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The water culture of the Order of Christ in the making of a self-sufficient and sustainable hydric system

Ana Duarte Rodrigues, Desidério Batista, Clara Marques, Ignacio García-Pereda and João Puga

KEYWORDS: **hydraulic system, water wheels, reuse water, water pumps.**

JEL CODES: **O13, O31, O33, Q25.**

Focusing on the Convent of Christ in Portugal, this article presents an overview of the power and control exercised by the Order of Christ over the territory's water management, inside the monastic enclosure and over the Nabão River, from the late fifteenth century until the nineteenth century. Based on multi-interdisciplinary methodologies, we argue that the monastic enclosure was multi-functional, sustainable, self-sufficient and the stage for the most sophisticated hydraulic system of early modern Portugal. Following a recent review, and based on archival research, a 3D reconstruction and mapping tools, we demonstrate that the system did not work exclusively through gravity. In an early phase, pumps were in use at the Convent of Christ circa 1537 to remove water from cisterns in a technology transferred from ships into gardens. Moreover, this article also reveals the total control of the Order wielded over the Nabão as a source of energy through to the abolition of Religious Orders in 1834.

A cultura da água da Ordem de Cristo na construção de um sistema hidráulico autossuficiente e sustentável

PALAVRAS-CHAVE: **Sistema hidráulico, rodas hidráulicas, água reutilizável, bombas de agua.**

CÓDIGOS JEL: **O13, O31, O33, Q25.**

Focando-se no Convento de Cristo, este artigo apresenta uma visão geral do poder e controle da Ordem de Cristo sobre a gestão da água no território, no interior da cerca e ao longo do rio Nabão, desde o final do século XV até ao século XIX. Baseado em metodologias multi e interdisciplinares, nós argumentamos que a cerca era multi-funcional, sustentável, autossuficiente, e palco para o mais sofisticado sistema hidráulico da Idade Moderna em Portugal. Contra trabalhos recentes, e baseados em investigação arquivista, reconstruções 3D e ferramentas de mapeamento, demonstrámos que o sistema não funcionava todo por gravidade. Numa fase recuada, cerca de 1537, no Convento de Cristo, bombas eram usadas para tirar água das cisternas – uma tecnologia provavelmente transferida das naus para os jardins. Para além disso, este artigo também revela o total controlo da Ordem sobre o rio Nabão como fonte de energia até à extinção das Ordens religiosas em 1834.

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Ana Duarte Rodrigues [orcid.org/0000-0002-9786-7465] *is a professor and researcher at the Inter-university Centre of the History of Science and Technology, Universidade de Lisboa Address: Centro Interuniversitário de História das Ciências e da Tecnologia, Faculdade de Ciências, Edif. C4, Piso 3, Gabinete 15, Campo Grande, 1749-016 Lisboa (Portugal). E-mail: amnrodrigues@fc.ul.pt*

Desidério Batista [orcid.org/0000-0001-5289-6185] *is s a researcher at CHAIA and professor at the Universidade do Algarve. Address: Universidade do Algarve, Faculdade de Ciências e Tecnologia, Campus de Gambelas, 8005-139 Faro (Portugal). E-mail: dbatista@ualg.pt*

Clara Marques [orcid.org/0000-0002-8480-8837] *is a researcher at the Inter-university Centre of the History of Science and Technology, Universidade de Lisboa. Address: Institutional address: Centro Interuniversitário de História das Ciências e da Tecnologia, Faculdade de Ciências, Edif. C4, Piso 3, Gabinete 15, Campo Grande, 1749-016 Lisboa (Portugal). E-mail: cxmarques@gmail.com*

Ignacio García-Pereda [orcid.org/0000-0003-1956-3412] *is a researcher at the Inter-university Centre of the History of Science and Technology, Universidade de Lisboa. Address: Centro Interuniversitário de História das Ciências e da Tecnologia, Faculdade de Ciências, Edif. C4, Piso 3, Gabinete 15, Campo Grande, 1749-016 Lisboa (Portugal). E-mail: ignnaccio@hotmail.com*

João Puga [orcid.org.0000-0002-5755-3074] *is a researcher at the Inter-university Centre of the History of Science and Technology, Universidade de Lisboa. Address: Centro Interuniversitário de História das Ciências e da Tecnologia, Faculdade de Ciências, Edif. C4, Piso 3, Gabinete 15, Campo Grande, 1749-016 Lisboa (Portugal). E-mail: joaopugaalves@gmail.com*

1. INTRODUCTION

The Convento de Cristo (hereafter Convent of Christ) takes a leading role in the history of Portugal after having served as the headquarters of the Templars before its later incorporation into the Order of Christ. This site has been recognised by UNESCO as World Heritage since 1983 and its rich history is embodied in its walls and landscapes. The Convent of Christ "is an authentic compendium of the history of architecture and surprisingly summarizes its various chapters" (Pereira, 2003: 10), since its structure comprises the Romanesque, Gothic, Manueline, Renaissance, Mannerism and Classicism (Pereira, 2009).

The choice for the convent's location, on the peak of a hill, and the meticulously thought out and built hydraulic program were to underpin the success of this religious community. Flanked by two valleys and with a steep slope, this hill contemplated ideal strategic military defensive conditions (Freitas, 2018: 81).

As a reward for the crusade undertaken by the Knights Templar Order against the infidels, the first king of Portugal, D. Afonso Henriques (*ca.* 1110-85), awarded them control over the Tomar region. Their convent was founded in the twelfth century and the main chapel, called the *charola*, was concluded circa 1230. However, following the abolition of the Templars, the Order's assets and properties were assigned to the Order of Christ, which maintained close ties to the Portuguese monarchy (Costa, 1771; Santos, 1879; Vasconcelos, 1988; Costa, 2008). D. Henrique (1394-1460), the Navigator, the mythical personality behind the voyages of discovery, led the Order of Christ in the first half of the fifteenth century. Another great leader of the Order, King Manuel I (1469-1521) undertook a significant phase of constructions in parallel with religious reformation. Moreover, he endowed the Order of Christ with exclusive rights over the waters of the Nabão River through a new charter law in 1510 (Rosa, 1971: 133; Valla, 2016). This is the opening landmark for our article as we seek to convey the absolute power held by the Order of Christ over water management, both in the convent's enclosure and in the region of Tomar through to the abolition of religious orders in 1834.

Focusing on the water management and control of the Convent of Christ, as well as the control over the Nabão River, this article aims to detail the upgrading of the hydraulic system existing in the convent's enclosure between the fifteenth to the nineteenth centuries and correspondingly demonstrate that this was the most sophisticated hydraulic system in the early modern Portugal.

The hydraulic systems of convents' complexes have received some attention in recent decades. However, studies covering the usage of waterpower from Ireland to France, from

Islamic Spain to Germany, have focused on the medieval period (Squatriti, 2000; Magnusson, 2002). International historiography acknowledges that medieval water systems, especially those concerned with drainage, are similar in every region of Europe, "except for Christian Spain" as this was "heavily influenced by Islamic technology and practices and seems to have stood somewhat apart from the rest of Europe in its hydraulic history" (Magnusson, 2002: xi).

In recent decades, the literature was expanded by studies on monastic hydraulic systems in Portugal (Quintela, 1996; Jorge, 2012, 2017, 2018; Puga, 2020). However, they have all primarily focused on describing the circuits and with many issues remaining unanswered, in particular, a better understanding of its relation with different historical contexts from the maritime expansion until its transference into private ownership, followed by governmental acquisition.

As regards the historiographic literature on the Convent of Christ, most studies focus on the imposing architecture built by the Knights Templar from the twelfth century through to its heyday in the sixteenth century (França, 1994; Moreira, 1995; Pereira, 2003; Bento, 2013; I. M. S. Silva, 2002; R. J. N. Silva, 2018). However, its surroundings have received less attention from historiography, despite some academic works on the convent's enclosure (Barbosa, 2003; Tibério, 2005). For example, the functioning of the Convent of Christ hydraulic system has already been addressed (Jorge & Mascarenhas, 1999), including particular works dedicated to the seventeenth century aqueduct (Jana, 1990; Antunes, 2009, 2012, 2019). Urban history has also paid attention to the unusual development of the city of Tomar, shaped firstly by the power of the Knight Templars and then by the Order of Christ (Trindade, 2014; J. C. Dias, 2017, 2019). Industrial archaeology has also dedicated some studies to the industries that emerged along the Nabão River in the late eighteenth and early nineteenth centuries, profiting from the energy generated by operational water wheels (Custódio, 2009; Barbosa & Genin, 2019).

Taking advantage of all these inputs, this article argues for a change in perspective through interweaving the boundaries between the history of science and technology, water history, agricultural history, and landscape studies in order to analyse the wise water management of the Order of Christ not only in the monastery's inner circle but also extending its reach to the convent's enclosure and controlling the Nabão River waters. This interdisciplinary research methodology enabled us to establish bridges between archival

research, historical printed sources, and field work, including drone flights, in order to apply several mapping tools[1] and generate a 3D reconstruction[2].

To unfold our arguments, we divided this article into four sections. Section one covers the integrated and systematic interpretation of the spatial organization and the reconstruction of the hydro system alongside the region's agroforestry patterns before and after the construction of the convent's enclosure in the 1530s. Section two is dedicated to the transformation driven by the construction of the aqueduct to meet the growing water needs of the religious community, specifically, to increase the production of edible plants at the turn of the seventeenth century. The third section approaches the building of multiple water wheels and hydraulic structures along the Nabão River to foster industrial[3] production in a period when the Order of Christ still retained the strength to block and/or control the construction of any water device along the Nabão River. In 1767, when the fields lost their status as a conventual establishment and leased out to a citizen of Tomar, Manuel Lopes, for the price of 150 *alqueires* (a historical agrarian measure), of olive oil[4], it became known as the Quinta dos Sete Montes (Seven Hills' Estate), celebrated in the novel "*Lusitânia Transformad*a" (Oriente, 1607). However, the powers of the Order of Christ only changed dramatically under a totally different political regime

1. The methodology used by Clara Marques (figures 1, 2 and A4) to create the urban maps was centred on the morphological decomposition of the space, in which the different extracts from different periods were mapped. This method of analysis is supported by the French and Italian schools of urban morphology, as well as the studies of the Portuguese school of geography. For the construction of the cartography of the conventual fence and enclosure, Portuguese Military Mapping Images by the Military Geographic Institute (number 310 for the years of 1969 and 2003) and maps and images created by Barbosa (1995, 2003), Bento (2013, 2014) and J. C. Dias (2017) were consulted, as well as other bibliographic references described throughout the text. The final maps presented were elaborated using the software Adobe Photoshop, Adobe Illustrator and CorelDRAW.

2. The three-dimensional representation made by João Puga (Fig. 4) were based on the following documentary sources: Topography of the terrain based on the Military Chart of Portugal, Geographic Institute of the Army, Series M888, Sheet 310; and modelling of the total extension of the aqueduct as well as the morphology on the ground was carried out in accordance with the designed pieces prepared by the architect Tiago Molarinho Antunes (Antunes, 2009).

3. The precise classification of each of these structures constructed along the Nabão River has been lost. Regardless, we can confirm that the most famous one, the Mouchão water wheel, follows the Syrian model, meaning a vertical water wheel with buckets in clay. Furthermore, the enormous water wheel from the Nabantina Factory, of 5 meter tall, is classified as a vertical undershot water wheel (Jack, 1989: 55), with variable power of 15 to 35 horsepower (Custódio, 2004: 10). For more about water wheel classifications, see Dias, Oliveira and Galhano (1959), Dias and Galhano (1986), and Reynolds (1983).

4. Arquivo Nacional Torre do Tombo (ANTT), Ordem de Cristo, Convento de Cristo, mç 76 and ANTT, Ordem de Cristo, Convento de Tomar, M.º 63 (Rosa, 1969: 366). *Alqueires* could refer to kilograms or to the area required to produce that amount of products. Therefore, we translated it into hectares and estimate that it means approximately 51 acres.

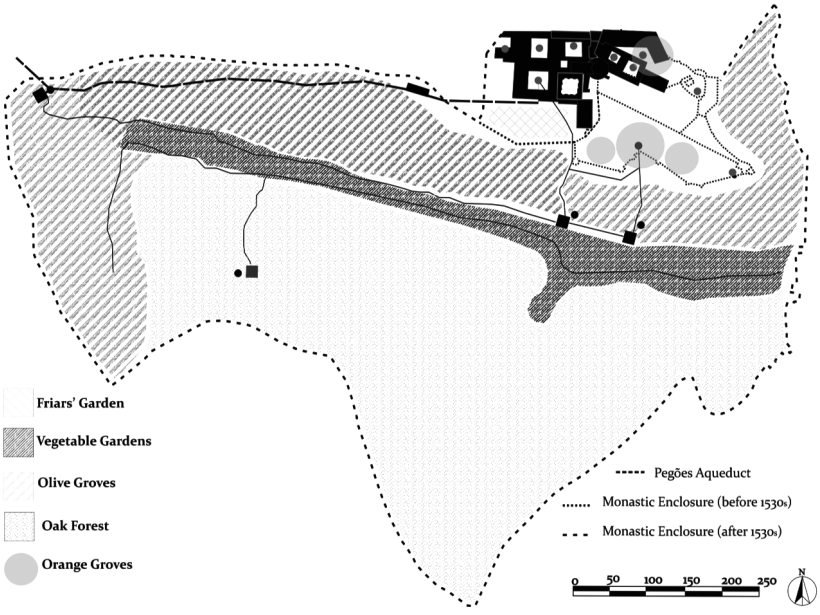
and in the wake of the closure of all religious orders in 1834. Finally, in section four, we tackle the fall of the Order of Christ's empire with the end of its absolute power over the waters of the Tomar region. In this phase, both the convent's enclosure and the rights to water usage along the river fell into the hands of private owners and Tomar's political, social and economic landscape changed sharply.

2. WATER MANAGEMENT EXPERTISE IN THE EARLY STAGES OF THE CONVENT'S HYDRAULIC SYSTEM

The wise management of natural resources, including water, stands out as the main principle adopted by religious communities in rural contexts. Therefore, valleys with fertile soils and available water were dedicated to irrigated agriculture with the driest areas given over to rainfed agriculture, such as olive groves, vineyards, and cereals; and these were complemented with forestry and pastoral systems further up the slopes of hills (Fig. 1). The landscape unit of the convent of Christ very much synthesizes this model. The sustainability of the religious community relied on this multifunctional model, which included production, protection, contemplation, devotion, and recreation.

FIGURE 1

Map of the monastic enclosure of the Convent of Christ high lightening vegetal cover



Source: Clara Marques.

The geomorphological conditions and the biophysical characteristics (relief, soils, water, vegetation, and climate) of the territory lay behind exercising control over the fertile land, access to water and protecting the populations. Settling on the east-facing slope, protected from the dominant winds of the northern quadrant, fostered bioclimatic comfort. The territory's geology is marked by the limestone massif that dates to the Jurassic and Cretaceous periods and in which rocky outcrops, shallow soils, reddish Mediterranean and even alluvial valleys may be identified. This forms part of the Coimbra-Tomar limestone massif landscape unit, bridging the transition to the landscapes making up the hilly area of the Ribatejo district, characterized by slightly rugged reliefs low in altitude (between 200 and 400 meters). Under the influence of a maritime and continental climate, with rainfall of around 780 mm/year, this region features typical Mediterranean vegetation in which the Portuguese oak stands out (Cancela d'Abreu *et al.*, 2004: 9-17). This biophysical support maintained a relatively dense and branched hydrographic network related to the karstic Penela-Tomar aquifer system, fed by direct recharges and drainage of underground water and lesser levels of permanent and temporary springs (Almeida *et al.*, 2000).

These natural conditions constitute the matrix structure to which the historical process of humanization of territories and the respective model of occupation and spatial organization adapt. This adaptation to ecological conditions reflects how successive territorial logics (territorial regroupings, multipolar territorialization, large territorial units, etc.) have been implemented. Historically, these establish the basis for constructing a multifaceted and diversified landscape in which land use was always fairly heterogeneous. This all resulted in a varied agricultural mosaic with areas of watered polyculture adjacent to watercourses and with the olive groves dotting the slopes having identified the region ever since medieval times in keeping with the donation of olive groves to the Order of Christ by the king and private landowners.

The olive groves of Maria Vasques, of Sete Montes and Sete Vales, Cardas and Cerzedo were integrated into the heritage of the Order of Christ in the fourteenth century (Rosa, 1940: 228). In the fifteenth century the olive grove of Nossa Senhora da Piedade was also donated to the Order of Christ (Rosa, 1965: 42). Consequently, the King donated the olive press, hitherto belonging to Pero Afonso, to the Order of Christ in 1499 in exchange for 168 *alqueires* (approximately 59 acres) of olive oil per year[5]. The Order of Christ then incorporated the olive grove called *Monte Piolhinho* in 1510, the *Monte de Santa Bárbara* in 1520 (Rosa, 1966: 351-57) and, with more olive groves from *Monte Piedade* donated to the Order by Maria Lopes, daughter of Brás Pires, in 1521 and

5. ANTT, Fundo da Ordem de Cristo, Convento de Tomar, M. 70, in Rosa (1971).

1524 (Rosa, 1965: 180, 201). The properties of the Order of Christ were continuously growing in keeping with the pace of donations both from the king and from private landowners and with a huge expanse of olive trees existing long before construction of the wall.

By the end of the fifteenth century, the medieval era building had been extended. King Henrique was the first to commission new constructions, such as his palace, the Claustro do Cemitério (Cloister of the Cemetery) in 1420, and the Claustro das Lavagens (Washing Cloister) in 1433 (Rodrigues, 2015). Given the impossibility of extracting enough water from wells, cisterns were built into each of these cloisters (Fig. A1, online[6]). At the turn of the sixteenth century, the decadence then prevailing in the Order of Christ led to the convent's first enclosure, ordered by King Manuel I with the first wall built in 1499. Moreover, the convent's surroundings already contained other landscape parcels by the end of the fifteenth century. Near the palace of King Henrique (Paços Novos) there was an orange grove (Rosa, 1972: 77). Moreover, in the area previously occupied by lay persons inside the old nucleus of the Tomar Castle[7], who were expelled in 1499, a new orange grove (*novo laranjal*) was planted. By the 1530s, this new orange grove was being embellished with tanks[8] and decorated walls, probably covered by tiles[9]. In addition to these orange groves, there was also an orchard (*pomar*), probably including different fruit trees or another word would have been applied[10].

Near the old palace, there was also a garden at an early stage in the convent's history. The literature already acknowledges this garden (Rosa, 1972: 77) but new data, stemming from the 1535-37 Book of Expenses, highlight some of its features. Indeed, usage of the word *jardim* (garden) in 1537 still remained rare. The most common Portuguese words for defining a garden and a gardener at the turn of the sixteenth century were *horto* and *hortelão*. This means the convent garden identified as *jardim* in all likelihood reflects a more

6. Complementary figures will be available online: https://doi.org/10.26882/histagrar.090.x06d

7. The Templars premise looked like a castle in medieval times. It is in the sixteenth century that the complex acquires the scope of a convent.

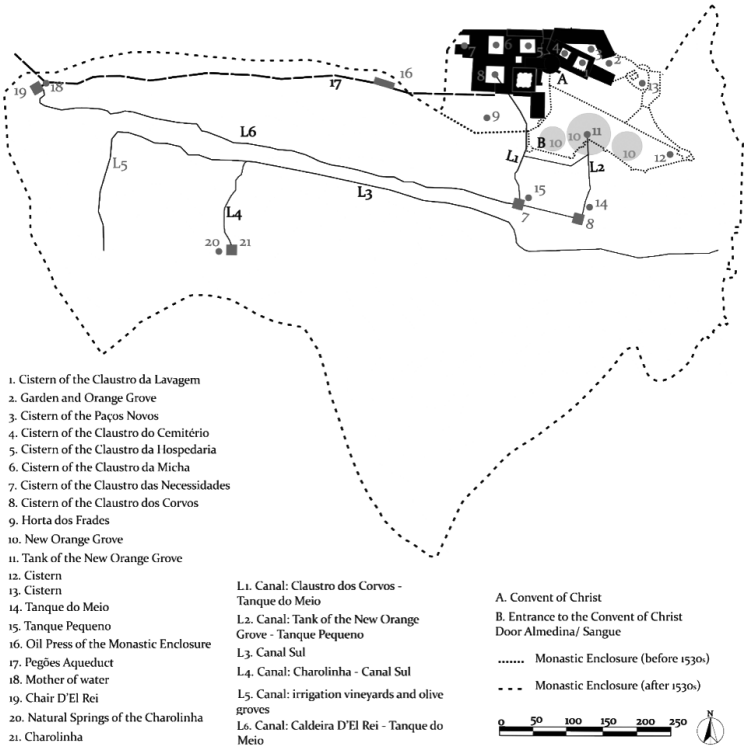
8. "item pagou de xj gatos de ferro para os tanques / do laranjal oytenta e oyto reis / item De dous aratees de chumbo pagou quorenta / reis para os dictos tanques /". ANTT, Fundo da Ordem de Cristo, Convento de Tomar, Book of Expenses (hereafter, ANNT/FOC/CT/BE), liv. 23, f. 71r, 1537.

9. "i*tem* pagou mais ao dic*t*o Anriq*ue* Bras de ladri / lhar hu*m* peitoril do lara*n*jal /". ANTT/FOC/CT/BE, liv. 23, f. 77v, 1537.

10. "item pagou mais o dicto recebedor a Martim Gonçallez ga/leguo de quatro meses que servjo nas obras /do pomar de dentro da çerca a rezam de trezentos /e trinta e cinquo reis por mjl iij R reis". ANTT/FOC/CT/BE, liv. 23, 1535.

erudite model. Documentary evidence tells us this was paved by a stonemason[11], and probably decorated with tiles. Moreover, watering the garden made use of water stored in a cistern extant on the site[12].

FIGURE 2
Map of the monastic enclosure of the Convent of Christ with water devices and structures



Source: Clara Marques.

Throughout the sixteenth century, and within the walled perimeter, terraces were compacted, courtyards were paved and the irrigation system was extended throughout the planted area (Fig. 2).

11. "item pagou a Fernande Annes pedreiro. de sua /empreitada de fazer a calcada do jardin /de dentro do cerco scilicet ate o poco. Mjl e iijc reis /". ANTT/FOC/CT/BE, liv. 23.

12. "item pagou o dicto recebedor a Anrique Bras pedreiro seis / mjl e cinquoenta reis de duzentas e duas / braças de ladrilho que ladrilhou nas ruas / e cisterna do jardim dempreitada de suas mãos / a rezam de trinta reis por braça perante mjm / Sobre dicto seprivão /". ANTT/FOC/CT/BE, liv. 23, f. 88v.

Archaeologists and architects have focused on interpreting the monument and advocated the system functioned exclusively by gravity (Jorge, 2018; J. C. Dias, 2019). However, we would argue that the system did not only work by gravity as put forward by recent review. Furthermore, with the technological advances available at the convent, the system was based on sustainable principles in which "every drop counts" seems to have been the leitmotif.

In 1590, one of the first chroniclers of the Order of Christ, the Spanish friar Hieronymo Roman, stated that the extension of the convent included the construction of tanks and cisterns in the fifteenth and sixteenth centuries[13]. There are only two medieval wells documented since the twelfth and thirteenth centuries: one in the Cloister of Cemetery and another near the north wall of the same cloister (Jorge & Mascarenhas 1999: 44; A. C. Dias, 2019: 63). These wells had supplied the community living inside the castle during medieval times, on the side that became the orange grove. However, in general terms, the water supply was secured by cisterns, and not by wells due to the prevailing geomorphological conditions and the aquifer (limestone rock with deep underground waters). At the same pace as the population grew, the construction of cisterns became mandatory for any closed and self-sustainable community. Thus, rainfall was channelled from the roofs to the cisterns with this system guaranteeing enough water for the basic needs of the religious community (Dias & Barbosa, 2018: 163). Besides this means of supply, the documentation reveals a curious fact: women would also carry water to fill the cisterns[14]. On the other side, pumps would then extract water from the cisterns at the Convent of Christ, as of 1537[15], including one located in the Washing Cloister[16].

This fact dismantles the idea that the Convent of Christ hydraulic system functioned exclusively by gravity. There is no doubt that human and technological inputs supplemented the system. Furthermore, to the best of our knowledge, the pumps in the gardens

13. Hieronymo Roman (1650-1750). *Libro primeiro [-segundo] de la historia de la ynclita Cavalleria de Christo en la Corona de los Reynos de Portugal; Historia de la inclita Cavallaria de Santiago en la Corona de Portugal; Historia de la inclita Cavalleria de la Orden de Avis en la Corona de Portugal*. Biblioteca Nacional de Portugal, OESA, Casa dos Condes de Tarouca, cópia do mesmo punho, atl-74.

14. "item pagou a duas molheres de carreto dagua /para a cisterna. Dia e meio cada huma /", and f. 26r, "item pagou mais a duas molheres de agoa que /a carretaram esta somana para a cisterna /". ANTT/FOC/CT/BE, liv. 23, f. 25v.

15. "i*tem* De huma arroba de breu p*ar*a as bo*m*bas / da cisterna e de vinte arate*e*s de ~~cumb~~ / chu*m*bo p*e*ra as mesmas bombas quat*r*o/cent*os* e quore*n*ta r*ei*s / i*tem* mais o dicto r*ecebed*or a Joha*m* Felipe / carpe*nteir*o de maconarja de seis dias e m*ei*o / q*ue* trabalhou nas dictas bombas a Lxxx r*ei*s /. ANTT/FOC/CT/BE, liv. 23, f. 69v.

16. "i*tem* De hu*m*a bomba p*ar*a a cisterna da crasta do*n* / de lava*m* os freires co*m* custos oytocento*s* / e dez r*ei*s os q*ua*es pagou o dicto r*ecebed*or /". ANTT/FOC/CT/BE, liv. 23, f. 89r.

were quite exceptional in this period. In general, water technology and its usage in gardens was conservative and based on the wisdom acquired by gardeners, who would only irrigate their plants with watering cans when necessary (Tchikine, 2016). We are only able to identify records of one other pump in the Queen's garden in the Paço da Ribeira Estate in 1526 with this technological advance clearly related with the crown and the ongoing maritime expansion. Moreover, documents reveal clearly that the pumps to the Queen's garden were transferred from the shipyards to the well in the garden[17]. There is data on pumps in the Roman empire, including a force pump used in mines in the Portuguese territory[18]. However, from Antiquity onwards, pumps became quite rare and their reappearance in Renaissance treatises on garden irrigation only occurs in the late sixteenth century. Specific pumps for watering gardens appear in Thomas Hill's *The Gardeners Labyrinth*, published in 1577. A larger array of pumps and different mechanical devices features in Salomon de Caus's *Les raisons des forces mouvantes* (1615). The recording of pumps at the Convent of Christ at such an early stage as if merely just one another technical artifact conveys how pumps were not rarely in use in Portugal. Furthermore, this also acknowledges how pumps for extracting water were already continuously in use in ships (Oertling, 1996; Bendig, 2020). As the Convent of Christ was closely related with the Portuguese Crown, the transfer of scientific and technological knowledge from the maritime expansion had huge impact into its development as occurred in every aspect of daily life, from social order to the scientific fields as medicine and artistic as theatre (Costa, 2016; Alves, 2019). Therefore, although the documents we quote are from the 1530s, it is possible that pumps were then in use at the convent in keeping with the building of cisterns, interweaving the technological novelties of the *Art of Navigation* pushed forward by the challenge posed by the maritime expansion.

The system's sustainability was secured by the reusage of grey waters –a key trend in contemporary times but already in effect at the convent in the fifteenth century. The convent operated a double hydraulic system, one with clean water and another with greywater. The storage in separate cisterns was completely different in accordance with the purpose of water usage (Berardino, 2018). The grey waters resulting from the friars washing and the kitchen were collected in the *bloco das necessárias* (sanitary facilities). During this process, grey waters were mixed with other organic materials, enabling the production of a

17. "Conheço e comf... eu ?ro Vaaz al*mox*arife destes pacos e casa da Jndia / q*ue* rece*b*i de Bastia*m* G*onçal*ez al*moxarif*e da Rib*ei*ra hu*m*a bomba /com sua vara p*ara* o poco do Jardim e fica(???) / em v*erda*de por mi...???... escriuão de seu cargoe fiz esta e asinamos... dos em xx de fevereiro /de LXXbi /... de Soejro Va*az* almox*erif*e / Das casas de hua /bomba e sua vara /q*ue* lha dey p*ar*a o poço / da Rajnha / Ano de 526". ANTT, Corpo Cronológico, parte 2, maço 139, doc. 53.

18. Information given by Matteo Valleriani. See this website on water machines in Antiquity. https://drupal.mpiwg-berlin.mpg.de/watermachines/home

natural fertilizer, that was then conducted to irrigate the *horta dos frades* (friars' vegetable garden) (Jorge, 2018) (Fig. A2). This was an intelligent and sustainable way to both reuse water and fertilize the land. Therefore, this has also been considered "one of the most ancient wastewater treatment systems" in Europe (Berardino, 2018: 636).

The moral decadence prevailing in the convent led King João III to enact further reform in the 1530s that, through deploying stricter rules for the closure of friars, led to the construction of another wall around the productive and forestry area as this fostered the self-sufficiency of the community of eighty friars. King João III commissioned a large program of works from the architect João de Castilho in 1530, which Fray António de Lisboa[19], a member of the Order of Hieronymites, was appointed to supervise (Guimarães, 1901: 121). He was inspired by the Rule of Saint Benedictine to reform the Order of Christ into a more purist way of living. This brought about not only the widespread renovation of the buildings, with the construction of more dormitories, cloisters, chapels, refectories, and another infirmary but also led to the implementation of an irrigation system based on local points of water adduction –the Charolinha natural springs and located near the convent's foothill.

The documentation regarding the assessment, selection, and allocation of properties to unify under the convent's rule is known (Rosa, 1966: 215). These properties were acquired in 1529 and with construction of the wall beginning in 1532, spanning around 40 hectares and, thus, establishing a landscape unit providing for the self-sufficiency of the religious community (Barbosa, 2003: 29). Henceforth, the water supply did not only depend on the cisterns and with the scope for taking greater advantage of the stream traversing the enclosure. Although the water from the medieval well and cisterns was able to meet the needs of the monks and the building in general, it was not enough for agriculture and horticulture in the monastic enclosure.

Therefore, to supply this new area of cultivation, which included a natural stream, the Order of Christ friars also built canals to transport water across the property called *levadas*[20]. The Ribeira da Ribafria (hereafter Ribafria Stream) traverses the monastic enclosure and with the vegetable gardens located along the banks of the stream. The area closer to the convent includes two tanks; the Tanque do Meio (the Middle Tank) and the Tanque Pequeno (the Small Tank) supplied by water running along a very rudimentary

19. António Moniz da Silva, known as Fray António de Lisboa, was prior of the Convent de Christ and was in charge of the expansion of the Convent, as well as the Order of Christ's religious reform. His dates of birth and death are unknown.

20. Stone canals built to conduct water from one place to another.

channel cut into the slope. On the other side of the Ribafria Stream, irrigating the vegetable gardens made recourse to a canal that transported water from the Charolinha (Renaissance circular temple) tank, which is presumably to have been constructed by João de Castilho in the 1530s, during the Convent of Christ expansion works (Moreira, 1991; Serrão, 2002; Costa, Rocha & Pereira, 2019). This was, in turn, fed by the natural spring that looks like a grotto. The Charolinha stands out as an example of the multifunctionality of water related spaces within the monastic enclosure. Here, the application of water reached far beyond utilitarian purposes. A Renaissance temple, in the manner of Bramante's centralized projects, stands in the middle of a circular lake, adding devotional and recreational dimensions to utilitarian purposes.

Between 1554 and 1562, the architect Diogo de Torralva worked on the Convent of Christ and in this period designed and built the Great Cloister on the orders of Queen Catarina in 1557[21] following the death of King João III. Hieronymo Roman considers that the cistern under the Great Cloister (1558) is one of the largest and with the highest capacity in the entire Kingdom of Portugal to such an extent that it would never be depleted. Therefore, we must conclude that water was available up until 1590.

3. RESHAPING THE SYSTEM THROUGH CONSTRUCTING THE AQUEDUCT

When Philip II of Spain became King Philip I of Portugal in 1580, he also became Master of the Order of Christ. The Convent of Christ was the site chosen by Philip II of Spain to gather the Court to recognize him as King of Portugal. Therefore, the significance of this powerful setting was further reinforced during the Philips dynasty. The leading Italian architect Filippo Terzi (1520-97) became Master of Works at Tomar in 1584. One of his tasks was to build an aqueduct to channel water into the lands of the convent's enclosure of the Seven Hills (Fig. 3).

Prior to this date, the only aqueducts built in Portugal were to supply towns with water, such as the Setúbal aqueduct commissioned by King D. João II in the fifteenth century, the Água de Prata aqueduct in Évora, and the Amoreira aqueduct in Elvas, both built by the architect Francisco de Arruda in 1537. Moreover, 1570 saw the construction of another aqueduct to supply the medieval village of Óbidos. The Convent of Cartuxa was getting its water from a well equipped with a *nora* from the seventeenth century and from a deviation built into the Água de Prata aqueduct, authorized by Royal Decree on 20th

21. ANTT, Ordem de Cristo, No. 102, f. 21 v., in Viterbo, 1922, vol. III: 130-31.

February 1592 (Caetano, 1991; Jorge & Mascarenhas, 1999). By this point, a new branch in the aqueduct must have been built to become the only case in which water from a public aqueduct was deviated to a convent's enclosure in sixteenth century Portugal. The Aqueduto do Convento de Cristo (Aqueduct of the Convent of Christ) represents the first to channel water exclusively to a religious complex. This work served as a "monumental statement of princely beneficence" and as a means of consolidating the relationship between royal power and that of the Order of Christ (Tchikine, 2020: 139).

FIGURE 3
The Aqueduct of the Convent of Christ

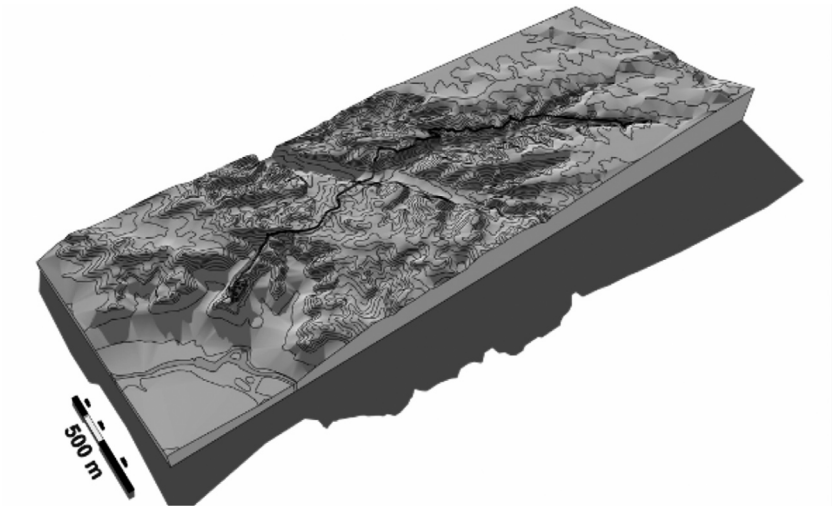
Source: photograph by Desidério Batista.

The aqueduct begins in the parish of Carregueiros at an altitude of around 153 meters (Antunes, 2012). It collects water from the Cano and Vale da Pipa, Cú-Alagado, and Porta de Ferro mines and springs (Fig. 4). Through half-reeds or "U" gutters, water was bled and directed towards larger structures where impurities were decanted before being fed into the great *levada*. This integrates storage tanks, manholes, flood control gates, discharges routes for transferring excesses, diversions for cleaning and connection boxes, sedimentation and impurity decantation, and even water division.

The aqueduct covers 5 miles over 180 arches settled along an irregular landscape of slopes and contour lines. Part of the architecture embeds 58 round arches over 16 pointed arches based on piers along extensive regular and homogeneous sections. The aqueduct guaranteed the gravitational flow of water through underground galleries, sur-

face sections, and elevated masonry arches (Antunes, 2012). The project implied the calculation of acceptable slopes, the sizing of considerable sections, the reduction of internal friction in the channel, the choice of suitable materials and surface coatings, and the introduction of energy sinks. This gentle decline could not be achieved only through empirical methods[22]. Hence, efforts sought to ensure reasonable flows by controlling their velocities and turbulence regimes and thereby reducing overflows and erosive processes that might potentially damage the structure. Its architecture also displays concerns over maintaining such a large construction. This reflects in the access built into the underground sections and the walkways and service passages that accompany the raised gutter channel.

FIGURE 4
The 3D reconstruction of the Aqueduct of the Convent of Christ over the topography



Source: João Puga.

The beginnings of such a vast undertaking started out with the acquisition of the lands around the springs through to the payment of the first salaries corresponding to work starting on the aqueduct's construction covers the period 1593 and 1595. From 1595 to 1600, the supply of materials was registered, including plumbing sticks, slabs and ash as well as wood, stone, gravel, and lime to construct the arks for fountains, springs, arches or the

22. In the opinion of the hydraulic engineer Dídia Covas from the Technical University of Lisbon (IST), some mathematical calculations typical of hydraulic engineers had to be made. The same can be deduced by the research and calculations on its slope along the entire length by Tiago Antunes (2009).

pegs and masonry buildings of stone, brick and stonework (Antunes, 2012: 268). In order to build the aqueduct in a straight line to diminish costs and time of execution, the construction was designed to overcome topographic impediments such as rocky obstacles, elevations or depressions to improve the work's efficiency (Antunes, 2019: 151-53). The water houses along the aqueduct were concluded in the late sixteenth century. The passage of water through these sections may be confirmed for 1613. The aqueduct finishes with a row of arches addorsed to the convent walls under the supervision of Diogo Marques Lucas (Rosa, 1980).

FIGURE 5
O Cadeira d'El-Rey

Source: photograph by Ana Duarte Rodrigues.

The aqueduct was officially inaugurated by King Philip III of Spain, II of Portugal, in person, revealing the aulic importance of the construction. According to the inscription engraved on the monument, King Philip I of Portugal ordered its construction in 1593 with its conclusion in 1613 during the reign of King Philip II of Portugal[23].

At the same time, a large reservoir at the highest level was built to overcome the shortage of in rainfall (partly stored in cisterns) and supplement the low flow levels of local springs, called Cadeira d'El-Rei (hereafter King's Chair) as it resembles a Baroque chair (Fig. 5). This perspective envisioned the entire monastic enclosure while once again in-

23. "O Invictissimo e Muito Catholico Rei | D. Philippe I do nome e da Pia Venera | vel memoria com real liberdade | mandou fazer este aqueduto em | o anno de mil quinhentos e 93 | com a mesma o Agustissimo e Cris | tisnismo Rei D. Philippe seu filho segundo do nome o fez acabar 1613".

termingling utilitarian purposes with aesthetical and recreational facets. The reservoir enabled an expansion in the irrigated cropland and acted as an aquarium for fish farming.

From 1614 onwards, the convent's enclosure began to be supplied by the water transported through the aqueduct which enters directly into the King's Chair. From this stage, the water is filtered at the Casa de Água (House of Water), and follows two different paths after this: on the one hand, the water flows into the olive press and, on the other hand, into the hydraulic system of the convent (Antunes, 2019: 158 and Silva, 1998: 12). It intentionally reaches the convent at the height of 127.15 meters, to ensure the capacity to distribute water across several levels of the building and directly or indirectly supply sources such as washbasins, sanitary facilities and kitchens (Antunes, 2012: 269).

The water reached the dormitory's lavatory –as the inscription on the stone reveals– in 1617 (Fig. A3). A brief comparison with the lavatory of the Monastery of Batalha highlights the sophistication of Tomar's case. In 1436, the Monastery of Batalha was devising the construction of channels to bring water from springs into the monastery's lavatory located in the royal cloister (Jorge, 2017: 108). This lavatory may resemble a cloister fountain but was dedicated to daily life activities as then often occurred (Rodrigues, 2015). This differed from the comfort provided by a washbasin located on the convent's first floor, near the novices' dormitory as was the case in the Convent of Christ.

Therefore, the whole construction stands out as an example of technological capacity, which engaged the best national and international experts (Berardino, 2018). The making of the aqueduct involved a large array of professionals, including cutters, bricklayers, carpenters, blacksmiths and many other skilled workers and servants. Functional and aesthetical concerns lay behind the options of the decision-makers to such an extent that the masters enrolled in this work decided to build the aqueduct in a straight line even though this was more expensive and just because it was "more beautiful" (Rosa, 1980: 14). Following the death of Filippo Terzi, the Portuguese architect Francisco Lopes pursued the construction of the aqueduct. This work was then continued under the supervision of Pedro Fernando de Torres, who oversaw water arriving in a new fountain established at the centre of the Great Cloister in 1619 (Antunes, 2012: 267).

A few decades after the construction of the aqueduct, the convent's enclosure would be reaffirming its capacities as a production unit structured precisely according to the water matrix. The complementarity and connection of the pre-existing sixteenth century irrigation system with the new aqueduct fed system, express the fundamental role of water, in conditions of flow and abundance, to boost horticultural production and meet the needs of the growing community of friars.

The hydro system was perfectly adjusted to the topography and morphology of the terrain, channelling water from the King's Chair through the *levada* excavated into the hillside, to the abovementioned pre-existing smaller tanks, strategically located on the left bank of the stream, at different levels of elevation, and from which gardens and orchards were watered in carefully worked and cultivated plots. In the former period, the vegetable gardens were limited to the irrigation provided by the two tanks near the stream. However, the King's Chair underpinned an expansion in the perimeter of irrigation and cultivation as it became possible to irrigate the valley's terrains from their highest point downwards.

The hydraulic system influenced the landscape of the convent's enclosure, enhancing its productive dimension through irrigated polyculture that was complemented by rainfed crops, such as vineyards and olive groves, the forests on the steepest slopes, and the crops and pastures in the hillocks. The diversified landscape mosaic of the convent's enclosure to date reproduced the traditional agricultural, forest, and pastoral system, configuring in its microcosm a multifaceted landscape that the religious community then built as a key factor for ensuring its self-sufficiency. In it, water plays a vital role related to both the established model of land exploitation and the multiple functions provided to the community: irrigated agriculture and fish production (in the big tank), watering of animals, manufacturing work (olive oil mill), and recreation. The landscape and the water heritage took on different expressions, more vernacular in the traditional irrigation system and more erudite in the reservoir and the Charolinha. Water spatially organized the convent's enclosure through a network of collection, transport, and distribution through a continuous and branched system whose functionality required technical knowledge across the facets of both construction, maintenance, and usage. In fact, the water-wise management and hydraulic infrastructures certify a repertoire of knowledge, techniques, and processes for a pragmatic, but also religious, approach to the usage of water.

4. THE POWER OF THE ORDER OF CHRIST OVER THE NABÃO RIVER

The exploitation of the river and its resources was an exclusive right of the Order of Christ, and constantly evoked by their members whenever disputes arose over the right to build water wheels, mills, and other structures along the Nabão River[24]. The Order of Christ had held exclusive powers over the Nabão River, by force of law, since 1510 and was reinforced by King Filipe I in 1590, who stated that no mills should be built along the stream

24. "Requerimento de Bernardo Daniel de Moraes para a abertura de uma Fábrica de Papel em Tomar, 1799" (Bernardo Daniel de Moraes' Application for the opening of a Paper Factory in Tomar). ANTT, Ministério do Reino, mç. 687, proc. 37.

of Tomar and, if necessary, the Convent should build them (Rosa, 1968: 26) This right also guarantee the Order of Christ absolute power over the management of the territory of Tomar, which led to the foundation of a unique patterns of urban occupation within the Portuguese national panorama.

The walled village appeared next to the Templars Castle in medieval times. At the same time, another settlement emerged in the lower zone: one lay at the foot of the castle hill and with the other located next to the Nabão River and the milling facilities built by the Order of the Temple to leverage the energy produced by hydraulic wheels[25]. The set of these structures was known as the Levada of Tomar, built in the twelfth century. The Levada has always maintained a social function in Tomar by producing the oil and flour necessary for the population and maintaining its fundamental worth for the local economic development. Along the Levada, new mills appeared and with the subsequent deepening of the Canal da Levada to provide appropriate conditions for the general operation of all the mills along the banks in this area.

At the turn of the sixteenth century, King Manuel I carried out a program to improve the Levada in search of better water service for the mills. A wall was built on the urbanized side of the village, enabling water devices to take advantage of the Levada's water flow. The former mill and olive press were renamed after D'El Rei, showing the royal power of Manuel I in the Order. The King reshaped the riverfront in order to enhance its productive facet (Fig. A4). These changes consolidated the importance of the Levada de Tomar. The following structural changes would only take place in the mid-nineteenth century following the abolition of religious orders in Portugal when industrial firms took over the Order of Christ mills.

Right from the beginning of the Templar settlement of this area, several edible gardens appeared on the banks of the Nabão River, such as the Order Garden, later renamed Horta d'El Rey[26] (the King's Vegetable Garden) (J. C. Dias, 2017: annexes, plan 7), the closed gardens of João Coito and others along with the Sítio do Prado (Prado's Site) and the

25. Regarding the water wheels and the mills in the Levada of Tomar, there is confirmation that "Three of the six mills are described *as azenhas*, three as *moinhos*. The distinction between azenha and moinho in this case is that the *azenhas* had vertical undershot water wheels, whereas the *moinhos* were powered by horizontal wheels called *rodizios*" (Jack, 1989: 54). It is important to point out that there is a great variety and different types of hydraulic wheels in Portugal, a justifiable aspect in view of the geographical and cultural diversity present in the Portuguese territory.

26. From the Horta d'El Rey came blocks of pavement to the convent in 1536. "i*tem* De vinte e seis carregos de lageas s*cilicet* de carreto dellas da /orta delrey a este *convent*o pagou o dicto r*ecebed*or a Joha*m* / F*e*rr*nandez* a cinquo r*ei*s a carrega /". ANTT/FOC/CT/BE, liv. 23, f. 50v.

Quinta da Granja (Granja's Farm). On the riverbanks, there were vineyards and olive groves, for instance, Vinha da Várzea (Floodplain Vineyard) and Olival do Flecheiro (Flecheiro Olive Grove). Indeed, they had, for centuries, marked and characterized the landscape of Tomar in conjunction with the water wheels built to irrigate these areas, such as the Mouchão vertical water wheel (Fig. 6).

FIGURE 6
The vertical water wheel of Mouchão in Tomar

Source: photograph by Ana Duarte Rodrigues.

The energy potential of the Nabão River fostered the construction of different hydraulic structures along its course down through the many centuries of human occupation in this region. Through applying David Egerton's "technology-of-use" concept, Ana Duarte Rodrigues and Magdalena Merlos Romero demonstrated that hydraulic wheels contributed more to the development of agricultural areas during the early modern period than when first invented in classical times. These systems were reinvented throughout this period, incorporating innovations and adaptations according to the different temporal and geographical contexts (Rodrigues & Merlos, 2020: 331). Simultaneously, the emergence of new cities and population expansion, coupled with the development of different industry segments, contributed to increasing demand and consequently driving the development of better water usage systems. As hydraulic wheels were designed according to their historical and geographical context, these structures were then modified to better integrate the landscape and needs of the region. Therefore, the technological transfers from Antiquity and from al-Andalus to the Iberian landscape of the early modern period were not a simple process imitation but rather managed to cope with several challenges in

adapting this technology to the Iberian context. Given the complexity of these structures, the construction of hydraulic wheels furthermore required specialist artisans (Rodrigues & Merlos, 2020: 340).

The Arabic influence becomes clear when comparing the existing Mouchão water wheel in Tomar to the Syrian model. In Portugal, due to a culture rich in regionalisms and different natural territories, there was a great typological variety of hydraulic wheels (Dias, Oliveira & Galhano, 1959). This thesis is confirmed by the existence of documents that cite different water wheels in operation along the Nabão River[27]. There were water wheels not only for the production of energy but also for irrigation, which provided agricultural surpluses and fostered a greater population density. Therefore, facilitating urban development.

The Mouchão water wheel in the center of Tomar is exceptional in the Portuguese national scenario, both due to its considerable proportions and its authentication of the historical reports of the Arab influence over the construction of hydraulic structures and the importance of water wheels to consolidating the settlement of territories. This water wheel served for irrigation and not for the production of energy.

The Mouchão weir, which serves the Mouchão water wheel, was typically built on pine poles, grass and sand, being destroyed at the beginning of the floods in October and rebuilt in May every year (Ferreira, 1976: 49). This type of weir, the "stilt weir", dammed up the water and sent it to the channels for the wheels to work. In order to reach the adequate current force, that is, the force necessary to push the wheel blades, a certain difference in level was needed between the various reservoirs of the weirs (Ferreira, 1976: 42).

Nevertheless, in Tomar, hydraulic wheels were essential both for irrigating lands along the banks of the Nabão River and for operating the mills and olive presses and, later, the industries that emerged in the region from the sixteenth century onwards. Thus, these wheels acted directly in developing and consolidating the city's urban space, characterizing and shaping the landscape along the Nabão River. The water wheel would only be replaced as the main energy source towards the end of the nineteenth century.

Although it was only following the abolition of the religious orders that fast and concrete industrial development came to Tomar, important industries had settled in the region in the eighteenth century. Among these, the Royal Spinning Factory stands out,

27. ANTT, PT/TT/ 77118, m0212-m0214; *ibidem*, m0201-m0208; *Diário de Governo*, No. 256 for auction on January 23, 1836, of the goods of the Order of Christ (Rosa, 1966: 430). Complete list of auctioned goods and lands, in Rosa (1966), and Dias and Galhano (1986: 46).

founded in 1789. The factory adopted the "water frame" system, a hydraulic spinning machine powered by the Nabão River, which operated a wheel chain that drove the machinery. Furthermore, this created the need for a weir, built in 1789 and now classified as a Monument of Public Interest, changing both the river and the landscape[28].

Before religious orders ended in Portugal, several attempts to build other factories along the Nabão River had been registered in plans to transform Tomar into a Portuguese industrial center (Custódio, 2009). However, since recent review, further documents have emerged revealing initiatives to build a paper factory on the Prado Site. In 1772, there was an attempt by the Marquis of Pombal to build a paper mill here[29]. In keeping with the intentions of the Marquis to transform Tomar into an industrial centre, the Real Junta de Comercio (Royal Trade Board)[30] expropriated the aforementioned buildings with the objective of converting them to paper industry production. However, the friars were not about to renounce their rights. The Convent of Christ friars maintained it was not only their loss but also of the public they served and this paper factory was never built. This event demonstrates the power of the Order of Christ in the decision-making processes over managing the Tomar territory, including the exploitation of its waters.

The second attempt to build a paper industry came from the entrepreneur Bernardo Daniel de Moraes in 1799[31]. The request of Bernardo Daniel de Moraes to open a white and brown paper industry on the banks of the Nabão River included a set of official reports produced by the different parties involved in the process. In view of the location chosen by the applicant to locate his industry and its expected utilization of the weir waters, positive responses were needed from the administrator of the Royal Spinning Industry and the head of the Order of Christ. The conflict of interests was evident.

Moraes intended to open a paper industry at Prado Site[32], in the same place where once a bloomery furnace had once operated. The applicant proposed using water from the Granja's Farm channel, owned by the Order of Christ, and the weir at the Prado Site. A short distance away, an old but well-built weir was found which, by damming most of the waters of the Nabão River, directed them through a ditch to operate the mills and olive

28. Ordinance No. 285/2013, DR, 2nd series; No. 91, 05/13/2013.

29. Document from the Royal Trade Board for the foundation of the Prado Paper Factory, https://www.papeldoprado.com/empresa

30. Portuguese state body responsible for regulating and promoting general trade.

31. Its transcription is published in Marques (2021).

32. Prado Paper Company came to existence but long after Moraes, in 1875, with the union of the Prado Paper Factory and Matrena Paper Factory.

presses owned by the Convent of Christ. Moreover, these waters also irrigated several fields owned by the Order of Christ and with the remaining used by the Spinning Industry. The requirement submitted to the King by Moraes was analysed by the *Mordomo-mor* (Lord Chamberlain), who deemed his proposal would cause damage to the irrigated lands and mills of the Convent of Christ. Likewise, the friars of the Convent of Christ stressed they also opposed the Moraes request. As the entire area of Tomar was owned by the Templar Order and, consequently, by the Order of Christ, it was their privilege to build mills and olive presses along the Nabão River. Thus, the population was unable to use the river's water resources without their consent. Therefore, just as in 1772, the Convent of Christ friars refused the Moraes request. They considered the weir and its waters were their own and maintained that the construction of the industry would cause a lack of water for the functioning of their mills and for such reason jeopardising the public interest and, ultimately, the Crown itself due to the loss of tithes. Moreover, there was a great concern that industrial activities on the Nabão River might alter and corrupt its waters. Although the Order of Christ had already entered into decline by the late eighteenth century, it still retained its powers of influence and decision in Tomar.

In both cases, the Order of Christ came out against the proposals and neither factory was built. Water is essential to life and, considering the exclusive right of the Order of Christ over the waters of the Nabão River, their members dictated the terms of development to Tomar. As the Order accumulated wealth and conquered a place of great power, directly influencing the political decision-making in the kingdom and dictating the rules for the development of Tomar, only after 1834 did any fast and focused industrial development in the locality become possible. Following the abolition of the religious orders in Portugal, the interest in these structures remained. The water potential of the Nabão River and the existence of hydraulic wheels that had once belonged to the Order of Christ but were now suddenly available attracted businessmen to the region. In the following period, the Marianaia Paper Factory, Sobreirinho Paper Factory, Porto de Cavaleiros Paper Factory, Prado Paper Company, and Matrena Paper Factory were all founded. Thus, Tomar had become a pole in the national paper industry by the end of the nineteenth century.

5. THE ECCLESIASTICAL DISENTAILMENT AND THE FALL OF THE ORDER OF CHRIST

The Tomar economy was adapting to industry and trade rather than agriculture and was one of Portugal's most prosperous and leading cities in the nineteenth century, a place of power in a prime location with access to the Nabão and Tagus rivers (Filipe, 2019). In May 1834, legislation was enacted that incorporated into the state all of the assets of

monasteries and male convents dissolved by the Court agreement (*Memória*, 1842). This represented the beginning of the process of ecclesiastical disentailment. Its roots may be traced back to Enlightenment ideology, but it was reinforced by the Liberals due to the financial difficulties encountered in the final stages of the *Ancien Régime* (Serrão, 1987).

The first measures took place in 1809 under the Napoleon imposed government of Jean-Andoche Junot (1771-1813), first Duke of Abrantes, suppressing the Portuguese monastic and mendicant orders and confiscating their property as national resources and extended to the seizure of the assets of ecclesiastical communities (Castelo Branco, 1989; Joanaz de Melo, 2015). In 1821, ecclesiastical communities were forbidden from acquire any revenue-producing property to prevent the establishment of new holdings under the auspices of the church. However, this first wave of disentailment gained practically no traction.

However, anticlerical ideas and the country's critical economic problems lay behind the abolition of religious orders in 1834. Under the terms of the Decree of 30th May 1834, the real estate, revenues, rights, and shares of male religious communities were declared national property while stipulating their sale at public auction. Moreover, the Portuguese government received full powers to begin seizures following a vote of confidence in the Court (Silveira, 1993). These were principles typical of every bourgeois revolution and must be understood within the atmosphere of the period and the government's constant dire financial straits, severely worsened by the civil war between liberals and absolutists (1832-34). The measures affecting male religious orders resulted in the extinction of 382 existing communities (Silveira, 1993). Female convents, which were not included in the 1834 Decree, were sentenced to gradual disappearance.

The intent to seize church lands and reclassify them as "national goods" for disposal to private owners was well-publicized (Maduro, 2017; Maduro *et al*, 2017). The criticisms of the religious orders –exposed at length in the preamble to the Decree of 30th May 1834– resemble those previously formulated in the early 1820s. The regular clergy had long been the object of criticism with its diffusion favoured by the decadence of monastic life, of which there are many testimonies from the second half of the eighteenth century (Beckford, 1835). The radicalization of the position of the liberals vis-à-vis the clergy was certainly dictated by the active participation of the friars in the civil war in the forces of the putative King Miguel I (1802-66). A flurry of articles highlights how the benefits and risks of the repartition of land were vehemently debated in the daily press.

The *Diário de Governo* of 9 November 1837 placed some of the Order of Christ estates up for sale. The building was put up for auction at a price of $4000 *reis* (historical

Portuguese currency) with the ruined section of the convent going for $800, including two vegetable gardens with wells, orange groves and orchards or fig trees; and the convent's enclosure available for $5000 *reis*, which included the inner walls and lands cultivated with wheat, vineyards, olive groves, orchards, vegetable gardens and forest (Rosa, 1967: 450, 462). The politician António Costa Cabral (1803-89), in May 1838, when only a national member of the Parliament, bought up sections of the Tomar Convent of Christ and its Sete Montes agricultural estate in May 1838 (Barbosa, 2003: 35). He had decided to establish his summer residence there and turn it into a productive estate. Attesting to his interest in these spaces and awareness of their high heritage value, he took measures to safeguard the convent that had been subject to plundering ever since the departure of the friars (Fig. A5). The convent's Sete Montes enclosure sought to provide a refugee, a site for reflection and the contemplation of nature, a peaceful location away from Lisbon's political turmoil.

Costa Cabral was a politician who, among other positions and functions, was a parliamentary member, Minister of Justice and Ecclesiastical Affairs, Minister of the Kingdom, and President of the Council of Ministers. After defending the September 1836 Revolution, his political conduct evolved in more moderate directions. Considered worthy of the attentions of Queen D. Maria II despite his modest origins, he was made Count of Tomar (in September 1845, when the Queen stayed in the Tomar convent). The royal family became regular visitors of Costa Cabral as Tomar was envisioned as an idyllic rural retreat.

Costa Cabral turned into one of the most controversial figures in the consolidation of the liberal regime, admired for his reformist talent, but vilified and openly accused of corruption. He was subsequently forced to go into exile in Madrid in the wake of the Maria da Fonte Revolution but he would return a few years later, thereby demonstrating his capacity for recovery and persistence, to become head of the government. As soon as Costa Cabral entered the government in 1839, he brought about the appointment of guards to protect what he deemed Portugal's most important monument as well as ordering some urgent restoration works. Tomar was also his refuge when he was experiencing great criticism and falling into political disgrace. At the age of 86, on his return from a long posting to the Holy See, he went to the convent to entrust its care to his eldest son. Until the 1930s, throughout three generations, the convent remained in the care of his descendants. However, these private owners could not keep the monument and sold it to the government in 1934 by 700 *contos*[33]. Following this sale, the convent and the surrounding fields

33. *Seminário Regionalista de Tomar*, 21 March 1934.

had different destinies that lay behind the segregation of this multifunctional landscape unit. The convent's enclosure that gathered the productive fields was disputed by the Ministry of Agriculture and Tomar City Council, and part of the convent was occupied by the Army and the other part by the Seminar of Colonial Missions. Only in the 1980s, the whole landscape unit was perceived as a monument of exquisite heritage value, being protected and enhanced until it became a UNESCO World Heritage in 1983.

6. FINAL REMARKS

This research highlights how the Convent of Christ hydraulic system was the most sophisticated in early modern Portugal. The double hydraulic system of clean water and greywater reveals their sustainable usage of hydric resources as every drop was reused. It has already been identified how the Convent of Christ's wastewater treatment system appears to be one of the earliest in Europe. Moreover, a sixteenth century chronicler evaluated the cistern under the Great Cloister as the most spectacular in Portugal, endowing such capacity that it never became depleted. More surprisingly, following archival research, we have been able to demonstrate that the system did not work exclusively through gravity and with pumps in operation to extract water from cisterns, again at an early stage by European standards.

This system also demonstrates the self-sufficiency of the religious community even prior to the construction of the convent's enclosure was built. At this stage, water wise management became mandatory. The enclosure demanded self-sufficiency and the community then had to rely exclusively on local water resources, such as the medieval well, the cisterns and the mine near the Charolinha. The expansion of the community and of their corresponding need for water, whether for domestic consumption or irrigation in the late sixteenth century, underpinned the construction of the aqueduct. Henceforth, this infrastructure secures the water supply of the convent and its enclosure. The sophistication of the construction highlights not only the utilitarian but also the aesthetical concerns of the community. The aqueduct had to be "beautiful", the Charolinha clearly evokes Bramante and the erudite layout of the Chair d'El-Rei reaches far beyond the technical requirements of a reservoir. This stems from the power, wealth, and knowledge of the Order of Christ for which the most acknowledged architects, masters and artisans had worked. We have no doubt that only the combination of local empirical knowledge with calculations based on theoretical knowledge can have resulted in such a complex work, driven by principles of classical architecture and engineering, as well as by Islamic water devices. The Convent of Christ hydraulic system stands out as a paradigmatic example of preindustrial values, such as water wise management, the sustainable production of

yields and aesthetical landscape values. In the nineteenth century, these values shifted, driven by the industrial paradigm focused on progress, resources exploitation and profit. This novel paradigm endangered this heritage as most water wheels were abandoned until they were rescued in the twentieth century by the elites and central government.

Furthermore, the power of the Order of Christ over the waters of Tomar resulted in the emergence of different water devices built along the Nabão River. Firstly, for watering gardens and agricultural areas and operating mills. Secondly, to launch industries in the region. The continuous modifications on the Nabão River, with the introduction of diverse water devices and the constant operation of water wheels and the construction of new weirs for these new industries, changed the river's landscape and remains as a showcase for the powers of the Order of Christ. Its eventual fall into oblivion would not dramatically change the landscape but rather convey the shift of property and rights into private hands. The water wheels along the river continue as the main source of energy into the twentieth century and the convent's enclosure dominated by olive groves maintained its productivity under the ownership of Costa Cabral and subsequently his descendants until it is transferred to the Ministry of Agriculture in the 1930s.

The convent, its enclosure and the Levada of the Nabão River represent a laboratory of water wise management driven by sustainability, self-sufficiency and multi functionality, emerging at the forefront of worldwide innovation in the early modern period. This stems from the privileged relationship ongoing between the Order of Christ and the Crown, from D. Henrique to King Manuel I and King João III, followed by the Spanish Kings Philippe II and Philippe III. This situation saw the technological innovations advanced by the maritime overseas voyages of exploration introduced to the conventual site. However, this strength turned out to be the convent's weaknesses following the fall of the *Ancien Régime*, hollowed out by the Napoleonic invasions before being sold off by the state after the abolition of the religious orders. Notwithstanding this outcome, the convent remains as a symbol of the Order of Christ's power and wealth that enabled the construction of both vernacular and erudite models of water devices and water structures, interrelating water and culture in a way unique to the history of Portugal.

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