain or well, marking the division of the space into four equal parts, analogous to the Four Rivers of Paradise. The gardens of the Alcobaça cloisters fall into this framework, with William Kinsey describing to us that "the square garden in the center of the cloisters is planted with cypresses, orange trees and a variety of beautiful shrubs, and contains the fountain which supplies water to the washbasin immediately in front of the cafeteria" (Kinsey 1828: 432) (Figs. 4 and 5).

Fig. 4 D. Dinis Cloister. Photos by the Author, 2016

Fig. 5 Cardinal Cloister. Photos by the Author, 2016

On the other hand, there are the much larger-sized gardens, with their spaces enclosed by walled features that contain orchards planted with several different fruit trees (especially lemon and orange trees), small woods, gardens and medicinal gardens that adjoin the infirmary areas that were generally located near what we call here the monastic fence. As the cloister garden held a much more thoroughly defined symbolic and contemplative character, the forbidden garden served as a space for the development of thought while the monks enjoyed their daily walks, simultaneously playing a therapeutic role for those who fell ill and needed healing. These were the places where monks grew vegetables to satisfy their food needs, but also where they planted the flowers that served to adorn the altars, in spaces where the beauty of the gardens reflected the splendour of Paradise (Macdougall 1986).

Over time, some gardens disappeared, both in their designs and boundaries, as is the example of the Myrtle Garden, "which was above all, the most artistic garden of the monastery, adorned with caves, of good marbles" (Natividade 1885: 98), and which today hosts a cemetery.

We should also emphasize the care with which the larger areas and the paths that interconnected the various spaces within the monastic fence were treated in landscaping terms, in particular, the 899 m long space between Rua Grande and Levada, "…a vast and exquisite garden, composed of long avenues of weeping, acacia, cedar and ailanthus, erected on a long tablecloth of plants and flowers, embellished by statuettes" (Macdougall 1986: 97).

8 Kitchen Gardens and Orchards

The kitchen gardens and orchards were areas of excellence and were fundamental for the sustainability of the monastic complex, ensuring the production of numerous vegetables and fruits, which particularly required, especially in the kitchen gardens, constant daily care and the application of numerous horticultural techniques that enabled intense cultivation and excellent crop yields (Martins 2015). These kitchen gardens, unlike other forestry crops, required an efficient and bountiful irrigation system for the intended level of production, which was generally ensured by the presence of a waterwheel or irrigation channel, alongside abundant tree growth that benefited from proximity to plentiful water. Among Beckford's numerous descriptions, he stated that, "From this immense sea of green leaves rose a number of plum, pear, orange, and apricot trees; the latter procured by the monks directly from Damascus, and bearing, as I testify, that most delicious fruit of its kind called 'eggs of the sun' by the Persians" (Beckford 1835: 29).

9 Vineyards

The Alcobaça monks also made an enormous contribution towards viticulture through applying and perfecting several ancestral techniques, including means of digging, cutting and pruning. The rigor and care in planting the vineyards turned them into places that reflected a splendid image of the landscape and were described at the time as follows: "The wide latticed windows of the apartment allotted to me commanded the view of a boundless vineyard in full luxuriant leaf, divided by long broad tracts of thyme and chamomile, admirably well-kept and nicely weeded" (Beckford 1835: 29).

10 The Meaning of Water and the Hydraulic System

The entire structure of the Couto of Alcobaça, however, depended on an element that was at its genesis and without which nothing could be accomplished: water.

As water has always represented a determining factor conditioning the existence of all humanity, it has, through its redirection and reconditioning, similarly enabled communities, particularly the monastic communities of the Middle Ages, to meet their basic needs, whether for hygiene or the production of everything else necessary for their existence and continuity in built complexes.

> The stratification of the Cistercian Society and the hierarchy of its spaces were paralleled in their management of water and its separation between rivers, channels and pipes, each with its own physical characteristics, its own flows, quotas, controls and risks and different purposes. (Tavares 2014: 210)

In addition to the physical dimension, water has also always held a spiritual meaning, and the utilisation of mechanisms associated with the hydric resources that existed in the monastery fashioned this cultural connection. Medieval Christianity, for example, associated water with spiritual fertility, healing, and religious conversion (Arnold 2007). All of this water-based symbolism led to the location of Cistercian monastic complexes in places "near streams, where, by channels or dams, they used the driving force or channelled the waters to fertilize lost lands" (Korrodi 1929: 26). This magnificence of the relationship with water described here also implied responsibility for respecting the will imposed by this element, hence also adaption to the episodes of flooding caused by the nearby rivers or streams. Correspondingly, the monks often had to build landfills or artificial platforms for such situations so as to avoid buildings collapsing and, when the water courses were farther away, the work carried out would be the reverse: diverting water lines, building dams, raising levees, drainage and regulation of the currents (Tomé 2016).

The application of the "good triangle" rule implemented the three vertices that were deemed fundamental for any monastic complex. The first vertex was that the area should contain good foundations that were able to secure the buildings, without any danger of the constructions coming to a precocious end. The second vertex

demanded that the site should be well served by rivers or other water lines able to cope with the hydraulic mechanisms that would contribute to the desired productivity rates. Finally, there needed to be an area of relatively flat zones for the implementation of the Cistercian Plan (Tavares 2014).

The Alcobaça hydraulic system was thus established and consolidated through the intervention of the monks, involving the implementation of a network of channels spanning several categories of watercourse. There would be the "channels for the adduction of community buildings and for the evacuation of water, channels for the production of the hydroelectric energy necessary for mills, sawing mechanisms, pumping stations, forges and other industrial equipment, channels related to the diversion of rivers and streams, with two basic purposes: field drainage, and a view to their recovery for agriculture" (Maduro et al. 2017: 96).

Upstream of the monastery, the water supply system extended over two kilometres. This spanned two fundamental elements: the irrigation channel, which experienced major flows, and the channelling of drinking water via limestone pieces, carefully placed, whether on the surface or in underground galleries, so that they might be periodically maintained. While the irrigation channel served industrial production, washing and power generation facilities, the pipeline met needs that required better controlled water quality.

The water mills, which once totalled forty in number, are now almost all extinct. However, one or two well-preserved examples of this very specific heritage have been safeguarded, so that we can today observe the richness of these lands in their peak years.

In the center of Alcobaça, there are also traces of this heritage related to water, perceptible, to a greater or lesser extent, as interrelated with the presence of the Alcôa and Baça Rivers. From the imposing stone gutters that run along the streets of downtown Alcobaça, the channel then passes underneath one or another building in the center of the village, or even supplies a fountain discreetly located near a particular building.

The natural resources of the region, and, in particular, the two waterways, Alcôa and Baça, became fundamental, firstly for the building of the monastic complex and, from there, for disseminating the interconnected structuring poles that created the Couto of Alcobaça (Figs. 6 and 7).

One of the driving forces of the Alcobaça monastic domain was the Alcôa River. This was the river that, after changing its course, then divided in two, near Alcobaça, with one section passing through the middle of the monastery cloister before arriving in the village. The local hydrographic structure clearly delineated the richness and diversity of Alcobaça, rendered visible in the monastery's structures, with the parishes distinguished by their functional specificities.

Monastic hydraulic engineering reached well beyond the diversion of streams or springs, instead being characterized by the implementation of intricate channel and drainage systems that sustained these monastic complexes and guaranteed their habitability by providing drinking water and disposing of waste waters. Ellen Arnold provides the example of the Maulbronn monastery in Germany, with a water channel that runs through the whole complex, and with its subterranean,

Fig. 6 The Baça River. Photos by the author, 2016

open-air canals containing at least one mill along their course, one of many examples in Europe (Arnold 2007).

All of the activities developed by the monastic communities had to be delineated in keeping with the hydraulic system and, therefore, designing a viable and efficient scheme across the different functional requirements constituted a great challenge. It

Fig. 7 The Alcôa River. Photos by the author, 2016

was first necessary to set up a drinking water network through recourse to extraction via mines or wells, the water then being channelled through an externally insulated plumbing system that was stored in cisterns or tanks before its final distribution throughout the various zones of the complex, such as the fountains, washbasins and kitchens. Alcobaça thus incorporated a base structure enabling the utilisation of

water, whether for domestic purposes, fish farming, agriculture or the powering of hydraulic mechanisms.

Alcobaça was itself supplied by an underground system of running water beginning 3.5 kilometres away on the site of Chiqueda de Cima, southwest of the village, although there is also some uncertainty over the existence of a spring well within the monastic fence that may have contributed to the decision to construct the complex there. However, the most important water line created was the irrigation channel that was connected to the Alcoa River, which not only provided a greater flow for the irrigation, but also powered the forges. Due to the irregularity of the flows, which rose in the winter before falling away in the summer, the monks needed to build a dam to regulate the water levels. Although this dam still remains in perfect condition, other sections of the water system have changed over the years, whether as a result of programmatic changes in the complex or due to landslides (Tomé 2016). These descriptions, resulting from observations made locally (Maduro et al. 2017), are, in many cases, difficult to decode, as the passage of time has modified these constructions, and the lack of written documentation, in some cases, forces us to formulate purely hypothetical solutions. However, the descriptions of the Alcobaça hydraulic system deserve our analysis and study of the various constituent parts, thus enabling a line of reasoning based on the available information that may more accurately gauge the reliability of the monastic hydraulic system structure. One of the most important facets of this structure was the irrigation channels that supplied water to the existing fields, orchards and kitchen gardens. There were synergies arising from these irrigation channels, specifically, the link with the fruit trees that benefited from the irrigation of the kitchen gardens. These spaces often contained, and Alcobaça would be no exception, a water point, a waterwheel (of Arab design), a dam or irrigation channels arriving directly from the river and designed and implemented by specialist monks called "openers" (Martins 2015). These devices constituted the primary structure of irrigation that then gave way to the farmers who administered the secondary channels. Finally, it was the task of the peasants to maintain these functional channels, which would become blocked during the winter as a result of the strong currents and debris carried by the heavy rains of that season. The level of water circulation in the channel network was insufficient, and retention correspondingly fundamental for times of greater scarcity, especially the drier summer period. This led to the installation of sinks or cisterns that would hold this water for farmers to use when needed. Two important sinks still remain visible today, both on Quinta de Vale de Ventos, which was once one of Alcobaça's monastic farms. The first, called Pia da Serra, covered an area of 15.00 × 9.00 m and was 3.00 m in depth, built out of blocks of limestone and covered by a cradle vault. This cistern is particularly interesting in terms of construction, given how it takes full advantage of the function for which it was built: it includes a small window in the smaller walls to obtain water via a bucket and a small exterior sink in a limestone block for the cattle to drink from, alongside a patio to collect rainwater for this same cistern through carved grooves on the floor. This would have served as a watering point for the livestock and, eventually, for the irrigation of sweet lime and orange orchards

(Maduro 2015). The other tank, called Pia do Olival, located about 800 m from Pia da Serra, was built in masonry and spanned 56.00 × 29.00 m, with a maximum depth of 3.50 m. We know that this was built in the third quarter of the eighteenth century by Luiz Pereira (Ribeiro 1908: 154) and with the key function of irrigating the extensive olive groves planted in the previous century, as well as some vegetable gardens and orchards (Souza 1929). Also forming part of this structure were the Alcoa river mills established on some of the Couto de Alcobaça farms. Such was the case with the four-stone mill and the six-sided mill of Quinta da Chiqueda, the three-stone mill of the Quinta das Freiras de Cós, and the Fervença factory. With the abolition of the monastic orders in 1834, these hydraulic engineering works were sold at a public auction, and many had been destroyed or had their uses changed by the end of that century. As we approach the interior of the monastery, the path of the waterways soon becomes clear, especially in the cloisters.

In the four existing cloisters, and although water remains the consistent source for the magnificent lavatory, it is in the Cloisters of the Cardinal and the Novices that the presence of water is most greatly felt, due to the channel that is fed by the irrigation channel arriving from the Rio Alcôa.

The water-related architectural details are a constant presence, be they testimony of the past, like the gargoyle mounted over the washbasin (*lavatorium*), which functions as a rainwater collection point, or resulting from contemporary interventions, such as the calcareous gutters that delimit the geometric design of the cloister's parterres.

If there is one built space that especially welcomes the water flowing through the channel, it is undoubtedly the majestic monastery kitchen, with its large sinks and famous water tank. Beckford (1835: 37–38) said, in his book *Recollections of an Excursion to the Monasteries of Alcobaça and Batalha*: "I verily believe, the most distinguished temple of gluttony in all Europe, my eyes never beheld in any modern convent of France, Italy, or Germany, such an enormous space dedicated to culinary purposes. Through the center of the immense and nobly groined hall, not less than sixty feet in diameter, ran a brisk rivulet of the clearest water, flowing through pierced wooden reservoirs, containing every sort and size of the finest river-fish."

From 1726 onwards, water made its presence felt in the Obelisk Garden, in the fountains lined with green tiles and white Moleanos stone and in the monastery kitchens beginning to fill their tanks with drinking water from the Chiqueda mine.

11 Conclusion

Over the course of Portuguese history, Alcobaça and its monastery have undergone continuous changes, a consequence of both climatic conditions and human intervention, in particular, the attempts at conquest by invading countries. The natural conditions were often adverse, especially flooding and the horrendous earthquake of 1755, which left deep marks. In relation to the direct actions of man, we encounter two destructive dynamics afflicting the monastic complex. On the one

hand, the actions carried out by Napoleon's troops during the French invasions and, on the other hand, the uncontrolled looting by the local population, which, as mentioned above, following the 1834 abolition of religious orders, irreversibly stripped away the great heritage held by the monastery.

Particularly remarkable was the excellence of the monastic library, which dazzled with its richness, its bibliographical content rigorously described by Manuel Vieira Natividade in 1885. Furthermore, today, despite all of these historical vicissitudes, it remains a respectable collection, distributed among several institutions (Giurgevich & Leitão, 2016), notably the National Library of Portugal.

Since 1989, Alcobaça has become one of the great examples of landscape and monastic architecture, with state institutions and civil society participating in carrying out a series of initiatives to recover and preserve this extraordinary monastic heritage of Portugal.

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