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CHARACTERIZATION OF THE HYDRO-AGRICULTURAL DEVELOPMENT OF THE LEZÍRIA GRANDE DE VILA FRANCA DE XIRA AND OF THE MOUCHÃO DE ALHANDRA

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Title

CHARACTERIZATION OF THE HYDRO-AGRICULTURAL DEVELOPMENT OF THE LEZÍRIA GRANDE DE VILA FRANCA DE XIRA AND OF THE MOUCHÃO DE ALHANDRA

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CHARACTERIZATION OF THE HYDRO-AGRICULTURAL DEVELOPMENT OF THE LEZÍRIA GRANDE DE VILA FRANCA DE XIRA AND OF THE MOUCHÃO DE ALHANDRA

Abstract

The agricultural area of the Lezíria Grande de Vila Franca de Xira is part of one of the case studies at the Tagus Research Site, in the scope of the BINGO project (Horizon 2020). Thus, as a support for the characterization of this area, three exploratory visits were performed to the agricultural area of the upper Tagus estuary, and in particular to the irrigation area of the Lezíria Grande de Vila Franca de Xira (Aproveitamento Hidroagrícola da Lezíria Grande de Vila Franca de Xira) and to one of the adjacent “Mouchões” (the local term for the islands formed by alluvial deposition), the Mouchão de Alhandra. This report summarizes the main findings of these exploratory visits.

Keywords: Exploratory visits / Lezíria Grande de Vila Franca de Xira / Mouchão de Alhandra / Floods / Droughts

CARACTERIZAÇÃO DO APROVEITAMENTO HIDROAGRÍCOLA DA LEZÍRIA GRANDE DE VILA FRANCA DE XIRA E DO MOUCHÃO DE ALHANDRA

Resumo

A zona agrícola da Lezíria Grande de Vila Franca de Xira integra um dos casos de estudo no *Research Site* do Tejo, no âmbito do projeto BINGO (Horizonte 2020). Assim, como um contributo para a caracterização desta área foram realizadas três visitas de reconhecimento a zonas agrícolas localizadas na área de montante do estuário do Tejo, nomeadamente a Lezíria Grande de Vila Franca de Xira e o Mouchão de Alhandra. Neste relatório sintetizam-se os principais resultados e informações resultantes dessas visitas de reconhecimento.

Palavras-chave: Visitas de reconhecimento / Lezíria Grande de Vila Franca de Xira / Mouchão de Alhandra / Inundações / Secas

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1 | Introduction

BINGO - Bringing innovation to ongoing water management - a better future under climate change (Horizon 2020 Research and Innovation Programme, Grant Agreement number 641739) aims at providing practical knowledge and tools to end users, water managers, decision and policy-makers affected by climate change to better cope with all climate projections, including droughts and floods. The project is focused on a set of selected research sites with a high transferability potential to other regions.

The research site in Portugal focuses on water systems from the lower Tagus transboundary river basin, which has pressures likely to be exacerbated by climate change. More than 3 million inhabitants and extensive areas of agriculture are served by these water resources. Water supply, agriculture and hydropower compete for water uses in a scenario that combines a history of riverine and estuarine floods and droughts, and the potential for salt water intrusion from the Tagus estuary. Three specific case studies are addressed at the Portuguese research site: the water supply to the Lisbon Metropolitan Area, the agriculture in the lower Tagus river and upper Tagus estuary, and the floods in the Trancão river basin.

The agricultural area of the Lezíria Grande de Vila Franca de Xira is part of the case study related to the agriculture. Thus, as a support for the characterization of this area, three exploratory visits were performed to the agricultural area of the upper Tagus estuary, and in particular to the irrigation area of the Lezíria Grande de Vila Franca de Xira (Aproveitamento Hidroagrícola da Lezíria Grande de Vila Franca de Xira) and to one of the adjacent “Mouchões” (the local term for the islands formed by alluvial deposition), the Mouchão de Alhandra. This report summarizes the main findings of these exploratory visits.

The report is organized as follows. Section 2 provides a general overview of the main characteristics of the Aproveitamento Hidroagrícola da Lezíria Grande de Vila Franca Xira and the issues related to droughts and floods in this area, and describes briefly the exploratory visits. Section 3 describes the exploratory visit to the Mouchão de Alhandra. The final remarks are presented in Section 4.

2 | Hydro-agricultural development of the Lezíria Grande de Vila Franca de Xira

2.1 General description

The Lezíria Grande de Vila Franca de Xira (hereinafter called Lezíria) covers an area of 13420 ha and is located in the Metropolitan Area of Lisbon, about 25 km upstream of Lisbon, in the municipalities of Vila Franca de Xira and Azambuja (Figure 2.1). The Lezíria is located in the transition between the Tagus estuary and the Tagus and Sorraia rivers. In particular, it is limited in the South by the Tagus estuary, in the North and West by the Tagus estuary and the Tagus river, in the East by the Tagus estuary and the Sorraia river, and at Northeast by the Vau and Risco rivers (Figure 2.1, Figure 2.2). This area is characterized by low elevation terrains (the elevation varies around 1 to 2 meters above mean sea level), with alluvial soils of both fluvial and marine origins (ARHT, 2009), and is surrounded by protection dykes. The Lezíria, along with the "Mouchões" (the local term for the islands formed by alluvial deposition), is extensively used for agriculture. The southern area of the Lezíria is also part of a natural reserve, the Tagus Estuary Natural Reserve, which is one of the most important sanctuaries for birds in Europe.

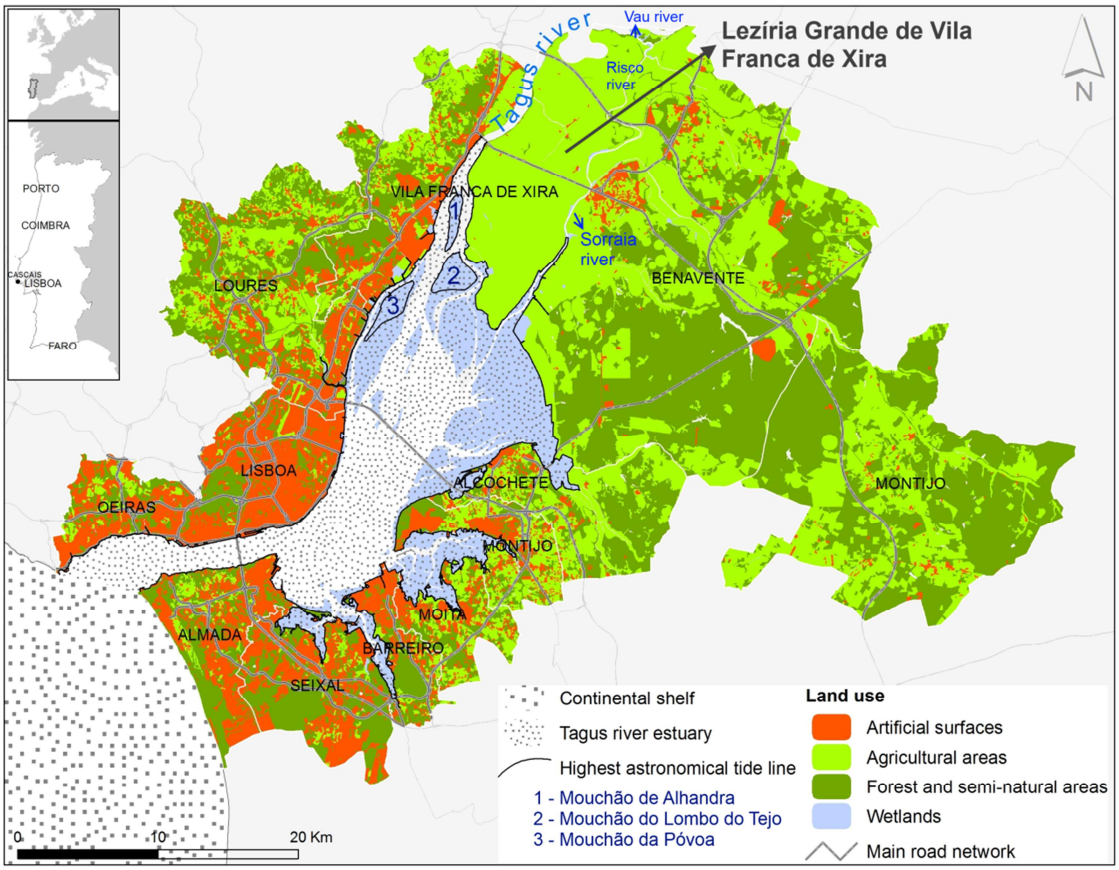

Figure 2.1 – Location of the Lezíria Grande de Vila Franca de Xira and occupation along the Tagus estuary margins (adapted from Tavares et al., 2015)

The irrigation area of the Lezíria is called Aproveitamento Hidroagrícola da Lezíria Grande de Vila Franca de Xira (Hydro-agricultural Development of the Lezíria Grande de Vila Franca de Xira, Figure 2.2). The main crops in this area are the rice (4082.4 ha), the tomato (2923.2 ha) and the corn (1019.4 ha), which represent about 91% of the cultivated area in 2015 (Figure 2.3). Over the past 20 years, both rice and tomato crops have increased significantly in the region: between 1995 and 2015 the area occupied by these two crops grew from about 20% to 80% of the cultivated area. The rice, in particular, has been preferably cultivated in the southern area of the Lezíria due to its higher tolerance to salty water. Presently, the investment in crops is about 60 million euros per year. During the irrigation period (Spring-Summer), the agricultural activities in this area involve about 6000 direct jobs and some additional indirect jobs to the companies providing services and equipment to the sector (https://www.publico.pt/local-porto/jornal/fecho-do-rio-sorraia-salva-culturas-da-leziria-grande-de-vila-franca-36092, accessed on February 12, 2016).

The Associação de Beneficiários da Lezíria Grande de Vila Franca de Xira (ABLGVFX), established pursuant to the terms of the Decree-Law no. 84/82 of November 4, is responsible for the management of the Aproveitamento Hidroagrícola da Lezíria Grande de Vila Franca de Xira, pursuant to the terms of the Decree-Law no. 269/82 July 10, amended by the Decree-Law no. 86/2002 of April 6, and to the terms of the Order no. 1473/2007 of November 15, amended by the Order no. 1001/2009 of September 8. The management of the Aproveitamento Hidroagrícola da Lezíria Grande takes into account the concession contract established between the ABLGVFX and the Direcção Geral de Agricultura e Desenvolvimento Rural (DGADR) in July 22, 2009, entitled “Contrato de Concessão para a Gestão do Aproveitamento da Lezíria Grande de Vila Franca de Xira”, and the concession contract for the use of the water resources established between the DGADR and the Agência Portuguesa do Ambiente (formely Administração Regional Hidrográfica do Tejo), entitled “Contrato de Concessão do Título de Utilização de Recursos Hídricos”.

Figure 2.2 – General map of the Aproveitamento Hidroagrícola da Lezíria Grande de Vila Franca de Xira. Main conveyance and drainage channel (blue line) and gates for water intake and drainage – "Portas de Água" (yellow circles). Background image from ESRI basemap. Adapted from ARHT (2009)

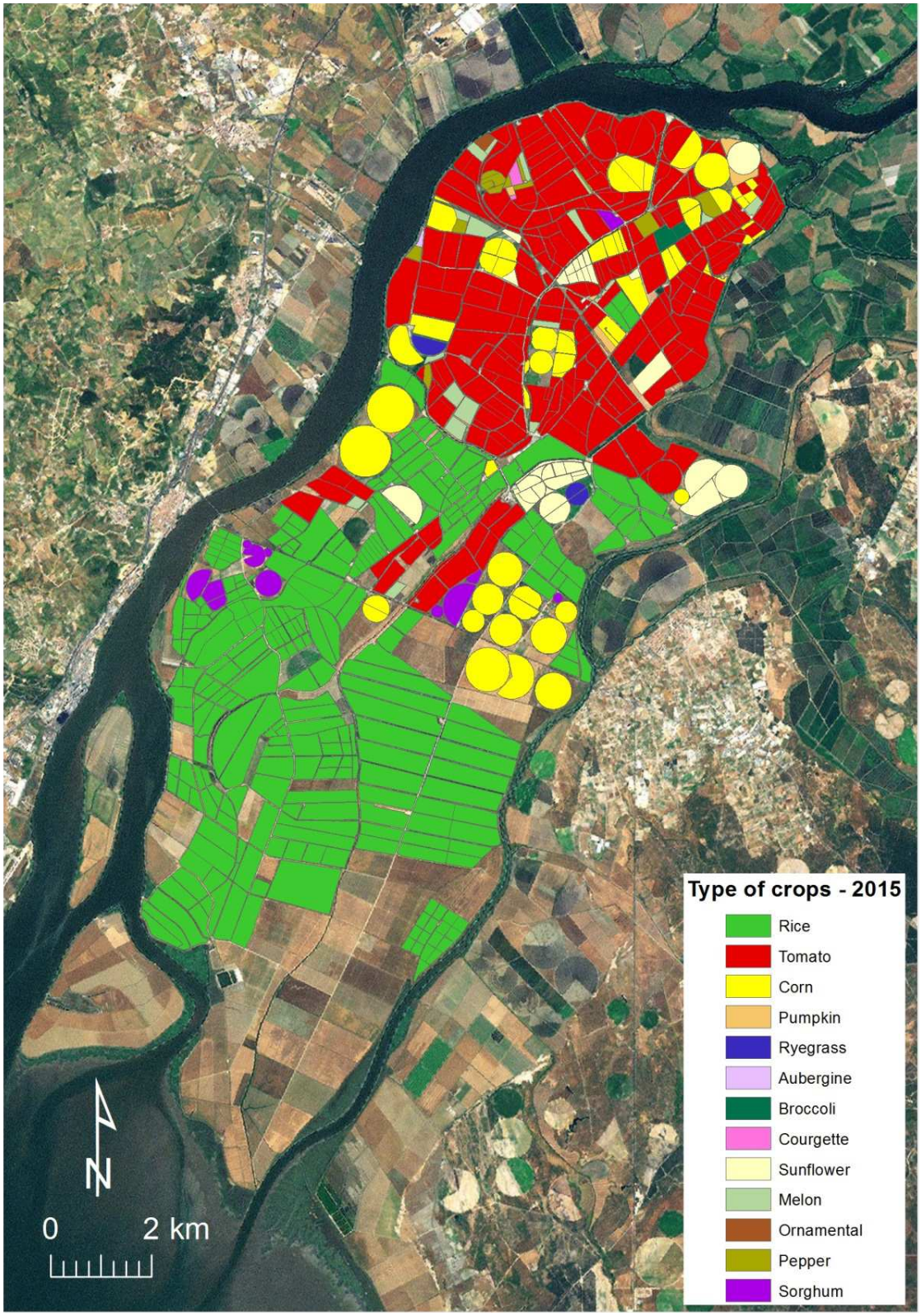

Figure 2.3 – Distribution of the type of crops in the Lezíria Grande de Vila Franca de Xira in 2015. Background image from ESRI basemap. Source: ABLGVFX

2.2 Exploratory visits

Two exploratory visits were performed to the Lezíria, on November 26, 2015, and January 15, 2016. The main sites visited are listed in Table 2.1 and their location is presented in Figure 2.4. Figure 2.5 to Figure 2.11 provide some views of the sites.

Table 2.1 – Sites visited

	Site	Coordinates (PT-TM06/ETRS89)		Observations
		X(m)	Y(m)	
1	Conchoso	-64226.50	-70994.34	Pumping station (water supply and drainage); main water intake
2	Confluence of the Vala Nova, Risco and Vau rivers	-62009.16	-72775.05	
3	Weir of the Risco river	-63381.93	-75294.29	Critical location during floods in the Sorraia river
4	Confluence of the Risco and Sorraia rivers	-62058.44	-78198.29	
5	Vala da Condessa	-66047.53	-80699.55	Location of the temporary weir built during droughts
6	Near the bridge of Vila Franca de Xira	-73097.97	-78887.40	
7	Esteiro do Ruivo	-69799.34	-75732.42	Pumping station (drainage)
8	Portas da Figueirinha	-69092.60	-73151.53	
9	Arriaga	-68912.51	-72522.83	
10	Area of the dyke break during the fluvial flood of 1979	-65384.65	-70916.97	
11	Old dock of Vila Franca de Xira	-73262.26	-79034.89	Area inundated during the February/2010 storm
12	Reference levels of past floods	-73193.05	-79078.23	
13	Reference levels of past floods	-73309.25	-79202.26	
14	Mouchão dock	-74689.81	-86474.74	Area inundated during the February/2010 storm
15	38 Moios	-73882.14	-90155.13	The dyke broke during the 1979 flood
16	Ponta da Erva	-72451.77	-92179.63	The top of the gate was overtopped during the February/2010 storm

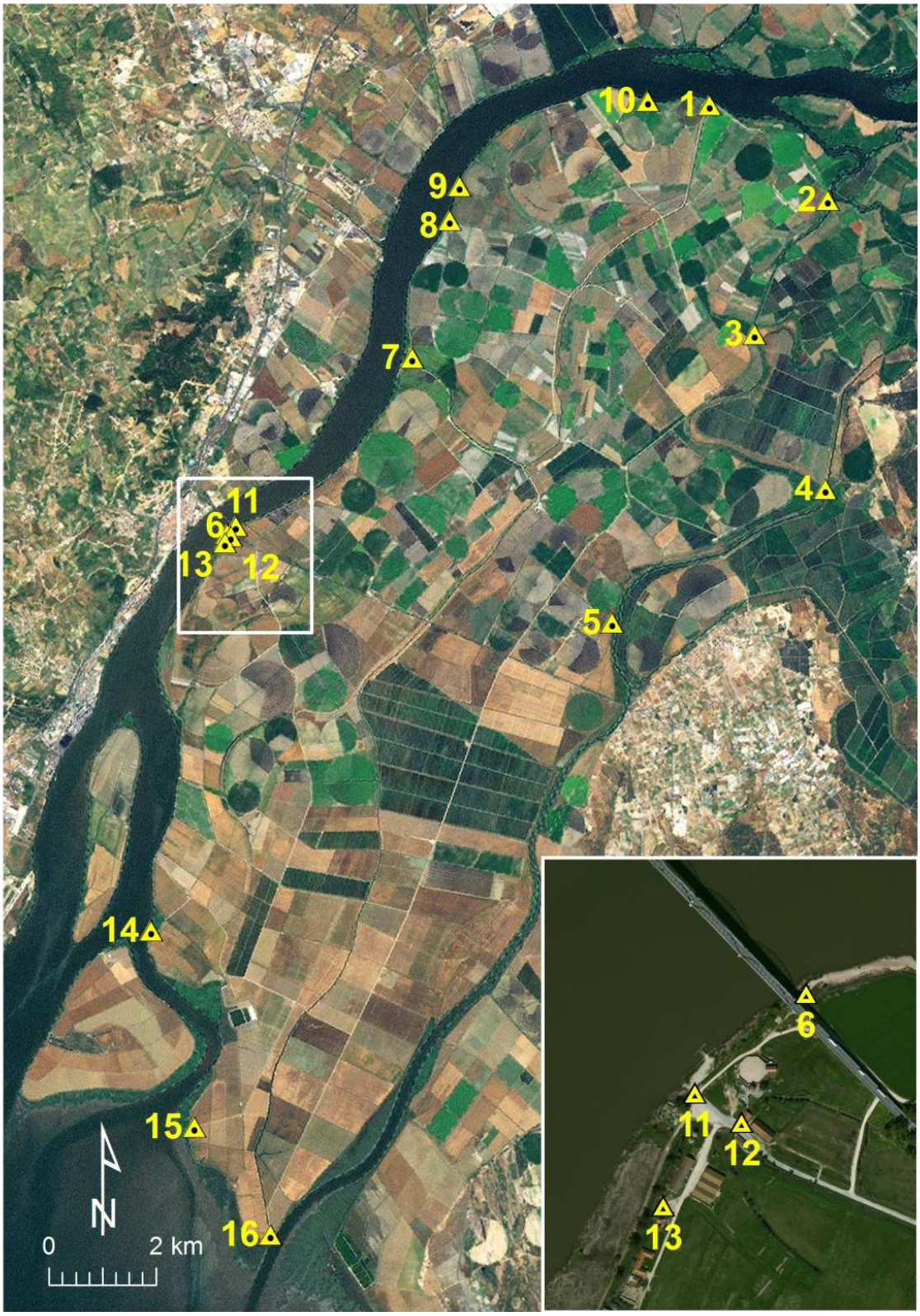

Figure 2.4 – Location of the sites visited during the exploratory visits to the Lezíria Grande de Vila Franca de Xira (Sites 1-10: November 26, 2015; Sites 11-16: January 21, 2016). Background image from ESRI basemap

Figure 2.5 – Site 1: Conchoso pumping station (November 26, 2015)

Figure 2.6 – Site 2: Confluence of the Vala Nova, Risco and Vau rivers (November 26, 2015)

Figure 2.7 – Site 3: Weir of the Risco river (November 26, 2015)

Figure 2.8 – Site 4: Confluence of the Risco and Sorraia rivers (November 26, 2015)

Figure 2.9 – Site 5: Vala da Condessa and Sorraia river (November 26, 2015)

Figure 2.10 – Example of internal erosions a few kilometers downstream of site 10 (November 26, 2015)

Figure 2.11 – Site 10: Area of the dyke break during the fluvial flood of 1979 (November 26, 2015)

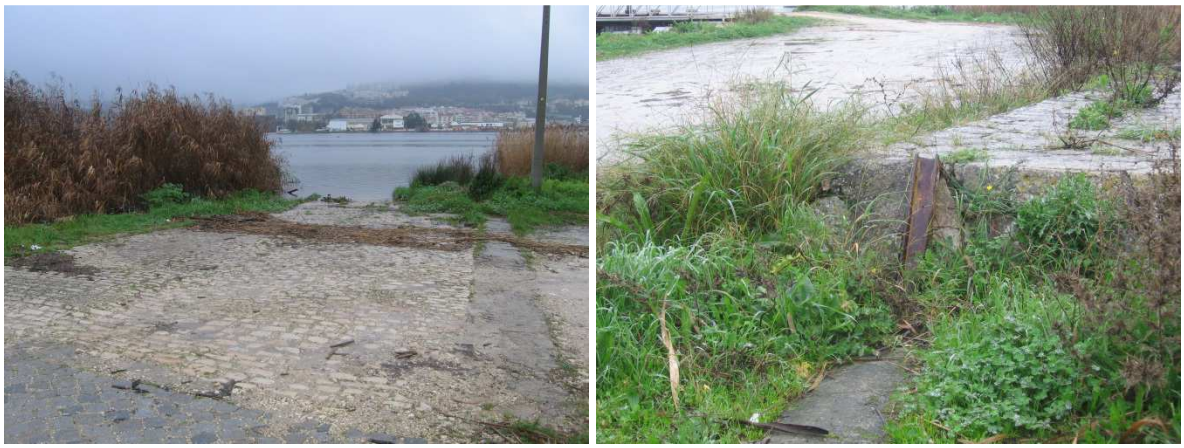

Figure 2.12 – Site 11: Old dock of Vila Franca de Xira (January 21, 2016)

Figure 2.13 – Reference levels of past floods (January 21, 2016)

Figure 2.14 – Reference levels of past floods (January 21, 2016)

Figure 2.15 – Mouchão dock (January 21, 2016)

Figure 2.16 – Vala de Mar de Cães and Ponta da Erva (January 21, 2016)

2.3 Irrigation and drainage system

The irrigation system of the Lezíria is composed of network of channels, 720 km long, connected to the surrounding rivers by several water intakes and drainage gates.

Several water intakes are located in the Tagus, Risco and Sorraia rivers that supply the freshwater for irrigation in the Lezíria, namely: Conchoso in the Tagus river; Barrão, Arcaus and Marqueira in the Risco river; and Condessa and Corte Nova in the Sorraia river (Figure 2.2). The main water supply to the Lezíria is conveyed by the Conchoso pumping station (Figure 2.5), which was designed to supply a discharge of 35.7 m^3/s (first phase) and 54.5 m^3/s (second phase). The water intake from these rivers is mostly by gravity, but a pumping system was recently installed at Conchoso. Since the Conchoso water intake is located close to the limit of the salinity propagation in the Tagus estuary, the water supply can be limited by the tides. Moreover, during very dry periods, the salinity at this water intake can reach concentrations that are inadequate for the crops. During these periods the water

supply is done, exceptionally, through the Risco and Sorraia water intakes. Generally, the irrigation period goes from April to October.

The Conchoso pumping station supplies the primary irrigation network through a main channel, the *Canal Principal* (Figure 2.2, Figure 2.5). The main channel has functions of both conveyance and drainage. This channel also receives water from the Risco and Sorraia rivers and supplies water to the pumping station of Ramalhão. The main channel is about 12.5 km long and crosses all the northern area of the Lezíria. It continues southward through the Vala de Mar de Cães, which is about 12.85 km long, until the southern limit of the Lezíria, Ponta da Erva (Figure 2.16). The connection between the main channel and the Vala de Mar de Cães is done at the *Estrutura Terminal*, which controls the flow levels upstream and distributes the freshwater to the some irrigation areas (blocks V and VI).

The irrigated area in the Lezíria has about 10000 ha, 40% of which are irrigated under pressure and 60% are irrigated by gravity. The secondary irrigation network is, thus, composed by open channels and pipes. The water to supply to the under pressure network is done by the pumping stations of Conchoso (to blocks I and II) and of Ramalhão (to blocks III and IV). An additional pumping station is also projected to supply water to the remaing blocks in the northen area of the Lezíria (blocks V and VI). Meanwhile, in these areas and in the southern area of the Lezíria, the irrigation is performed with individual pumping systems placed along the open channels.

The drainage flows are discharged into the Tagus, Risco and Sorraia rivers through a system of gates ("portas de água"), that operates by gravity, and by two pumping stations, Conchoso and Ruivo. The drainage network is composed by open channels and ditches. It is 460 km long, of which 60 km are primary channels, 110 km are secondary channels and 290 km are terciary channels. At the northern area of the Lezíria, the main channel (*Canal Principal*) and Esteiro do Ruivo receive some of the affluent flows, and discharge them into the Tagus river through the tidal gates or the pumping stations gates, in order to keep water levels of -0.5 m inside the network. The remaining effluents that flow to the gates by gravity are discharged into the Tagus and Sorraia rivers. At the southern area, the Vala de Mar de Cães is the main drainage channel that also operates by gravity. This channel discharges the flow through the Porta de Mar de Cães (mural gate) and Porta da Ponta da Erva (tidal gate). Due to the interconnection between the *Canal Principal* and the Vala de Mar de Cães the southern area of the Lezíria also ensures part of the drainage of the northen area.

2.4 Dyke

The whole Lezíria Grande is surrounded by a dyke that aims at protecting the farmlands from flooding. The total length of the dyke is 62 km, along the Tagus, Sorraia and Risco rivers. Topographic data of the dyke crest are available approximately between the Diogo and Condessa gate, in the Sorraia river, and Conchoso (Figure 2.17), in the Tagus river. In this 45.3 km long stretch, the crest height varies between 2.4 and 7.2 m above mean sea level (Figure 2.18).

The dykes of the Lezíria are typically made of soil covered by vegetation (Figure 2.11), occasionally protected with riprap on their outer flanks (e.g., Figure 2.8). In some areas, there are indications of internal erosions caused by water (Figure 2.10) or by burrowing animals.

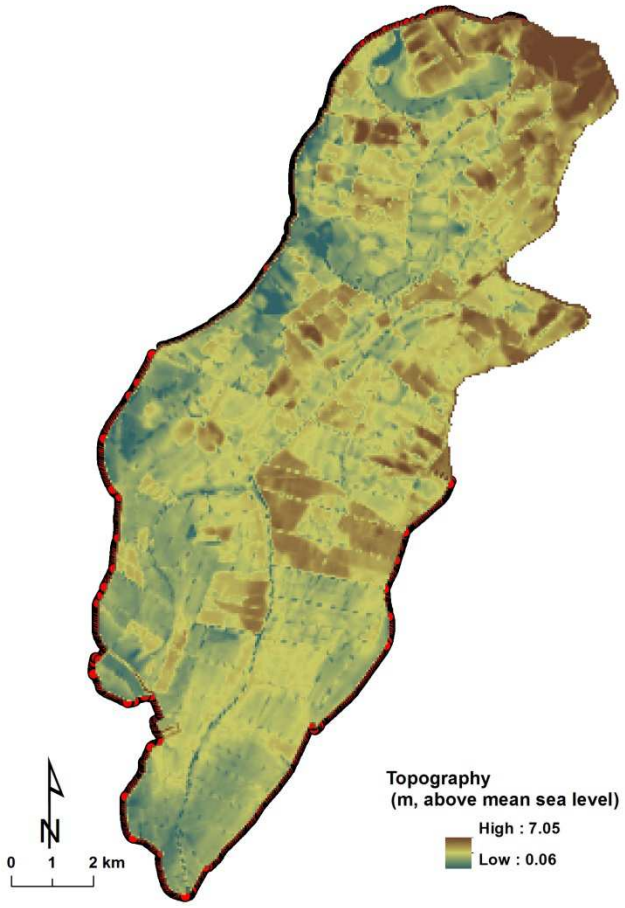

Figure 2.17 –Topography of the Lezíria and dyke crest where the topographic data are available (in red)

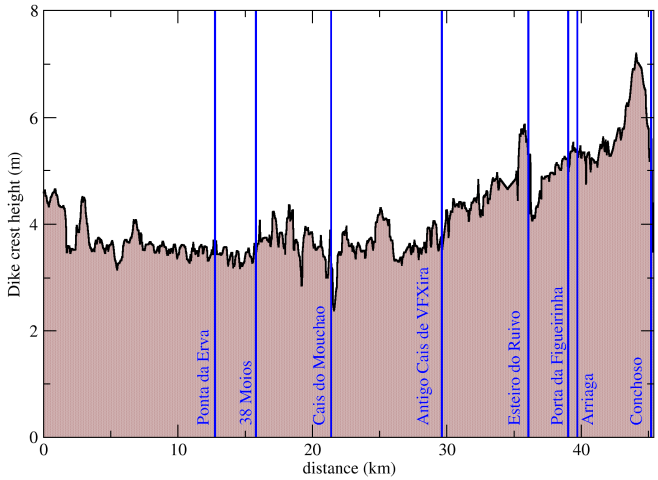

Figure 2.18 – Height of the dyke crest along its extension. The origin of the abscissa is located close to the intersection between the Sorraia and the Risco rivers

2.5 Relevant historical flood and drought events

2.5.1 Floods

The flood occurrences that affect the Lezíria have different origins: as a consequence of high water discharges in the Tagus and Sorraia rivers (riverine floods), mostly affecting the northern sector of the Lezíria; and/or due to estuarine high water levels forced by tides and storm surges (estuarine floods) particularly affecting the southern area (Figure 2.19).

The most severe wind storm to have hit the Iberian Peninsula in the 20th century hit the Portuguese coast on February 15th, 1941. The whole Tagus estuary was severely hit. While the details on the consequences of this storm on the Lezíria are poorly known, MUIR-WOOD (2011) provides some information. According to this author, the town of Alhandra houses were flooded with more than 1 m of water, and 25 of its inhabitants drowned. Since this town is located on the margins of the Tagus estuary across from the Lezíria, it is expected that the Lezíria itself was flooded as well. According to local reports, (Companhia das Lezírias, 1941, cited in Madaleno, 2006), this storm destroyed all the channels and dykes in the Lezíria. A storm following a similar SW-NE path but clearly less intense, Xynthia, struck the Portuguese coast on February 27th 2010. Like in 1941, the storm coincided with spring tides, exacerbating its consequences. Again the data about this storm in Portugal are scarce. In the days preceding the storm landfall the river flows were high, and floods are reported in riverine towns, such as Santarém (http://otejo.com/2010/02/25/, accessed on February 5, 2016). In the Lezíria, there is evidence of flooding during the 2010 February-March storms (Figure 2.19, Figure 2.20). During three consecutive days, witnesses report that the dykes were overtopped during the night and dawn.

The floods occurrence in the lower Tagus river is influenced by persistent rainfall associated with the Atlantic fronts that cross the western Iberian Peninsula during winter and with the operation of several dams located upstream, particularly with their ability to store and gradually release floodwaters. In the floods history of the lower Tagus, maximum flood discharges were registered in 1876, 1940, 1941, 1978, 1979, 1989, 1996 and 2001. One of the riverine flood events with the most relevant impacts in Lezíria occurred in February 1979, during which the dyke suffered a rupture in both the north and south sides (sites 10 and 15 in Figure 2.4) and an extensive flood occurred in the Lezíria agricultural lands. During flood occurrences in the Sorraia river, such as the one that occurred in March 2013 (Figure 2.21), the gate of Ponta da Erva (Figure 2.2) is opened to prevent the rising of the water levels within the Lezíria.

Figure 2.19 – Most affected areas during past flood events of riverine origin (in blue) and estuarine origin (in green). The area affected by the February 2010 flood event is marked in red. The location of the temporary weir built in the Sorraia river during drought periods is marked with a star. Background image from ESRI basemap

Figure 2.20 – Flooding during the 2010 February-March storms and the consequent reinforcement of the dyke (source: ABLGVFX)

Figure 2.21 – Fluvial flood from the Sorraia river: water levels at the weir of the Risco river and opening of the Ponta da Erva gate (March 27, 2013; April 1, 2013; source: ABLGVFX)

2.5.2 Droughts

Since the water supply for irrigation depends on the availability of freshwater in the rivers surrounding the Lezíria, droughts can have negative impacts in the agriculture in this area and, consequently, adverse effects on the local economy. Moreover, since the main water intake (Conchoso) is located close to the limit of the salinity propagation in the Tagus estuary and the water intake is limited by the tides, some of these impacts may be exacerbated. On average conditions, the saline tide reaches about 50 km upstream from the mouth, near Vila Franca de Xira. During droughts, saline water has been detected about 14 km further upstream, at the Conchoso water intake. During these periods, the water scarcity usually starts in July, when all of the investments in crops have already been made by the farmers. The maintenance of freshwater water availability in the Lezíria is, thus, fundamental to guarantee the required water demands for the crops. In particular, rice, which represented about 45% of the cultivated area in 2015, requires 8000 m^3/ha more of water than the other irrigated crops.

In the last 75 years several major drought episodes occurred in Portugal. The frequency, duration and severity of each of these droughts varied from North to South due to the latitudinal spreading of the Portuguese territory along the Atlantic coastline. Particularly severe were the droughts of 1943/46, 1965, 1976, 1980/81, 1991/92, 1994/95, 1998/99 and 2004/06. The 2011/12 drought also had some

severity: the winter of 2011/12 (December, January and February) was the driest since 1931 (GPP, 2013). The annual precipitation in 2011/12 (554.1 mm) was higher than in 2004/5 (410.8 mm), but still below the average (the average between 1979-2000 was 882.1 mm). In July of both 2005 and 2012, the South of the country was in extreme drought according to the Palmer Drought Severity Index (GPP, 2012; Figure 2.22).

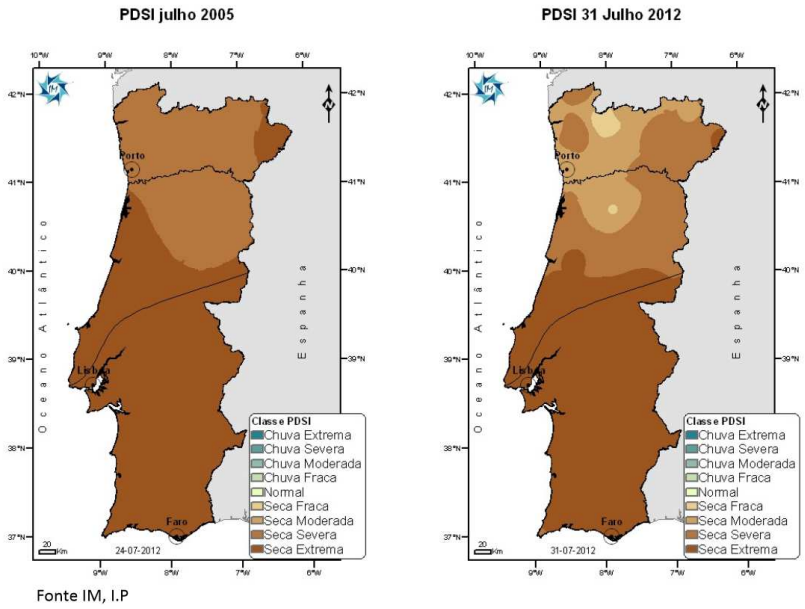

Figure 2.22 – Comparison between the Palmer Drought Severity Index (PDSI) in July 2005 and July 2012 (Source: IPMA in GPP, 2013)

The most recent droughts, in 2005 and 2012, affected the agricultural activities in the Lezíria and emergency measures were undertaken to minimize the negative impacts of water scarcity and, in particular, the loss of crops. Usually, the recommended threshold of salinity for irrigation water in the area is 0.8, with a maximum of 1. During July and August of both 2005 and 2012, salinity reached concentrations at the Conchoso water intake that were inadequate for irrigation. In 2012, in particular, water with salinity of about 1.1/1.2 was used for irrigation, which led to a decrease in the production. However, the adverse impacts of the 2005 drought were more severe for the farmers in the Lezíria, since the drought itself was more severe and the ABLGVFX had fewer resources and was less prepared to deal with these events. In 2005, from mid-July onwards the water supply to the Lezíria started to be made exclusively from the Risco river water intake. However, in mid-August the salinity at the Risco river was of 1 (comparatively to typical values of 0.3) and a temporary weir was built in the Sorraia river to route the freshwater available in this river. Similar measures, although more timely, were undertaken in 2012, with an improvement of the water intake at the Risco river and the construction of the weir in the Sorraia river in July (Figure 2.19, Figure 2.23). To increase the resilience to droughts, the ABLGVFX made some recent improvements that included the installation of a pumping system at the Conchoso water intake, allowing the pumping of the water from the Tagus

river during low tide, and the construction of a removable weir in the Risco river (Figure 2.7).

Figure 2.23 – Temporary weir in the Sorraia river during the 2012 drought (July 2012, source: ABLGVFX)

3 | Mouchão de Alhandra

3.1 General description

The Mouchão de Alhandra is an island formed by alluvial deposition, located in the upstream area of the Tagus estuary (Figure 2.1). The island has an area of about 255 ha (Figure 3.1). The terrain elevation is very low, typically 0 to 1 m above mean sea level. The island is thus protected by dykes along its contour. Two internal dykes provide additional protection in case of a localized breach. This island is also part of the Tagus Estuary Natural Reserve.

The Mouchão de Alhandra is used for cattle grazing, currently with a population of 200 cows, and the crops are exclusively of cattle feed. Two main buildings, where two people live permanently, and other three for agriculture support are the only artificial surfaces of the island. The water used for agriculture has groundwater origin.

Figure 3.1 – Mouchão de Alhandra general overview. Background image from ESRI basemap

3.2 Exploratory visit

The exploratory visit to the Mouchão de Alhandra was performed on December 1st, 2015. The visit consisted in a boat tour of the island, which provided a detailed view of the dykes.

The dykes are very heterogeneous (Figure 3.2). Some are made from soil covered with vegetation, others are protected by riprap or wooden stakes. In several areas, there are strong evidences of erosion of the dykes.

Figure 3.2 – Mouchão de Alhandra (December 1st, 2015)

4 | Final remarks

BINGO - Bringing innovation to ongoing water management - a better future under climate change (Horizon 2020 Research and Innovation Programme, Grant Agreement number 641739) is focused on a set of selected research sites and aims to provide practical knowledge and tools to better cope with all climate projections, including droughts and floods. The research site in Portugal focuses on water systems from the lower Tagus transboundary river basin, which has pressures likely to be exacerbated by climate change. The agricultural area of the Lezíria Grande de Vila Franca de Xira is part of one of the case studies at the Tagus research site, related to the agriculture.

To support the characterization of this area, three exploratory visits were performed to the agricultural area of the upper Tagus estuary, and in particular to the irrigation area of the Lezíria Grande de Vila Franca de Xira (Aproveitamento Hidroagrícola da Lezíria Grande de Vila Franca de Xira) and to one of the adjacent “Mouchões” (the local term for the islands formed by alluvial deposition), the Mouchão de Alhandra. The exploratory visits to the Lezíria were performed on November 26, 2015, and January 15, 2016. The exploratory visit to the Mouchão de Alhandra was performed on December 01, 2015. The main findings of these exploratory visits were summarized in this report. A brief characterization of the irrigation and drainage system of the Lezíria Grande de Vila Franca de Xira was presented, as well as of its protection dyke that is 62 km long and surrounds the entire perimeter of the area. A brief characterization of the most relevant historical flood and drought events that affected this area was also presented.

Lisboa, LNEC, May of 2016

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