Consecutive dams and mills system

Water Late Medieval Systems including mills, fish farms and dams in El Paular charterhouse, Spain

Javier Sanchez Jimenez

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Figure 1: Charterhouse of El Paular

Context.

Location:	Rascafria, Region of Madrid
Landscape Type:	Mountain area.
Area:	5288.3 ha (original monastery lands).
Function:	Energy and fishfarming, agriculture.
Water Quality:	Fresh.
Dynamic:	Continous waterflow

The Valley of Rascafria is a narrow dale which opens to towards the North, located in the Sierra de Guadarrama, the north-western border of the Madrid region in Spain. The valley has a minimum altutude of 1125 above sea level and it is surrounded by mountains over 2000 meters high

Hidrologically, is an open valley crossed by a number of small streams that overflow from the glacial lagoons tha form in the small plateaus between the mountain peaks that eventually converge in the larger Lozoya. This later water course, although it is not a seasonal river- it flows all the year through-, it presents a marked seasonal flow variation. Since the beginning of the steady human occupation- which started with the construction of the Monastery of El Paular- in the Middle Ages, this irregularity has been mitigated through the use of dams. This has greatly stabilized the flow of the river, which is only interrupted in winter time, when the water freezes down.

Figure 2
Spain

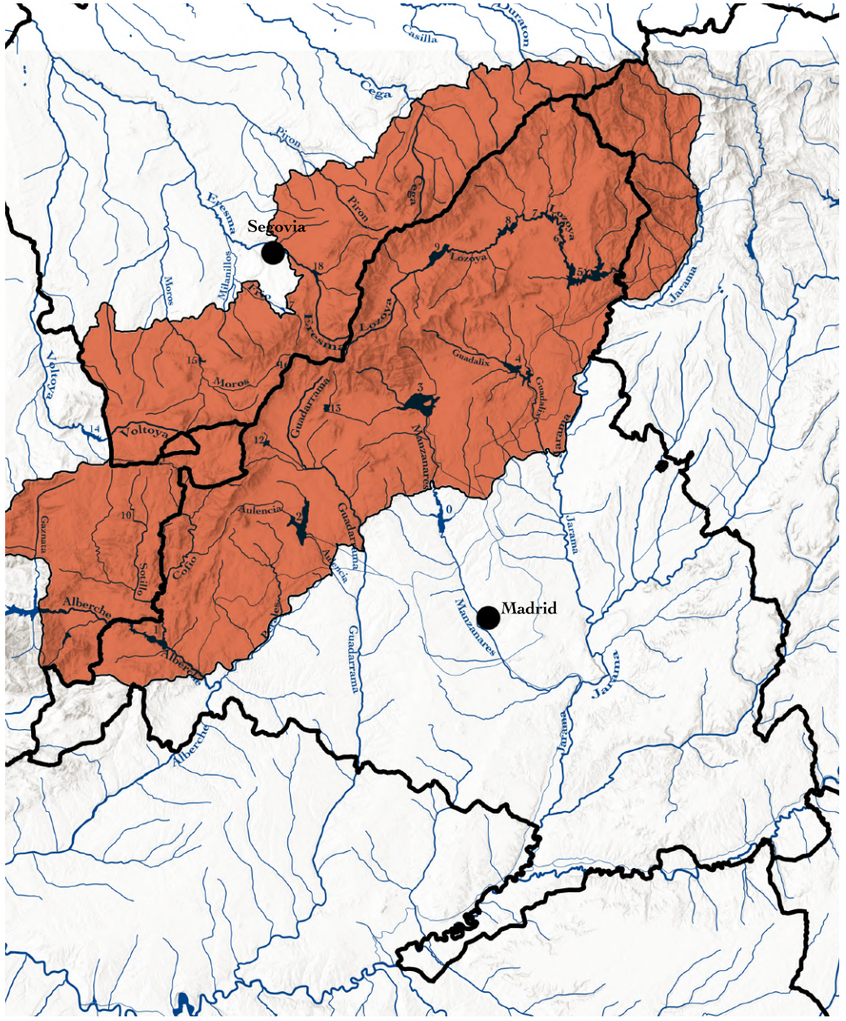


Figure 3
Region of the Sierra de Guadarrama

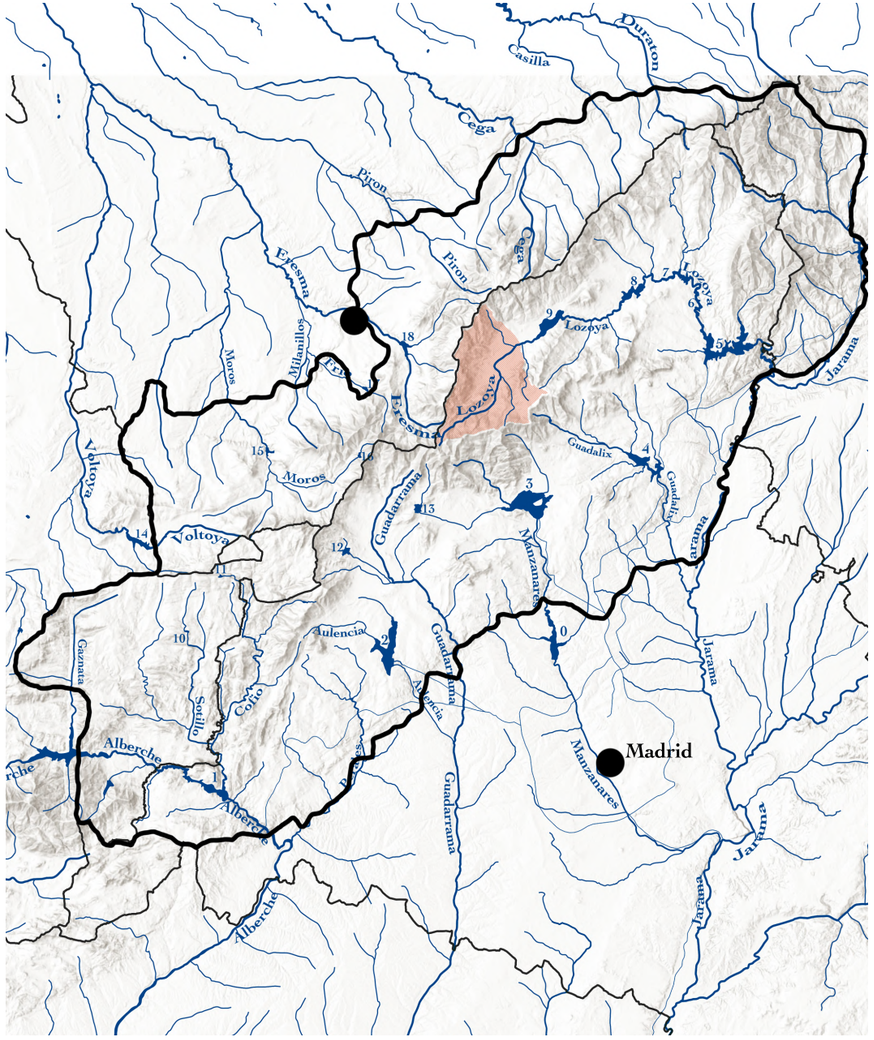


Figure 4
Situation of the Rascafria Valle

Catchment area

The monastery lands are situated within the upper Lozoya catchment area. This basin is a valley encircled by steep mountains that encircle a flatter plateau. one could suppose that this plain would be a fitting place for agriculture; however, the soil is too rocky for that. Regarding the quality of the water, it is exceptionally good since it comes from either rainfall or melted snow that runs down through a hard soil, which prevents it from contaminating with sediments

The perimeter reflected in Figure 5 are just orientative, since the limits were unstable during history and no concluding information of any period has been retrieved. The area in the figure coprises not only the farming lands, but also the forests, which were likely never fully defined- so the southernmost extremes are the last places where signs of replantation have been found

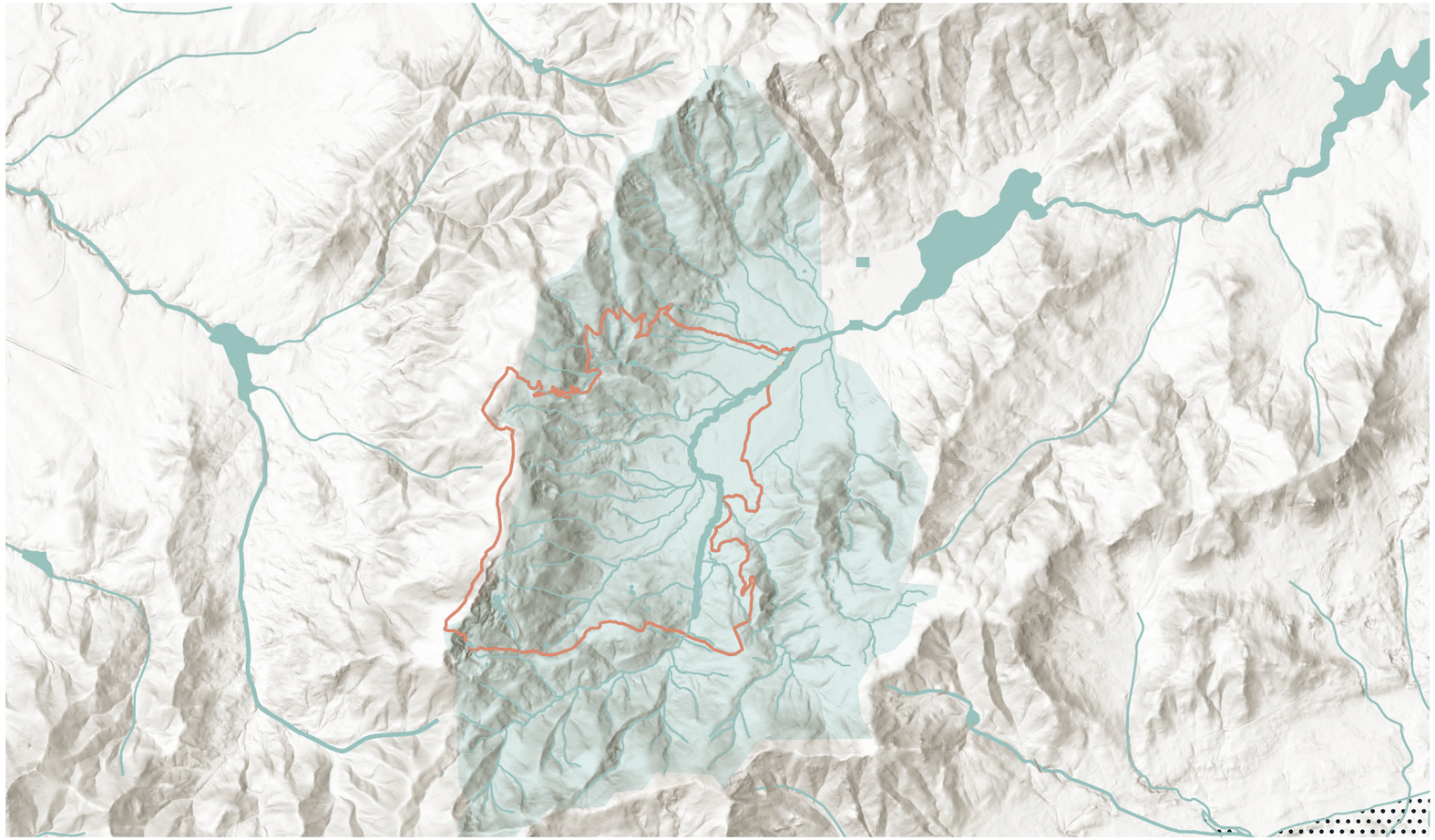


Figure 5
Catchment area of Rascafria (right)

Climate.

Climate zone: **Mediterranean**
Sub-climate: Warm summer
Cold summer

Climate & Weather Averages

High t°:	12.5°C
Low t°:	2.5°C
Mean t°:	7.5°C
Humidity:	54%
Dew point:	6.8°C
Wind:	1.6 km/h
Pressure:	1017hPa
Annual Rainfall:	996.6 mm per year

(Data according to AEMET and Meteopozuelo)

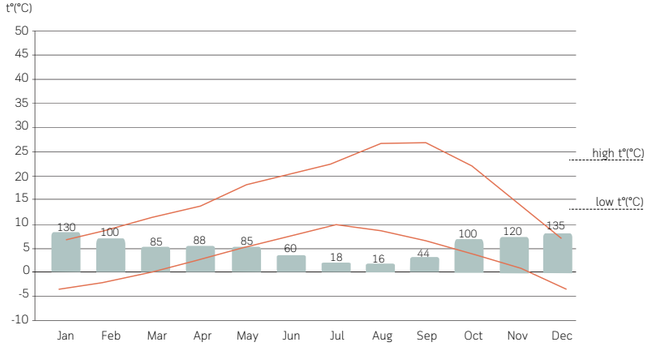
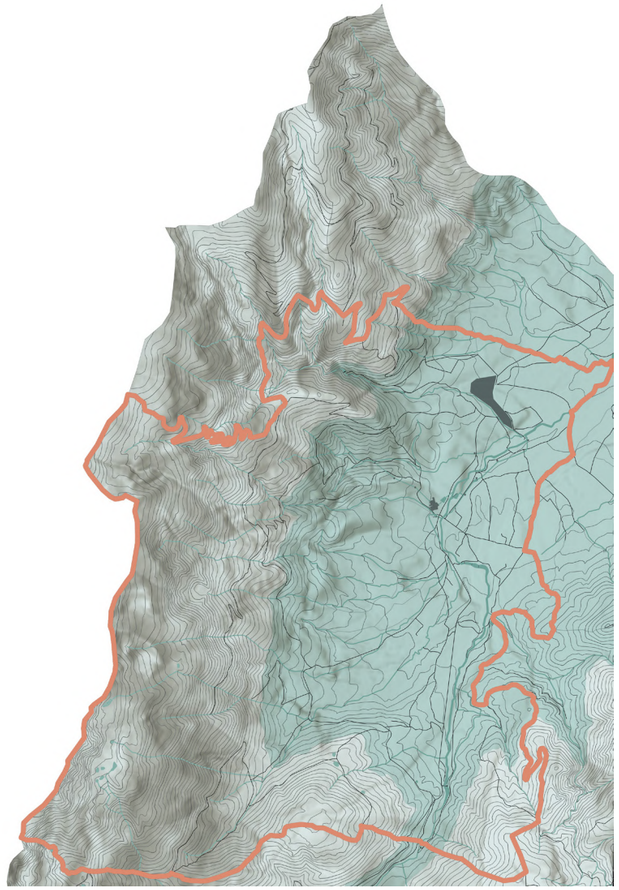


Figure 6
Temperarture and amount of rainfall



Sub-Climate
Dsd (humid continental climate)
Csc (Cold summer Mediterranean Climate)

(Data acording to AEMET)

Annual precipitaton (mm)
Over 1500
1000 to 1500
800 to 1000

Figure 7
Sub-climates of the Valley of Rascafria

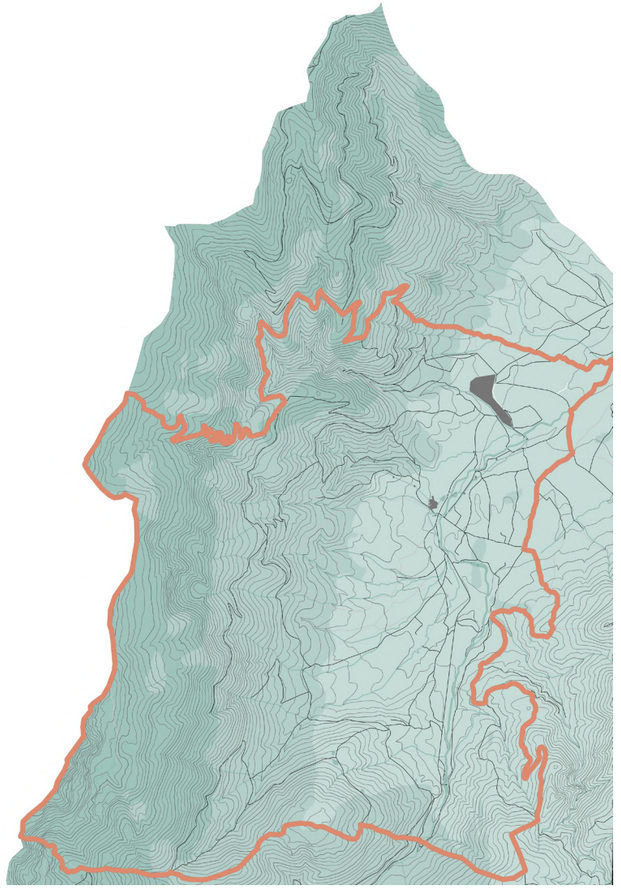


Figure 8
Annual precipitation of the Valley of Rascafria

History.

The valley was sparsely inhabited until 1390, when the works for the construction of a monastery started at the behest of king Henry the 2nd of Castille. These works proceeded for 50 years under the reign of his son John, until the completion of the Carthusian convent of El Paular. Further construction took place in the following centuries, for enlargements, refurbishments and renovations: the most notable of them happened in the Late Gothic and Baroque periods.

The construction of the monastery was the last stage of the strategy of consolidation of that the Christian kings of medieval Iberia consistently applied on the newly conquered land, awarding enormous plots of land to the noblity to force it to become populated and later founding religious institutions to consolidate the area and provide it with a reliable transportation network- Iberian kings would usually stay in monasteries during their trips. However, in stark contrast with the rich monasteries of the plateau, the valley of Rascafria was-is- barely arable.

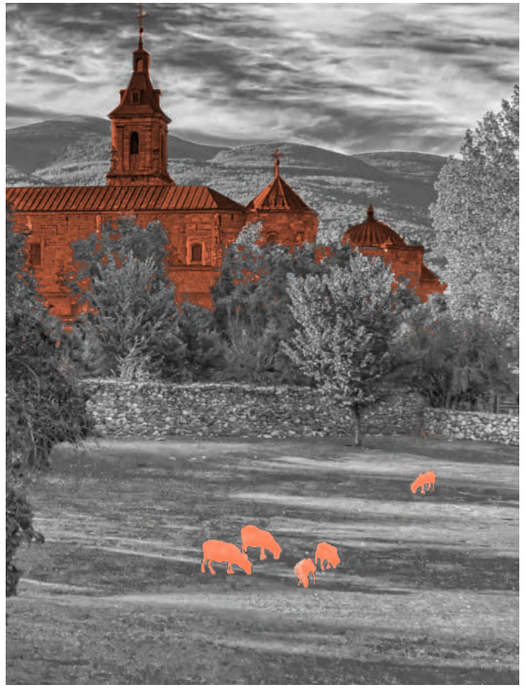
It is likely that the first way the Carthusians exploited the water bounty in the area was through fish farming; both the river Lozoya and some of their tributaries must have formed natural pools. By damming them they must have created the artificial fish farms.

Figure 9: Outdoor of an "Arca" (cleaning through decantation). This example belongs to a similar water system in El Escorial (Top left).
Figure 10:: Interior of an "Arca" (cleaning through decantation). This example belongs to a similar water system in El Escorial (Top middle).
Figure 12: Water pavilion with fountain (Top centre).
Figure 14: The former fishfarms, now converted into a popular recreation area (Bottom left).
Figure 15: The stone dams of the former fishfarm ((Bottom right).

History.

Shortly after, in order to provide the monastery with a steady and significant income, the monks -presumably with a large initial investment that only religious orders could afford at the time-started building a series of cascading watermills, and dams that would ensure that there was enough water to power them in the summer. These were not (only) for grinding wheat, but aspired to a greater economical benefit-which, in turn, required more knowledge and technical skills.

The monks initially cattered the very profitable wool sector. They even bred a race of black sheep so not to have to dye the wool afterwards- the black sheep were reintroduced some 20 years ago. Shortly after they started to produce paper, another high-end product. From the 16th century on, thanks to the intense contact with the Northern European world, especially Flanders and the Netherlands through Charles the Fifth, especies such as the birch were planted industrially. Later, when the works for the Royal Palace of Valsain and the Monastery of El Escorial took place, they also took it to the sawing of the timber, both the one produced in their own forests and the neighbourhounding ones- an activity that would survive the dissolution of the monastery in the 19th century, when a still existing Belgian company took over it. At the beginning of the 19th century, the last dam was built, this time for electricity production



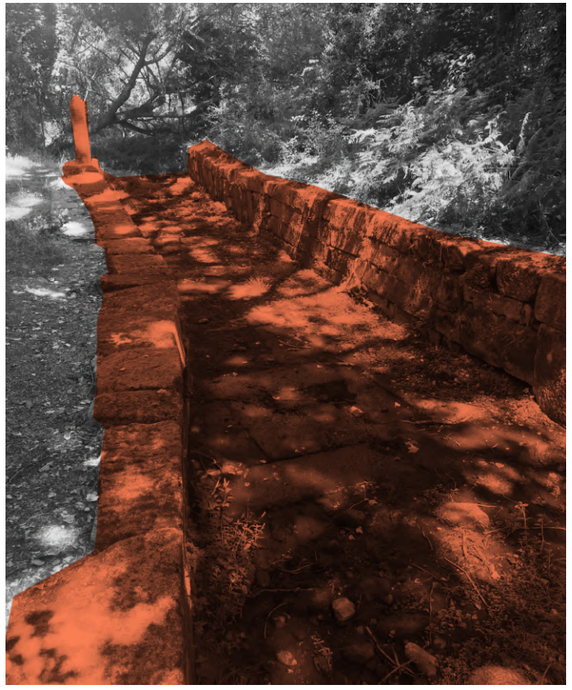


Figure 16: Meadow next to the charterhouse with the typical black sheep grazing (Top left).
Figure 17: Birch plantation, n offspring of the original paper production forest (Top centre).
Figure 18: Canal leading to a mill (Top left).
Figure 19: The so-called "timber house", a 17th century sawmill (Centre).
Figure 20: Ruins of the paper mill complex. The lower buildings are warehouses and the mill itself: the tower is actually a dovecote (Bottom left)
Figure 21: Detail of a wooden weir to divert the water from the river into a canal

Landscape transformation.

The landscape was transformed through the construction of cascading dams, both for fish breeding and to store water so to power the mills even in the summer.

The mills were never in function all at once. In fact, we could divide the evolution in two periods

1. The monastic era: it lasted from 1390, when the monastery was built, to 1835, when the monks were removed after Mendizabal's Church Estates Supression Act. Subsequent mills and fish farms were built, with their correspondent dams. The forests were substantially exploited and replanted, and new species, such as birch and cedar were introduced for paper or timber production.

2. The modern era: the mills fell into disrepair and many of them collapsed. The fish farms were abandoned and became pools once again. However, the dams were much sturdier and prevailed without relevant damages or fisures. The birch forests were largely abandoned and they became naturalized. The timber forests, however, have been mantained, lodged and replanted thill this day, with further introduction of foreign species, chiefly the Douglas spruce. In the last century, a new dam built for electrical production and the fish farms were converted into recreation facilities. Today, the remaining structures are consolidated, the monks and sheep have been reintroduced

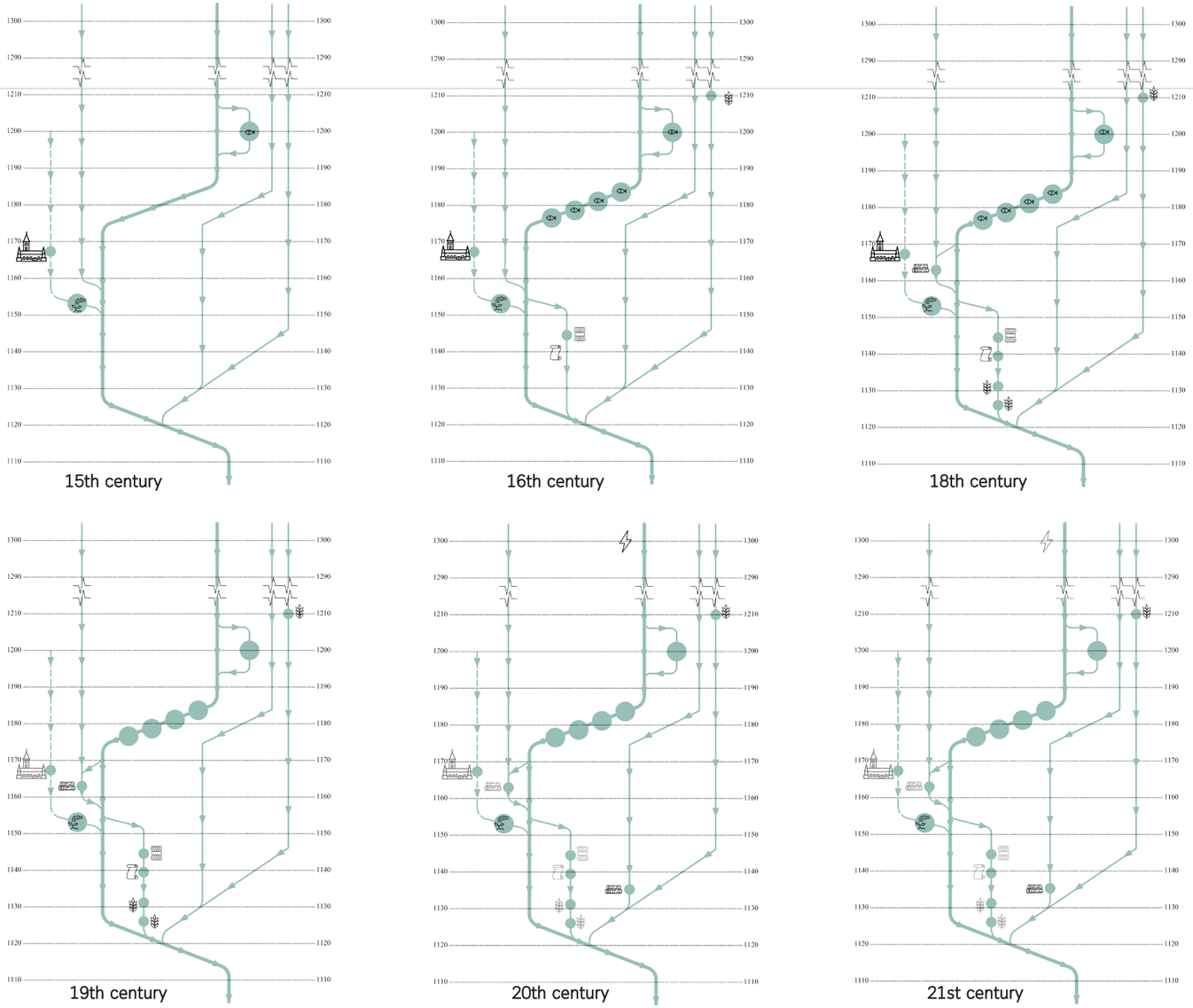


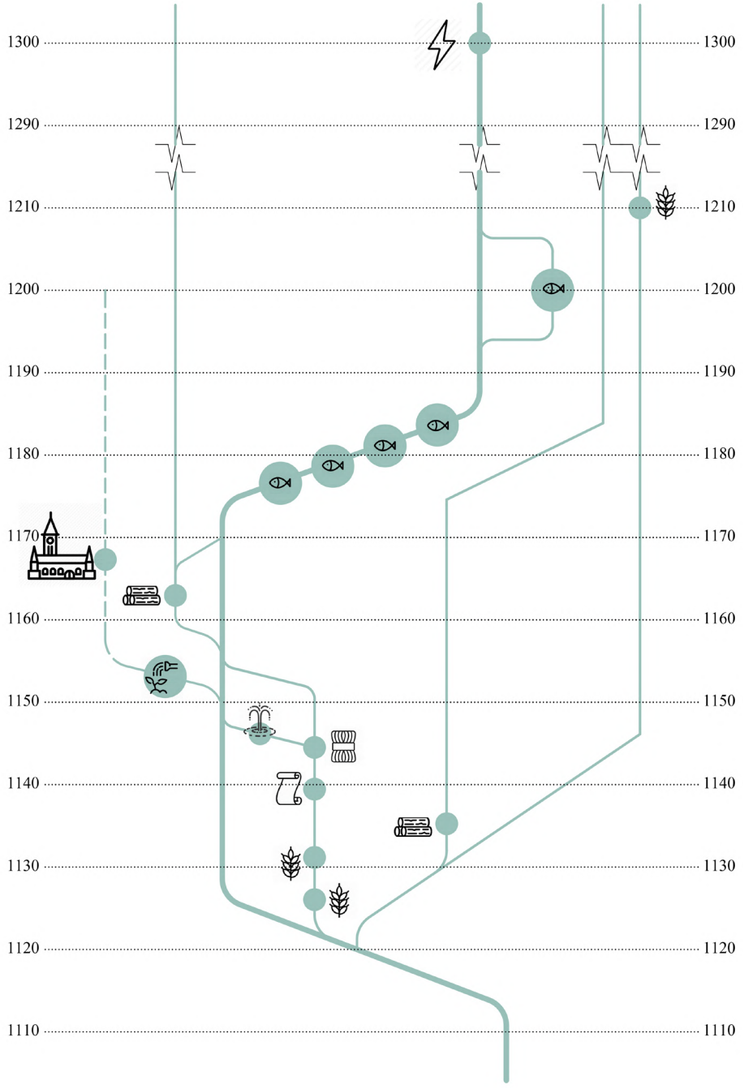
Figure 22: Development of the system, depicting its rise and fall since the 15th century to today

Watersystem.

The water system was heavily modified, by the construction of consecutive dams. However, it is very significant to note that the ones that interrupted the river- the fish farms ones- were relatively short, not more than a meter and a half high. The only exception is the modern hidroelectric plant's dam

The higher ones, corresponding to the mills, are separated from the main river course, from which the water is diverted to them through canals.

In consonance with the modern times, new recreational facilities have been introduced, such as the lake of the Finnish forest or the reuse of the old fish farms as swimming pools



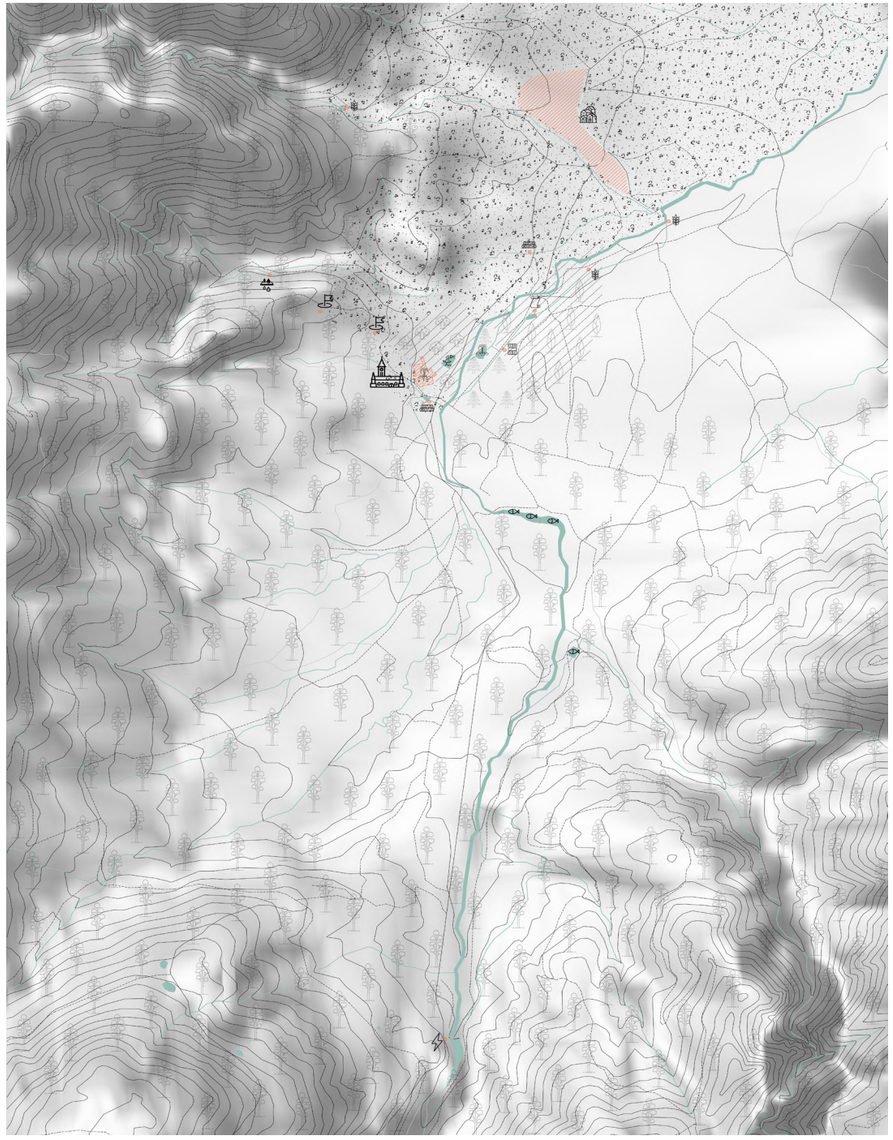
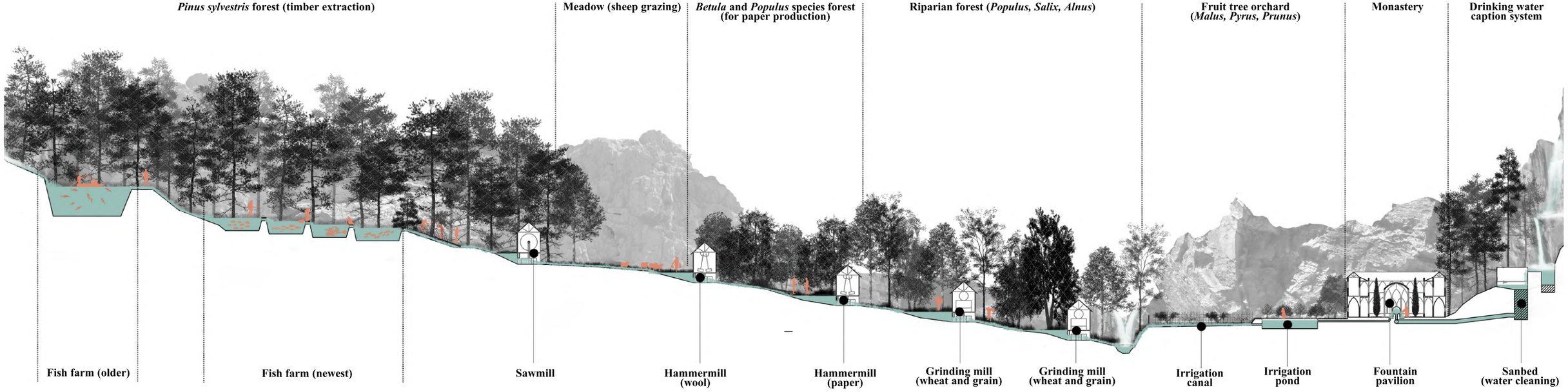


Figure 23: Diagram of the system, with all the existing ponds and dams still existing and their past uses. (Left)
Figure 24: Plan of the water system, also reflecting its interdependence with the vegetation. (Right)

Circularity system

The relationship between the watersystem and the vegetation is extremely close in this example, and sometimes is hard to distinguish which of them came first. The native Pinus sylvestris has historically been cut for timber- actually, the vast majority of the historic buildings of Madrid where built using at least beams and many times pillars made in these pines' timber. The freshly cut trunks were dumped in the river, so the rocks would clean them by peeling the bark ank breaking the branches. Then, once by the sawmill, they could be retrieved and sawed in planks. Some of the cleared areas were kept like that for grazing meadows for sheep, conveniently near the hammermill for wool beating. Some other of the cut areas was planted with birch trees, which thrived thanks to the water abundance. They were later cut, and their trunks smashed into pulp for paper making. The birches would later naturalize in the native riparian forest. On a different side, the drinking water of the monastery was later discharged into the orchard bedore being flushed again into the main river

Figure 25:
Diagramatic section showing the interdependence betwen the vegetation and the water system.



Circularity.

The existing watersystem is the origin of all the economical activities in the area and deeply intertwined with the kind of society that was able to settle and thrive here: one that did not depend on crops and had an easy access to grain- a log-lasting produce that could be grinded into flour to make bread and within an easy reach in the Castillian Moors, just at the other side of the mountains. This implied a certain level of initial wealth that enabled them to buy or build the high tech equioement needed in the watermills to produce the expensive elaborate products in which the monastery based their wealth.

Figure 26:
Circularity of the system / Representation of sustainability.

Traditional methods.

The system in el Paular did not survive the charterhouse's closure following the Mendizabal's Church Estates Supression Act in 1835, four years before the internal of the daguerrotipe-as a consequence, it is impossible to retrieve any photograph from the period when the mills and dams system was active. However, due to the enormous amount of similar systems-yet, most of the time, not as complete, it is possible to find pictures depicting the same or similar methods

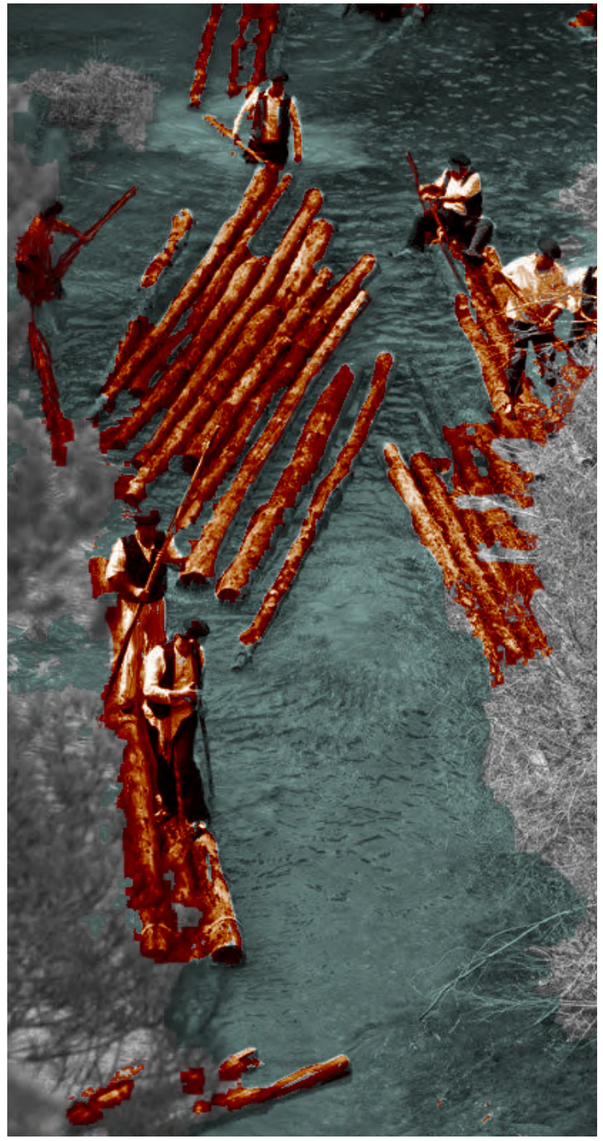


Figure 27:
Old watermill in Manzanares El Real. The miller and his son stand in the bridge in front. (Top left)
Figure 28:
Almadia (trunk barge) in Navarre. Since many of the lumberjacks were of a Basque origin, this way to transport trunksis likely to be identical to the one used in Rascafria.(Right)
Figure 29::
King Alfonsus the 13th fishing in La Granja , in a fishing farm identical to that in Rascafria. (Bottom left)

Conclusion.

El Paular consecutive dam system's virtues are evident if we take into consideration how much it was replicated in the area- if in most of the cases to a lesser extent. Although the initial motivations for the building of this complex was economic and could be deemed as unfirtting in a world powered by fossil fuels and electricity, its values greatly overpass its initial premise, and after centuries of perfectioning, it is a perfect example of circularity, connection with the environment and respectful and all-around-ish human interventions in nature

Landscape Values - The creation of the dams, against all odds, has had a positive influence on the landscape; not only the masonry dikes are beautiful and escenic themselves, especially when they are overflowed forming waterfalls, but also the reservoirs work as a prolongation of the mountain glacial lagoons at a lower alititude and create a still, mirror-like ponds in the turbulent and ever-moving mountain streams. Yet another value is the one derived from the imported plants, which greatly contribute to the beauty of the scenery because of their contrast with the native. we must not be afraid of including new especies as long as we do it carefully and with respect to the natives

Strategic values - This system teaches us how nature and industry are not so opposite as we could first think, and how industry can contribute to nature. Also, the smart use of water, which is profited several times before being released.

Material and tangible values - The valuable heritage, especially the architectonic one, is probably one of the most remarkable features of this syste,

Values of sustainability and circularity - One of the most surprising features of this system is that, except for the fish farms, the main river current is never interrupted. Instead, the water is diverted to the dams using canals, minimizing the ecological impact on the area and then bringing the water back to its source

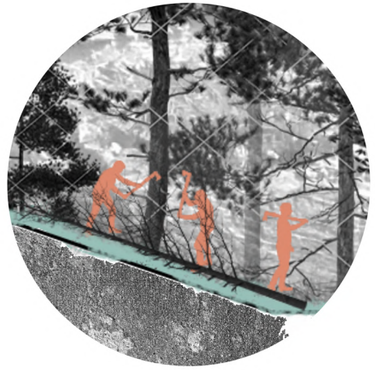
Ethnographic and identity values - The wealth and knowlwdge of the monks enabled them to built or bring with them costly and complex engines that would enable them to participate in the lucrative market of luxurious goods in the Late Middle Age, and, later, in the burgueoning construction industry of , first, Valsain and El Escorial and later Madrid and the urbanisation of the Royal Seats.

This model quickly spread, and there is hardly any town in the area that does not have at least one mill. Most of them are for wheat grinding, but there is also a large number of hammermills for wool beating. El Paular's one is, to my knowlwdge, the only one used for papermaking-abut there are at least two sawmills and-quite surprisingly, a mill that was built exclusively to cut and polish stone for the Monastery of El Escorial. All of them come with their respective dams.
Fish farms where, however, much more scarce and often vinculated to the royalty. Only two more where ever built to my knowledge: that in La Granjilla de la Fresneda in El Escorial and the one in La Granja de San Idelfonso's palace gardens

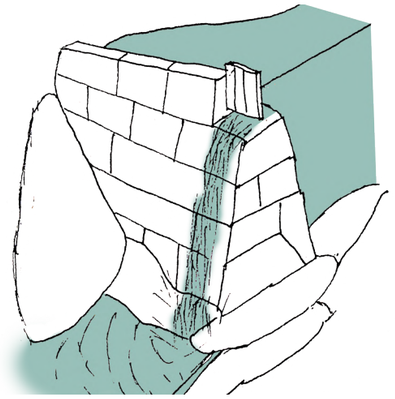
Lessons to learn This system is a good proof of how to make a good use of every drop. The stepping of the different uses allowed to reserve the less contiminated water for the most water-quality exigent uses. Also, the diversion of the existing water streams using secondary canals instead of directly building the dams on it is a good show of respecting the natural water courses and, so, leaving their ecosystems untouched.

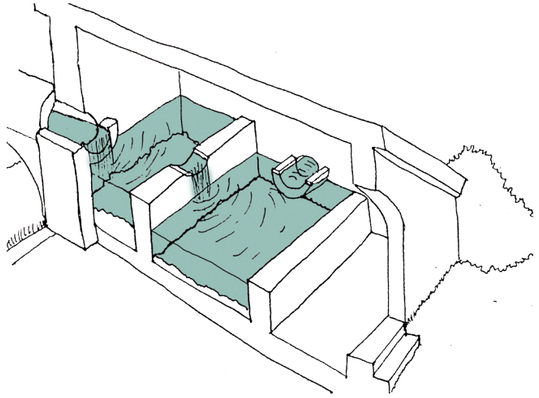


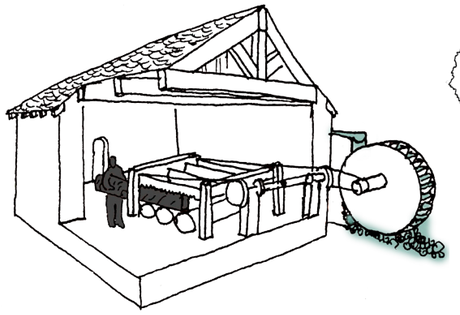


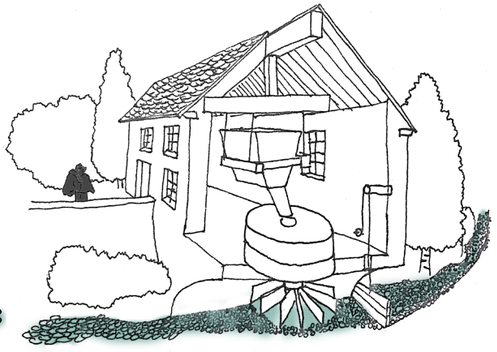



Glosary.









Presa:
Dam

Small masonry wall buit in a creek in order to hold water

Project: Consecutive dams and mills system- Sierra del Guadarrama, Spain
Climate: Mediterranean- continental
Year: 1400-1700 AD
Water type: Freshwater.
Landscape: Mountain
Altitude: 1200-1800m a.s.l.
Soil condition: Granite rock, sand, gravel
Material: Granite masonry
Temporality: Fixed
Form: Point
Function: Water storage

Arca:
Sand trap

Coming for the Old Spanish word for chest or coffer, its a water harvesting and cleaning device that renders water optimal for drinking

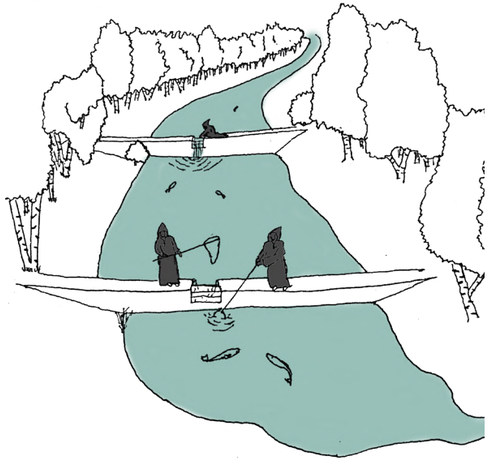
Project: Consecutive dams and mills system- Sierra del Guadarrama, Spain
Climate: Mediterranean- continental
Year: 1600-1800 AD
Water type: Freshwater.
Landscape: Mountain
Altitude: 1500-2300m a.s.l.
Soil condition: Granite rock, sand
Material: Granite masonry
Temporality: Fixed
Form: Point
Function: Water cleaning and sand trap

Molino harinero, aserradero y batán:
Grinding mill, sawmill and hammermill

Different kinds of mills used in Castille since the Middle Ages to the late

Project: Consecutive dams and mills system- Sierra del Guadarrama, Spain
Climate: Mediterranean- continental
Year: 1400-1900 AD
Water type: Freshwater.
Landscape: Mountain
Altitude: 1500-900m a.s.l.
Soil condition: Granite rock, sand, gravel
Material: Granite masonry for the walls and canals, timber for the structure and moving parts, slate or ceramic rooftile for roof.
Temporality: Fixed
Form: Point
Function: Wheat grain grinding, timber cutting, wool beating

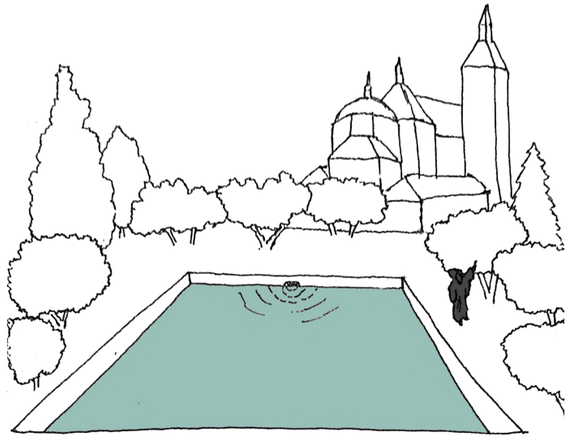
Glosary.



Pesquería:
Fishfarm

This is an Old Spanish word for fishfarm- modern one is piscifactoría. They were made by damming natural river pools with stout, big boulders. Often they are over one meter deep so the fish can survive when the surface freezes down in winter

Project: Consecutive dams and mills system- Sierra del Guadarrama, Spain
Climate: Mediterranean- continental
Year: 1400-1900 AD
Water type: Freshwater.
Landscape: Mountain
ALltitude: 1200-1800m a.s.l.
Soil condition: Granite rock, sand, gravel
Material: Granite stones (rough, uncarved)
Temporality: Fixed
Form: Surface
Function: Fishfarming



Alberca:
Pool

This word, coming from the Arab, is translated as “swimming pool” in Mexico, but in Spain it is a pool excavated in the earth-in this case, in the stone- with walls and and bottom clad in waterproof materials-which, in this case, are not necessary

Project: Consecutive dams and mills system- Sierra del Guadarrama, Spain
Climate: Mediterranean- continental
Year: 1400-1900 AD
Water type: Freshwater.
Landscape: Mountain
ALltitude: 900-1500m a.s.l.
Soil condition: Granite rock, sand, gravel
Material: Granite masonry for the borders and platform, rough excavated rock for the bottom and underwater walls
Temporality: Fixed
Form: Surface
Function: Water storage

Almadia:
Wooden trunk barge

This tradition, consisting in floating down the trunks down the river was brought from Navarre and the Basque country by the Basque lumberjacks

Project: Consecutive dams and mills system- Sierra del Guadarrama, Spain
Climate: Mediterranean- continental
Year: 1400-1900 AD
Water type: Freshwater.
Landscape: Mountain
ALltitude: 900-1500m a.s.l.
Soil condition: Granite rock, sand, gravel
Material: Granite masonry for the borders and platform, rough excavated rock for the bottom and underwater walls
Temporality: Fixed
Form: Surface
Function: transportation of logs and cleaning of the small branches and bark