

## **Chapter 1**

# **Water and Agricultural Production in the Venetian Terra Firma in the Sixteenth and Seventeenth Centuries**

## **Irrigation and Land Reclamation**

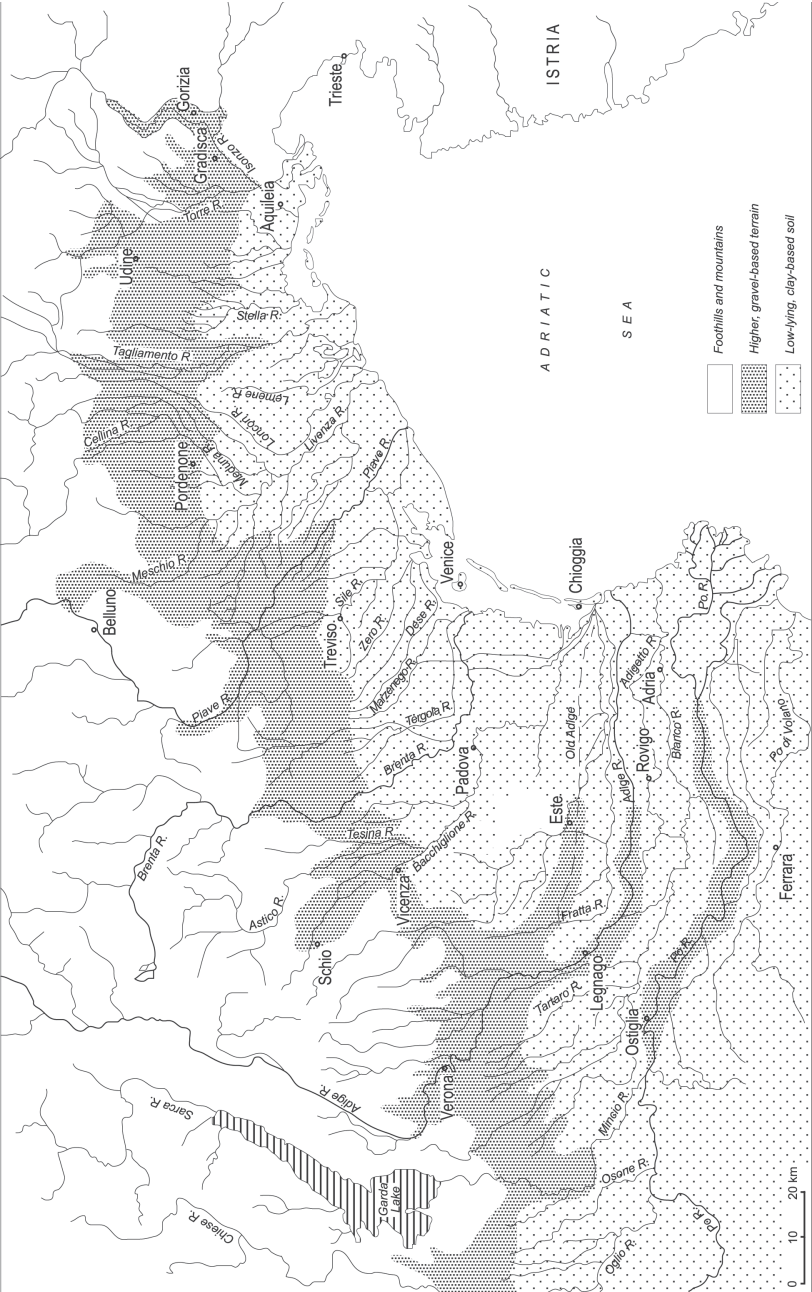
It is now generally accepted that, in both ancient and modern societies, the mastery of water – as either a resource or a threat – is one of the essential premises for the establishment of state institutions, with work on irrigation canals and protective dikes influencing social hierarchies and stimulating economic development. No less important a factor in productive activity than land or labour, water has always revealed the interplay of social relations and environment, with development obviously being conditioned by access to this finite resource. Adopting the terminology of Fernand Braudel, one might therefore define the environment as a whole as an *ensemble des ensembles* in which the various social agents contend for available resources (water undoubtedly being one of the most important), the degree of their success depending upon the relative power they can exert. Hence, water has long been the object of disputes. These range from its purely agricultural use (in irrigation and drainage); its use as a source of power (for the waterwheels drove mills, fulling machines, jacks, paper mills and the whole range of varied machinery that existed in the era preceding the Industrial Revolution); its use as a domestic urban resource (water supplies for cities).

If one is to focus exclusively upon agricultural uses, one initial methodological consideration emerges immediately: can one really talk about irrigation in isolation from land reclamation? The notion of 'integrated land reclamation' as developed a few decades ago would seem to make it clear that one cannot. For agronomists, drainage does not involve simply digging canals to 'carry off excess

water', it also means using that excess for efficient irrigation of the land reclaimed. In effect, irrigation is 'essentially a part – a very important part – of the overall plan of integrated land reclamation'.<sup>1</sup> And within the Venetian Republic itself, the term 'land reclamation' (*bonifica*) covered both the drainage and consolidation of marshy land and the irrigation of dry, gravelly terrain. Given this, it would be arbitrary to analyse irrigation within the Veneto without taking a detailed look at the various land-reclamation consortia which emerged during the sixteenth century – the period of greatest expansion – and then continued to be active through the first decade of the seventeenth.<sup>2</sup> However, one should make some initial comments here. Land reclamation, in the wider sense just used, was a practice that emerged rather late. And if it is true that the 'mandate' of Venetian *Provveditori ai Beni Inculti* [Department of Uncultivated Natural Resources] considered irrigation of dry land and drainage of marshy terrain as two aspects of the same process, it is also true that for a long time agricultural practice kept the two procedures well distinct from each other (depending upon the immediate requirements dictated by the nature of the terrain being dealt with).

Nevertheless by the seventeenth century this process of 'integrated' land reclamation – in the Republic of Venice and elsewhere – was primarily concerned with the recovery of marshy or ill-drained land. 'Reclamation' was intended not so much to boost agricultural productivity as to find some agricultural use for marginal – and frequently malaria-infested – terrain, the authorities' main concern perhaps being to remove the health risks that infested marshy areas posed to the urban centres situated nearby. However, overall I would argue that in the majority of cases the main considerations were agricultural and economic – as one can see from the fact that there was intense work on traditional land reclamation schemes in the river-plain areas of the Veneto, while irrigation work in the foothills and upland areas tended to be ignored.<sup>3</sup>

Nevertheless, even within the areas most affected by land reclamation (primarily the Po valley and delta regions), irrigation work was rather scarce as it clashed with the interests of those whose prime concern was to see excess surface water removed. The same paradoxical insufficiency of irrigation can be seen throughout the lowland areas of the Veneto: in the region of Treviso, for example,



Map 1. Variations of Terrain within the Veneto. Source: C. Grinovero, *Ricerche sull'economia dell'irrigazione. Risultati economici delle irrigazioni nel Veneto*, II, Rome-Milan, 1933, Plate XXXII (simplified).

herd grazing was quite extensive but a 1646 census of the territory of the commune reveals that out of 125,123 *campi* of grazing pasture a total of 53,667 were not irrigated. And even in the Verona and Vicenza areas, although there were irrigation projects, they did not have the direct impact upon livestock farming which they had been intended to. In 1555, for example, Verona declared that it could not supply Venice with the livestock quota that had been imposed in 1529 (1,000 head of cattle) and had to turn to the nearby Mantua region for sizeable supplies of fodder. In 1573, grasslands accounted for little more than 13 per cent of all the terrain recorded in the census of the Verona and Vicenza areas, whilst in the area below Padua that figure fell as low as 6 per cent, and dropped even further in the foothills around Treviso (3.3 per cent). Although by 1618 grasslands and meadows in the Vicenza area accounted for 18.5 per cent, in the Padua area at the beginning of the eighteenth century they still only accounted for 9.9 per cent of the total land dedicated to the production of cereal crops.<sup>4</sup> As Marino Berengo has pointed out, such inadequacies in the production of fodder and the raising of beef are ultimately 'the result of all the defects to be seen in the agriculture of the Veneto under the Republic'.<sup>5</sup> The debate over the reasons for this failure to develop livestock herds has long occupied scholars. Ugo Tucci is, however, probably right when he suggests 'the availability of reasonably cheap livestock supplies from Hungary [...] discouraged farmers within the Veneto from investing in herds, given that this would have meant sacrificing areas that might be used for cereal crops or, in certain zones, laid out with mulberry plantations – both of which were much more profitable'.<sup>6</sup>

So, whilst the focus upon the draining of lowland or marshy areas is perfectly understandable, it did – from an agronomic point of view – lead to a totally mistaken evaluation of the advantages/disadvantages of irrigation. In 1788 the *Deputati all'Agricoltura* were still expressing perplexity – if not outright opposition – with regard to the irrigation of the Padua area, which – they argued – was unsuitable because a large part of the terrain there was clayey, an obviously erroneous judgement which failed to take into account the fact that one can adjust times/duration of irrigation to qualities of soil type. Whilst not denying that irrigation might be useful for other types of crop, the *Deputati* insisted that its result here would be excessive humidity that would have a detrimental effect upon the quantity and quality of grasses and

turn meadow-lands into swamps. The rather paradoxical result of all this were still to be seen in the recent past: with the exception of the Rovigo area, in the 1930s all the various zones of the Veneto were still a long way from meeting the needs of modern irrigated agriculture. Important works of drainage had been carried out, but there was no counterpart in irrigation, and hence agriculture had remained largely extensive rather than intensive. With its 266,000 hectares requiring irrigation and only 1,000 hectares requiring drainage, the Padua area in the 1930s is clearly the one which most strikingly demonstrates the long-term contradictions within these attitudes to the two main aspects of land reclamation.<sup>7</sup>

The more perceptive agronomists of the sixteenth and seventeenth centuries were aware that irrigation not only increased the value of land<sup>8</sup> but could also result in an increment in average annual output from some 20 to 500 per cent, depending upon soil quality.<sup>9</sup> Development would have been very different if greater account had been taken of the role water could play in increasing output in a whole range of crops: maize, legumes (sedge, clover, vetch and sainfoin), vines (as long as sparingly irrigated), fruit orchards, rice, vegetables, mulberry, tobacco, beets and wheat.<sup>10</sup> However, it is an almost impossible task to give an even approximate quantification of agricultural 'productivity' during these centuries: documentation is too incomplete and provides no certain information on such fundamental factors as quantities of seed crops, areas cultivated, fertilisers, irrigation. Hence, rather than a measure of productivity what one really has is 'a measure of the echo – and a distant echo, at that – of productivity'.<sup>11</sup>

What is certain is that irrigation marked a break with the traditional cycle of crop rotation. As Pierre Vilar observes with regard to Catalonia, 'irrigation put an end to fallowland (*jachère*) for good. And even outside the *huertas* proper, it made it possible to intermit the usual cereal and legume crops with the much more profitable hemp, or multiple harvest fodder crops such as alfalfa'.<sup>12</sup> The Venetian Republic of the sixteenth and seventeenth century does not always seem to have been aware of these technical possibilities, and this inevitably had important consequences upon policy-making and the economy; the limitations within the agriculture of the *terra firma* become all the clearer when we compare it not only with the more fortunate and dynamic regions of northern Europe but also with such Italian regions as Piedmont and,

above all, Lombardy. The Venetian Republic's most prestigious neighbour, this latter had been developing an integrated system of canals since the twelfth century: work on the Naviglio Grande that carried water from the Ticino to Milan dated from 1179; the Basca canal, from the Sesia, was dug before 1300; the Martesana, which brought water to Milan from the Adda, was completed by 1456, and the Novara and Lomellina areas also had their own networks of canals (the Biraga, the Bolgara and others). As Braudel remarks, the capital of Lombardy had become 'an important water station, which meant that it received wheat, iron and, above all, timber, at lower costs'. The developments within agriculture were no less encouraging, with extensive investment, early introduction of fodder plants in the crop-rotation cycles, the spread of irrigated pasture-land and a resultant increase in livestock herds.<sup>13</sup> It was Lombardy that would first see those structural changes within agriculture that would have such a profound effect on the very appearance of the region (land reclamation work, the introduction of rice-fields, the occupation and cultivation of a large part of church-owned land). As Cipolla underlines, in the second half of the fifteenth century the focus was more on meadow/pasture land than upon putting land to the plough, which meant that 'there was a more expansive trend in livestock production than in the production of vegetable crops; in other words, the areas of Lombardy were undoubtedly tending towards the more developed phases of agriculture',<sup>14</sup> and from the eighteenth to the nineteenth century, irrigation would not only become widespread, it would also achieve the highest technical standards.<sup>15</sup> In fact, as early as the sixteenth century almost half the usable land in the Lodi area – the veritable 'jewel' of the Milanese state – was benefiting from irrigation, with production boosted enormously by the fact that fields could be alternated between cultivation and pasture. Around Cremona, too, a good 20 per cent of cultivated land was irrigated, whilst the figure for the Novara and Como areas was 13 per cent, and that for Pavia and Lomellina was 12.2 per cent. Moving ahead to 1880, the figures paint an even clearer picture, with the percentages for irrigated flatland terrain in Lombardy, Piedmont and the Veneto being 55, 46 and 7 per cent respectively<sup>16</sup>.

But agriculture in the Veneto did not just suffer from the lack of a full capillary network of irrigation canals; the very nature of its development was unsound. While in Lombardy and Piedmont there was a clear propensity to invest in agriculture (even in periods of

stagnation), with the creation of extended agricultural concerns that were managed along capitalist lines and employed salaried labour, the situation was very different in the Veneto. In the early decades of the sixteenth century the Venetian patricians had shown a clear willingness to invest in the countryside, thus stimulating capitalist development;<sup>17</sup> however, one soon sees the re-emergence of pre-capitalist – and sometimes even feudal – practices: land was rented out in smallholdings and properties were split up as the patrician class showed little interest in running their estates themselves. G. Corazzol's research into the later decades of the sixteenth century reveals that increases in rents and leases were being paid in kind (grain), a phenomenon which provides further proof of the gradual impoverishment and expropriation of the peasant-farmer class by urban capital searching for ways to protect itself against the growing inflation of the period.<sup>18</sup>

## Agronomical Literature

The limited resort to irrigation in the Veneto during the sixteenth and seventeenth century contrasts strangely with the abundant quantity of published material on the subject that was circulating within the Venetian Republic. In effect, none of the agronomical treatises or translations that were published in Venice failed to deal with the question, sometimes with original observations, sometimes with an eclecticism that drew heavily on classical and medieval discussions of the subject.

Leading figures in those discussions had been the Bolognese Pietro de Crescenzi (1233–1320) and the Arab scholar Ibn-al-Awwām (1180–1220). The former's *Opus ruralium commodorum* would initiate a revival in the studies of agronomy that reached its peak in the sixteenth century. Far from being a mere observer of the past, de Crescenzi showed a truly modern spirit in his treatise: not only did he discuss the problems caused by excessive exploitation of plain flatlands as a result of the sharp increase in population during the twelfth/thirteenth century, he also considered remedies for the land erosion watercourses caused in hilly areas.<sup>19</sup>

For his part, Ibn-al-Awwām marked the high point in Arab studies of agronomy, which after him would begin to go into decline. Whilst it is true that the *Le livre d'agriculture* by the most important Arabic

writer in Spain would not be translated into European languages until the eighteenth century, it is undoubtedly the case that his teachings made their mark felt beyond the Arabic-Spanish world.<sup>20</sup> The influence of the Arabic tradition within the Mediterranean area should not be underestimated: inheriting Graeco-Roman teachings and applying them to the Arabic-Spanish world, this tradition would result in medieval Spain becoming one of the earliest and most fascinating examples of a *civilisation d'eau*. The canals of the kingdom of Valencia were justly famous for the fertile *huertas* that they supplied, with the characteristic landscape of the irrigated *regadío* contrasting with that of the *secà* (arid lands).<sup>21</sup> It may be true, as Bolens points out, that treatises in medieval Andalusia dedicated less space to irrigation than to the urban use of water (aqueducts and canals to supply mosques and princely residences), but it cannot be denied that such writings reveal a modern approach to the use of water in agriculture, with clear attention being paid to the need for balanced environments, natural fertilisation and a prudent selection of the land to go under the plough (indeed, a much higher degree of attention than that one sees in the agricultural policies followed nowadays).<sup>22</sup>

The decline of this glorious agricultural achievement would start towards the end of the Middle Ages, when the interests of a more livestock-centred agriculture would focus on the extensive development of terrain and on the so-called *Mesta*, 'ultimately [overwhelming] the great hydraulic civilisation created by the Moors'. The same destructive policy would be followed in Latin America, where 'the aggressive warriors of Navarra and Castille ... destroyed the hydraulic core of the high American civilisations with the self-same political and economic weapons they had used against the centres of Moorish irrigation in Cordoba, Seville and Granada'.<sup>23</sup>

And even such a figure as Gabriel Alonso de Herrera, considered one of the most important agronomical authors of sixteenth-century Spain, would ignore Arabic achievements in this field to focus solely on the works of Classical Antiquity, which he outlines – often with slavish fidelity – in his *Obra de agricultura, compilada da diversos autores*, a work that enjoyed substantial success throughout Europe (a total of 16 editions were published in Spain, whilst there were eight of the Italian translation – one being published in Venice in 1558).<sup>24</sup> However, I would argue that the Arabs' achievements in hydraulics did have a fundamental effect upon both agricultural

practices and agricultural legislation within the Mediterranean area. In fact, when after Cateau-Cambrésis the Spanish took control of Lombardy, the legislation introduced with regard to such matters was inspired by that applying in Spain,<sup>25</sup> with the result that this region became a more advanced model for the neighbouring Venetian Republic, to which it would ultimately export both technology and legislation. Hence the fascinating image emerges of a true circuit of ideas and knowledge embracing the whole of the western Mediterranean and stimulating a constant series of advances and developments.

Alongside this Arabic-Spanish tradition, that of classical antiquity was to be no less influential in a sixteenth century which saw numerous editions of the works of Frontinus, Pliny, Vitruvius and Columella.<sup>26</sup> But soon, both of these traditions together were joined – and to some extent overtaken – by the contributions offered by contemporary authors – people such as Palissy, Olivier de Serres and the above-mentioned Gabriel de Herrera.<sup>27</sup> As recent studies have shown, foremost amongst these contemporaries – both for the number of works published and the range of themes discussed – were Italian writers on agriculture, with treatises originating in Venice offering important theoretical contributions from some of the most innovative agronomists in Italy.<sup>28</sup>

Within the Venetian state a fundamental role was played by the Brescia area, where Giacomo Chizzola would seem to have founded the region's first Academy of Agriculture at Rezzato in around the year 1568; the authors and experimental agronomists active in this zone included figures of European standing – such as Agostino Gallo and Camillo Tarello – as well as significant minor figures like Giacomo Lanteri and Giuseppe Milio Voltolina.<sup>29</sup> Bordering the more developed and better-irrigated Lombardy, the Brescia area was one of the most agriculturally-dynamic in the whole of the Venetian state; numerous accounts mention its abundant crops and its intensive use of irrigation. It was within this context that a very lively theoretical debate developed, with Agostino Gallo and Camillo Tarello being rightly seen as early champions of a capitalistic development of agriculture based on rational crop rotation and the use of fodder crops in alternation with fallow (a policy whose well-known results are increased soil fertility and the provision of stable feed for livestock).<sup>30</sup>

Irrigated pasture and arable land were the linchpin of the theories outlined. In the words of Gallo, 'I would urge that one takes the land with water rather than otherwise. Because, with abundant watering ... it is almost impossible that one does not get double the yield that one gets from all the others'.<sup>31</sup> However, at the same time, he warned against excessive irrigation of land, observing 'that giving each field the water it requires, that field receives it as it would its own good mother; but the longer it holds that water within it, the more it begins to feel it as the worst of stepmothers'.<sup>32</sup> He did nevertheless focus largely on those crops (rice, flax and hemp) that required intensive irrigation. The fact of the matter is that, like many of these writers on agronomy, Gallo paid less attention to the narrow problems of his own farm than to making proposals and suggestions for the owners of large- and medium-sized estates in the fertile valley area below Brescia. His main concerns therefore were how to intensify commercial-based agriculture; how to supply urban markets; and how to improve the income of agricultural landowners.

In his *Ricordo d'agricoltura* (1567), Camillo Tarello too discussed how to increase agricultural productivity in order to meet the demand from a growing population and remedy the downward trend in profits. In effect, the patent that he submitted before the Venetian Senate aimed to achieve these ends thanks to the regenerative influence of fodder grasses as part of the crop cycle – the so-called 'Tarello Revolution', which was based on a good two years of fodder crops within a four-year cycle. There was, however, a clear contradiction in his view that intense irrigation of terrain to increase crop yields of grasses or hay would be detrimental. Clover 'which grows in non-watered land', he observes, 'may grow in smaller quantities than it would in watered land, but it will be better and more tasty'. Hence, the fallow field envisaged by Tarello was a dry one, not the irrigated field to be seen in neighbouring Lombardy (where repeated irrigation made it possible to obtain multiple crops of hay throughout the year, and thus provide the fodder necessary for flourishing livestock herds). What is more, the type of agriculture Tarello aims to develop is still of the subsistence kind, with small-sized holdings and grain crops (the only sort that he believed could guarantee survival and feed the rapidly-increasing population). As Berengo has pointed out, what was actually required was to wean landowners from this obsession with grain and encourage them to

make heavy investments in other crops, which would lead to the establishment of another kind of agriculture; but the farmers to whom Tarello was addressing himself – his message being propagated at a local level by parish priests – did not have the sort of capital necessary for such a change. The very property farmed by Tarello himself – the ‘Marcina’ – covered only 36 *piò* and thus revealed all the theoretical and practical limits of the formula he proposed.<sup>33</sup>

The same sort of approach can be seen in the work of Africo Clementi, a Paduan notary who, from intellectual curiosity and a taste for experimentation rather than any material need, leased a few areas of farmland outside his native city. Produced in a situation of endemic food shortages amongst the peasant population, his *Trattato dell'agricoltura* continued to focus on cereals and vines as the fundamental crops, with only a hasty mention of those crops linked with a capitalistic development of agriculture. The distance between his outlook and a modern approach can be seen in the scarce attention he pays to the subject of livestock herds and fodder: in fact, he argued tree foliage was enough to feed the scant herds in the Padua countryside. And as for soil fertilisers, the key strategy he proposed was the *sovescio*, the digging-in of the plants which grew up there.<sup>34</sup> Clementi did, however, see the importance of fish-farming, which in modern Europe presented an alternative to the raising of livestock herds<sup>35</sup> (this was undoubtedly the case in France at least, given the importance of the Paris market for fish; the situation in Italy and other European countries has been less extensively studied).<sup>36</sup>

In effect, it was the widespread belief that irrigated pasture-land meant less land for precious grain crops which would ultimately hinder its introduction, and that not only within Italy or the Venetian Republic. The size of the population played a key role in the contraposition of the needs of arable crops and livestock – a contrast that was not without its social implications. As Braudel points out, acre for acre, crop cultivation inevitably beat livestock farming, being able to feed ten or twenty times as many people.<sup>37</sup> And even in the Lombardy area around Lodi – where the battle for irrigation had not come to a total end, even if there could now be no doubt as to its ultimate outcome – it was commented that ‘it would be better, especially for the poor, that they were sooner without meat and

cheese than without bread. Before the Lodi area had the water drawn from the Muzza it was always in need of all sorts of forage; then when most of it was converted for fodder crops, thanks to the convenient supplies of the water ... primary foodstuffs for its own inhabitants became correspondingly less abundant'.<sup>38</sup>

The accusation is clear: forage and livestock had become economic speculations, providing meat and dairy products for the tables of the wealthy, offering landowners higher returns, and thus leading to a cutback in the traditional cereal crops that supplied the stable diet of the poorer classes.<sup>39</sup> However, as Ceredi insists in his account of this lively and interesting debate, it would have been wrong to try and put the clock back: far from simply causing a drop in the production of such a basic crop as grain, irrigation made for more varied and differentiated agriculture, which was ultimately to the benefit of the population as a whole.<sup>40</sup>

Agricultural literature paid equal attention to other irrigated crops: millet, flax, hemp, mulberry, maize, sorghum (sometimes confused with maize), oats, various types of fruit plants and, above all, rice.<sup>41</sup> The greater space dedicated to this latter crop was undoubtedly due to the complexity of the water supply required at the different phases of growth and the fact that the banks, canals and locks of rice-fields needed constant attention. If there was one crop whose very survival depended on abundant supplies of water, it was rice. Between March and May, water for the rice-fields had to be plentiful: when the crop was planted, Giuseppe Falcone recommended, 'there should be about a finger's depth of water over it ... Then it begins to break the surface and branch upwards. When it begins to turn the colour of millet, it is mature and the water is drained off ...'<sup>42</sup>

But there was also open hostility to rice, arising primarily from dietary and sanitary considerations (these latter to be found in the whole of the Po valley and not just the Veneto). And even when one looks at very different regions, at different periods of history, the criticisms of rice as a crop are the same. Again there was the fear that rice occupied land that could be used for precious cereal crops; and again 'the cultivation of rice – like the planting of vineyards – was attacked due to the fear of timid traditionalists that the population would be left without wheat and the army without straw'.<sup>43</sup>

However, the most violent criticisms were made in the name of health conditions: doctors and scholars protested against rice-fields,

and even more vociferous were the people who were exposed to those periodic fevers which we now know to have been malaria. But these voices of the weak had little chance of making themselves heard against the powerful interests involved. From Catalonia to the Verona area, the 'lords of water' easily managed to minimise the dangers of rice-fields, insinuating the doubt that it had yet to be shown that 'the poor health conditions in the lowlands depended exclusively on one type of agriculture'.<sup>44</sup>

A high-profit, speculative crop, rice provided a 'limit case of a specialised eco-system', requiring massive capital investment that only a large landowner or wealthy tenant could afford; given his scarce financial resources, the share-cropper showed very little interest in rice. To have an idea of the expense involved, one need only mention that during the eighteenth century the cost of water (including transport and the regular maintenance of canals and ditches) could amount to 15 per cent of all the monies that the entrepreneurial rice-grower spent in a year (depreciation included). For example, in the Mantua area, the annual upkeep of a rice-field was, acre for acre, four times higher than that for dry-land crops. However, these high initial costs were rewarded with a return that was at least twice as high as that from corn. Given this, one can see how difficult, if not impossible, it was to convince a landowner to destroy a rice-field or sacrifice a harvest (protests against rice generally broke out during the summer, after the crop had been sown). The most that could be obtained was a restriction of rice-fields to certain areas (the low-lying lands or marshy zones), or their removal from the vicinity of cities and villages. The first proclamation in Milan prohibiting the planting of rice within six miles of the city (or within five miles of the other cities of the region) came in 1575, and stirred loud protest from the farmers concerned; in 1662, the restriction was reduced to four miles for Milan and Novara, and three miles for other cities.<sup>45</sup>

The same sort of thing also happened in the Veneto. But such restrictive legislation proved ineffective; and in spite of criticisms that would go on being voiced until well into the nineteenth century, it was rice which emerged triumphant. The crop 'gained ground' throughout the Po valley area – from Piedmont to Mantua, and from Verona to Ferrara – though obviously the rate and timetable of expansion varied from region to region.<sup>46</sup> And in this inexorable

advance of rice, the crop's properties as a foodstuff also played their key part: Giuseppe Falcone, for example, commented 'it might make the air of such a site malignant, but the return [on rice] does not take this into account, given that from the crop one can derive soups, loaves, bread (when mixed with other flours) and a lot of strength and energy'.<sup>47</sup>

## Legislation and Technology

Within medieval Europe water had long been used both for irrigation and as a source of power; however, the regulation of those uses had largely been at the level of individual communities. With the expansion of agriculture in the sixteenth century, there is no doubt that in most of the countries of the continent there was a corresponding development in the legislation governing such matters. 'Water rights' were defined in legal terms, even if that definition was sometimes inadequate to the complexity of regional and national situations which dated back centuries. Roman Law had, in fact, already drawn a key distinction between rivers and major watercourses on the one hand, which were to be considered as public, and minor watercourses, which could be privately owned and managed. Nor should one overlook those traditional, communal forms of water management which existed at a village or small community level, but whose legal definition was insufficiently clear. The problem was made all the more complex by the fact that the definition of water rights could not but reflect the economic strategies and relations of production that existed within each of the individual 'case studies'. In effect, then as now, the definition of water as a 'public asset' or as a private 'commodity' that answered to the laws of the market was an essential part of a wider political debate.<sup>48</sup>

In the Venetian Republic it was the establishment of the *Provveditori sopra i Beni Inculti* that opened the way to more complete and precise legislation with regard to water concessions. As far as agriculture was concerned, the declared aim was to increase the production of cereal crops by bringing marshy land under the plough and also providing irrigation for arid areas. In proposing this policy, it was pointed out that the area of land dedicated to grain production was insufficient: there were frequent famines and it was not always easy to obtain supplies from other states (who, due to their own

internal shortages or open hostility to Venice, might prevent exports).<sup>49</sup> But other factors were to play an equally decisive role here: the slow and extensive transformation of the Venetian patrician class from one of merchants to one of agricultural entrepreneurs (or, at least, landowners); the shift of investment from trade to land, which was seen as safer and more profitable; the various difficulties encountered by Venice's ships at sea; the need to counterbalance trading losses with more remunerative investments on the *terra firma*; the high price of grain.<sup>50</sup> There is no doubt that in the second half of the sixteenth century, the patrician class of Venice became much more interested in the *terra firma*, with a resultant stimulus to all the economic activities associated with that area (including those owned by the local nobility): land reclamation and irrigation projects, the spread of new crops, the publication of agricultural treatises and the development of new technologies and machinery are all clear evidence of this shift in interest – as are the institution of such public agencies as the above-mentioned *Provveditori ai Beni Inculti*, or the later instituted *Provveditori sopra i Beni Comunali* (set up in October 1574 to oversee the exploitation of collectively-owned land).<sup>51</sup>

The areas of uncultivated natural resources to be reclaimed by the *Provveditori ai Beni Inculti* (the three-man agency had first been elected in 1545, and became a permanent part of the Venetian administration in 1556<sup>52</sup>) were located around Padua, Vicenza, Verona, Asolo, Rovigo and Istria. The agency's brief did not, however, include the areas around Brescia, Bergamo and Crema, which were the best-irrigated of the mainland Republic<sup>53</sup>; that their superiority was recognised becomes clear when one sees that the 1519 legislation regarding the widening of the old Rosà canal in the Treviso area laid down explicitly that the measures regarding the use of the waters from this new canal were to be based on those applying in the Brescia and Bergamo areas. In effect, when one looks at Venetian legislation concerning water resources it becomes clear that, with some variations, it is modelled on that adopted in Lombardy.<sup>54</sup>

However, one must move forward to the decree of 5 February 1556 to get a full picture of the legalisation at the basis of the work performed by the *Provveditori ai Beni Inculti*. Public ownership of all watercourses – be they large or small – was asserted categorically, with those wishing to exploit such resources having to pay a certain

sum for the concession (in effect, once granted, this concession could almost never be revoked). In Lombardy, on the other hand, the individual users of the water enjoyed private property rights, even if there were lease concessions, multi-year rent contracts and – though this was rare – temporary contracts. It is this which, as Mario Romani argued, accounted for ‘the absolute perfection which emerged over time in the division and use of water resources, unlike the case in the Mantua area or in the Veneto, where the benefits gained from irrigation were lower than they would have been if a freer hand had been given to private individual interests’.<sup>55</sup>

The legislation in Lombardy, therefore, was similar to that in the more open, dynamic areas of Europe – for example, Valencia or Castellón in Spain.

Another problem that existed was the possible division between the owners of the water and the owners of the land, a situation which guaranteed that the former exerted social and economic dominion over the latter, triggering off a process which in the long run resulted in the re-emergence of backward, feudal relations of production – as would happen in some areas of Spain (Elche, Alicante and Novelda), the Canary Islands, and in part of Sicily (Palermo).<sup>56</sup>

Further evidence of the influence of Lombardy on irrigation within the Venetian Republic can be seen in the fact that Venice had in the early decades of such projects to draw on the services of Lombard, Brescian or even Piedmontese experts to assess the conditions of the terrain through which the irrigation canals were to be created. It was not until 1568 that the Republic appointed three of its own ‘permanent experts’, expressing the hope that they would prove to be less ‘ignorant with regard to the qualities and evaluation of water’ than some of their predecessors, who had turned out to be ‘very negligent, and not very diligent in perceiving and reporting the true state and value of these waters’.<sup>57</sup>

However, the precise norms governing land drainage that were promulgated in the sixteenth and seventeenth century were not always applied coherently, or perhaps even respected at all. A far from secondary aspect in evaluating a state’s administration, this gap between regulations and the observance thereof is all the more important and significant when one is assessing a political entity such as the Venetian Republic, which – with undoubted justification – was

celebrated throughout Europe in the political writings of the sixteenth and seventeenth centuries.

Before the establishment of the *Provveditori ai Beni Inculti*, the *Savi alle Acque* [Water Magistracy] was already informing the Senate that there 'were numerous encroachments upon many stretches of the Brenta Nuova and other places'; and – as continuing complaints reveal – even when he held an official concession, the leaseholder might not always respect limitations regarding the quantity of water to be drawn, the way it was to be used, or the number of fields to be irrigated.<sup>58</sup> At a certain point, it was argued that the financial losses suffered were due to the low price at which the water was sold; and though we cannot assess how justified this claim was, it did result in the suggestion that instead of a (substantial) initial payment, leaseholders should pay a yearly fee based on the value of the water. However, the proposal came to nothing.

In effect, precise assessment of the value of this natural resource was considered to be difficult, if not impossible, as it had to take into account such vague and uncertain variables as the quantity and 'quality' of the water drawn and the use to which the concession-holder put it. Given the technical and scientific instruments available at the time, even the mere measurement of the quantity was difficult enough; and as for the 'quality', that was even more difficult to pin down, with water being divided into different broad categories (river, torrent, spring, rain and channel – that is, drained water which had already been put to a use) and experts attempting to assess its other characteristics ('fat' water as opposed to 'cold', 'muddy' as opposed to 'clear'). What is more, the evaluation of price had to take into account the time when the resource was being used, given that in dry periods or in other circumstances it might be in short supply.<sup>59</sup> Similarly, one had to consider the type of soil being irrigated – meadow, plough land, rice-fields, vegetable plots, orchards, gardens – and the type of machinery that might be powered by the water. Nevertheless, in spite of the enormous variety of cases, a basis for quantification can be derived from an analysis of the different concessions. Water drawn off directly from rivers – especially sizeable rivers – was obviously the most costly, whilst the cheapest source of water were muddy, perhaps seasonal, streams and the drainage canals carrying water away from the fields of other users.<sup>60</sup> Water for rice-fields cost the most, given the high profits the crop could yield, whilst personal use

(for non-speculative ends) enjoyed some sort of subsidy. Of course, there was a wide variety of uses between these two extremes, from the irrigation of meadow and grassland (the cost of which always took into account the relation between the extent of the terrain and the amount of water available) to that of orchards.<sup>61</sup>

Difficulties in assessing the quantity of water used were due not only to individual fraud but – as has already been mentioned – also to the limited technical knowledge of the day (and the even more limited grasp of it by the appointed technicians and experts). Right up to the end of the eighteenth century, measurement was so rule-of-thumb that accurate quantification was out of the question; technicians frequently admitted their inadequacies, especially when it came to measuring spring or torrent water. In effect, they simply measured the vertical section of the opening of the mouth of the watercourse in square feet – that is *quadretti*<sup>62</sup> – and totally ignored water speed and time in their calculations; not until the scientific revolution of the seventeenth century – and, in particular, the work of Benedetto Castelli (1577–1643) – would a more mathematically-precise approach be taken, with Castelli's *Della misura delle acque correnti* (1628) marking the beginning of water technology based on rational first principles, which would then expand into a whole domain of in-depth scientific enquiry.<sup>63</sup> Perhaps Paolo Frisi exaggerates when he claims that hydraulic science was born in Italy, 'where it was practically perfected, and where written works explored all aspects of hydrometry and hydraulic laws'.<sup>64</sup> Yet there is no denying the contribution made by such authors as Evangelista Torricelli, Domenico Guglielmini, Galileo Galilei and G.B. Barattieri, whose rigorously-exact definition of this area of scientific enquiry resulted in a key contribution to theory. Castelli's own theorem is posited on the idea that the volume of running water is directly proportional not only to the sectional area of the channel in which it flows, but also to its speed.<sup>65</sup> In more exact terms: 'the mass of fluid that in a given moment passes through a given section of a river or a canal is equal to the product of the area of the vertical section and the average velocity of that section'. And given that it was difficult to measure such average velocities, an eighteenth-century source indicates that one took the section to be a rectangular figure and considered the speed as equal to the square root of the depth.<sup>66</sup> From that century onwards, some leases of concession would take this

factor into consideration; but when Castelli was writing – that is, in the mid-seventeenth-century – such variable velocities were totally ignored in water-volume calculations (in Lombardy as in the Veneto).<sup>67</sup> And even when during the course of the seventeenth century Venice did issue some regulations concerning the assessment of velocity, they were – as Zendrini points out – so obscure they failed to put an end to the usual abuses of the system:<sup>68</sup> for example, the canal might be widened both upstream and downstream of the evaluation point. What is more, given the irregular shape of many vertical sections and river beds, calculation of the area remained little more than theoretical (even modern hydraulics finds itself faced with similar problems). And while it may be true that the 1764 treaty drawn up between Maria Theresa of Austria and the Venetian Republic – in resolution of a long-running dispute regarding the use of border watercourses<sup>69</sup> – did adopt new and rational terms when fixing the regulations governing the drawing-off of water, it is also true that there is no evidence that these regulations were respected, either in that border area or anywhere else within the mainland Republic. When we look at the more developed irrigation system of the neighbouring Lombardy, one sees the same rule-of-thumb methods being adopted in the eighteenth and even into the nineteenth century.<sup>70</sup>

Throughout the Early Modern period, therefore, one can see only certain constant features in the regulation of water use within Venice's mainland Republic. The experts limited themselves to insisting that at its mouth, the last ten *pertiche* (poles) of the irrigation canal should be faced with hard stone, thus protecting the opening at which the water was drawn off. Sometimes, the water was diverted into the canal by means of a barrier placed across the watercourse from which it was being drawn; necessary when the water in the river was low, such *roste* or traverses could either be made into a permanent feature or else lowered as a temporary obstacle that only hampered navigation for a short period of time. At other times, the diversion barrier might be a simple *pennello* [screen] of canes and stone jutting out part-way from one bank of the watercourse.<sup>71</sup>

Having flowed into the terrain, the water was then fed into a number of small canals, using the system nowadays known as 'flow irrigation'; the most common method then in use, this is to be distinguished from the 'submersion' irrigation of rice-fields or the

much less frequent 'infiltration' method of irrigation (the fact that this latter was used much less than 'flow' irrigation can be seen from the numerous drawings and charts in the archives of the *Beni Inculti*, which clearly show the main canal dividing up into a number of rivulets).

A certain incline worked to the advantage of the 'flow' technique, but if it was too sharp – or the field sank towards the middle – then the water either ran off too quickly or stagnated.<sup>72</sup>

Throughout the sixteenth century various systems were studied for carrying the irrigation water most effectively to the land to be irrigated; in many cases, the same machinery might be used to drain and then irrigate terrain. Taking up a classification proposed in the eighteenth century by Simone Stratico, one might divided hydraulic machinery into: first, that which raised water using force, for example, pressure or aspiration pumps; second, that which raised it smoothly from the watercourses below – for example, all the various types of wheel used to lift water up to higher levels, or the Archimedes' Screw.<sup>73</sup>

Although more complicated machinery was developed and proposed by the relevant authorities, the 'bucket' waterwheel would remain widely used along the rivers of the Venetian Republic for years to come.<sup>74</sup> Set up in such a way as not to hinder the movement of barges or the operations carried on within riverside buildings, these did however prove costly to run – so much so that they were only used by noble families or civil and religious bodies with rather ample means.

The various Venetian bodies responsible for such matters – the Senate, the *Savi alle Acque*, the *Provveditori ai Beni Inculti* and the *Provveditori di Comun* – were frequently presented with designs and patent applications for machines which their inventors unflinchingly described as exceptional. However, many precious details of these remain either obscure or have been lost altogether, partly because the applicants reserved the right to fully illustrate their designs only after they had obtained their patent (which was not always granted, given the repetitive nature of a number of proposals) and partly because, even after receiving their patent, they did not always supply more specific details.<sup>75</sup> One such inventor, Giovanni Ceredi, did not fail to note – with a certain satisfaction – that within the secret archives of the *Provveditori di Comun* there were many designs for hydraulic machines, but 'being of no greater utility than their predecessors,

they will remain secret'. Obviously, that was not the fate he envisaged for his own invention, presented not to the Republic but to Alessandro Farnese, Duke of Parma and Piacenza, with the hope that the reception of his machine would not be limited to that small state. In effect, what he had produced was just a variation upon the Archimedes' Screw<sup>76</sup>; but he claimed that his machine would profit the whole of the Po Valley, given that he had successfully completed a design that many others – Venetians included – had been striving for in vain.<sup>77</sup> However, his hopes for his brainchild were to be disappointed – at least within the Veneto, where his machine does not seem to have been widely adopted. This one example might be taken as partial confirmation for the claim that many of the machines designed in Italy were merely theoretical, with a sharp divergence emerging between the rich theoretical literature of the day and the practical application of the ideas it put forward.<sup>78</sup> Yet even if this was the case, it is still undeniable that, up to the very end of the sixteenth/beginning of the seventeenth century, Italian hydraulic technology would remain second to none in Europe.

## Utopia and Reality: The Canals of the Veneto in the Sixteenth and Seventeenth Centuries

Even if a whole series of canals were dug there during the Middle Ages, it was in the fifteenth century that the Veneto saw an increase in the creation of canals which could bear some sort of comparison with the more technologically-advanced system in Lombardy. The following century would simply develop upon what had been started already, re-adapting or enlarging existing canals. In effect, there was no overall project for the sort of canal system that is essential for an integrated irrigation system.

At the beginning of the sixteenth century there were: the Brentella and Piavesella canals, drawn off the Piave in the first decades of the fifteenth century to provide irrigation in the Treviso area; various medieval channels and canals on the left and right banks of the Brenta (these included the Battaglia and Rosà; the latter, on the left bank, was an important and long-standing source of irrigation and dated from 1370);<sup>79</sup> other canals drawn off the Brenta since the Middle Ages (these numbered at least 14); and the canals of Este and Monselice, another *Brentella* and the Piovego – that linked the Brenta with the

Bacchiglione to the west of Padua<sup>80</sup> (these dated from the twelfth to fourteenth century). All of the above irrigated the Padua, Vicenza and Treviso areas or else served as important routes of transport for merchandise (for example, the Lipsida stone which was carried along the Battaglia canal from the Padua area to Venice). Other less important canals had also been created in the Verona and Friuli areas in the Middle Ages.<sup>81</sup>

Although, over time, the limitations of the way it was used would emerge, the Piave does offer an important example of a rational and well thought-out exploitation of water resources in the Early Modern period. Irrigation in the northern stretches of the Treviso area dated back some time, but it would only become fully consolidated with the 1436 creation of the Brentella canal; drawn off the Piave at Pederobba, this would soon prove to be inadequate and be followed by the creation of the Piavesella in 1447 (drawn off the Piave at Nervesa). Though both canals were destined to serve the same area and exemplified one and the same policy with regard to water resources, their use went beyond meeting irrigation needs and providing water supplies for the fifty-nine towns and villages in the area. Concessions were granted for the use of the water to power mills, saw works and hammers, thus giving rise to a long-lasting conflict between those interested in the water as a source of energy and those more concerned with irrigation and urban supplies.<sup>82</sup>

The local administrators responsible for the distribution of the water were chosen from amongst the wealthiest families in the city of Treviso, and it was the abuses resulting from their vested interests which were subsequently blamed for the gradual deterioration in the maintenance of such hydraulic facilities. But even though the twelve *Provveditori* or *Deputati alle acque di Treviso* were accused by the *rettori* [Venetian City Governors] of favouring relatives and friends, any attempt to eradicate such privileges encountered stiff local opposition, thus hindering the introduction of an integrated irrigation policy for the whole of the mainland Republic.<sup>83</sup>

By 1572 the inefficiency of the *Consorzio Brentella* was clear: the water was insufficient for the four major towns, let alone all fifty-nine; and it came nowhere near its target of providing irrigation for 4,700 *campi*.<sup>84</sup> At this point a solution was put forward by Nicolò Cicogna, who voiced the interests of a Venetian patrician class that was increasingly attracted by the opportunities it saw in the exploitation

(and possible expansion) of the Brentella.<sup>85</sup> Thus a Venetian point of view was superimposed upon those local interests that had first led to the creation of the canal. In effect, Cicogna offered to carry out the work required by his project in return for one quarter of the water, the rest remaining to the cities and towns concerned. This meant there would be no resort to *caratade* – taxation or fees upon possible future concession-holders – as would have been the case if the work of renovation and expansion had been undertaken by the *Collegio di Treviso*. However, the city's response was that Cicogna, under the pretence of extending the canal, was actually trying to take control of what was public property. Given that the Venetian Senate's water policy was predicated upon a centralised, publicly-run exploitation of the resource, the Republic turned out to be very receptive to such arguments; as a result, it was the city of Treviso that was given the task of creating a fourth *porta*, with the requirement that work be completed within eighteen months.<sup>86</sup>

The speculative nature of Cicogna's proposal must have been clear to everyone; but it is far from clear that Venice made the right decision in rejecting it. In effect, eighteen months later the work had not been completed; nor was it brought to an end during the various extension periods granted the city of Treviso (though *rettori* continued to stress the urgency of new restoration and refurbishment work, funds continued to be insufficient). At one point, it was proposed to extend the Brentella as far as Treviso itself, and thence use the canal as a waterway for transporting merchandise – above all, the timber that was carried by the Piave down from the Alps to the Venetian lagoon. But again, nothing came of this and the Brentella continued to be inadequate for the purposes it had been intended to serve.<sup>87</sup> All in all, the fact that it was one single city that decided the use of the canal did little to help – indeed, hindered – the implementation of more far-sighted policies.

The picture is no better when one looks at the contribution made by the other Piave canal – the Piavesella, drawn off the river at Nervesa; again, incoherent use resulted in little real improvement in the area. True, a plan was drawn in 1549 to widen and deepen the canal, but this ran up against another fixed point of Venetian water policy – the need to protect the hydraulic equilibrium within the lagoon – because it seemed that increasing the volume of water flowing through the canal would infringe an essential priority:

keeping the waters of the Piave away from Venice. The more respected of the hydraulic technicians pointed out that part of the river's waters already flowed to Treviso along the Piavesella canal, making a contribution to water supplies in the surrounding area; but, they added, the 13-miles canal, whose long tortuous course followed the natural slope of the river, merely released the pressure of water within the Piave and did not present any sort of overflow risk for the lagoon. That risk, they argued, would increase if the volume of water in the Piavesella increased (above all, when the river was running full): in such cases, the Piave would pour down towards Treviso and the lagoon, damaging both. The possible advantages to water transport and irrigation (the latter anyway seen as difficult to achieve) were far less important than the mere possibility of a threat to the delicate environmental balance within the lagoon. In the words of Cristoforo Sabbadino, the technician who could be taken as the champion of this rigorously protective policy, one should think less 'of the profit one might get from wheat [than] of the conservation of the lagoon, which is the fortress of Venice'.<sup>88</sup>

In the Bassano region and the area between the cities of Padua, Venice and Treviso, the numerous irrigation canals drawn off the Brenta were put to no better agricultural use. To increase irrigation resources, the opening of the Rosà was widened in 1519, with the water being sold at the undoubtedly remarkable price of a good 2,900 ducats a *quadretto*.<sup>89</sup> This exceptionally high tariff does not seem to have been matched anywhere else, and it undoubtedly made it difficult to sell the water: in 1556 Zuanne Donà, the official of the *Rason Vecchie* (a *magistratura* that managed state assets) was sent to the area to conclude negotiations of the still uncompleted sales. Nevertheless, the volume of water carried by the Rosà and the other canals drawn off the Brenta can have been in no way inferior to that carried by the Brentella, without in any way diminishing the importance of this latter: the eighteenth century estimate of its water volume as not above eight *quadretti* must have been an all-time 'low'. Then as now, among the other canals it was the Rosà that drew off the most water, with the maximum volume at the end of the seventeenth century being calculated at 60 *quadretti* (for a section 15 feet wide and four high); however, generally not more than 48 *quadretti* were drawn from the river. Then came the Cappello canal – named after the family that held the concession (although part of it seems to have

been assigned to the Mocenigo, the Contarini and, above all, the Dolfin): the maximum capacity of its opening was 35 *quadretti*, though usually it only drew 23 (which is still more than the above-mentioned minimum for the Brentella).<sup>90</sup>

The various other canals drawn off the Brenta carried about the same as the Brentella, if the volume of water often did not reach this maximum.<sup>91</sup>

Most of this water was used for irrigation and to power mills, fulling machinery and hammers. From Bassano to Padua a total of 135 *quadretti* was drawn off, 28 *quadretti* to power mills at Dolo alone whilst only 6 served to meet the water needs of Venice. Clearly, at times the Brenta might appear to be exhausted by the demands upon it – so much so that at one point the *rettori* applied for the closure of the *Taglio Novissimo*, the ‘new cut’ which was a valuable waterway for navigation and carried a further 150 *quadretti* from Mira to the sea.<sup>92</sup>

Thus the needs of agriculture had to be balanced with those of other economic sectors (including manufacturing), even if the use of most of the various canals – above all, those drawn off the Brenta – was primarily agricultural. The Rosà continued to serve the Castelfranco area efficiently, whilst the areas of Bassano and Vicenza were served by such canals as the Grimana, the Cappella, the Morosina, the Isacchina and the Zangiaca, whose names echo those of the powerful aristocratic families who were the concession-holders. Other examples of efficient canals might also be cited in various areas of the Republic.<sup>93</sup>

Numerous projects were put forward in the Verona area; focusing primarily on the Adige, they were however both too ambitious and too abstract, not always taking adequate account of the hydro-geological environment concerned. Although this intense range of publications and writings dealt mainly with irrigation, there was also interest in increasing the volume of river traffic, with the whole series of complex problems involved raising serious doubts as to the actual creation of such canals. In 1587 Antonio Glisenti – known as ‘Il Magro’ – re-proposed a scheme that had already been put forward in 1568 by the Venetian Republic’s famous expert on hydraulics, Cristoforo Sorte, who subsequently made an accusation of plagiarism. This plan envisaged digging a canal from Lake Garda, with Verona paying for it with half of the *decima* it would subsequently receive

from the irrigated land. The city rejected such demands as excessive, pointing out that whilst it financed such work, 5 per cent of the water drawn would go to Glisenti. As happened with the Cicogna project for the Brentella at Treviso, this clash with the interests of the financial elite of the city meant that the scheme ultimately came to nothing.<sup>94</sup>

The irrigation plans put forward by Teodoro da Monte and Benedetto Venier, in 1591 and 1594 respectively, were inspired by the same principles as those behind the schemes of Sorte and Glisenti, even if they did vary in some details (both of the authors, however, insisted on the entire originality of their proposals). The 'regulation' of the Adige was seen as part of an enormous land-reclamation scheme involving some 80,000 *campi* (just under 25,000 hectares) between that river and the Tartaro, with the work also covering a number of minor rivers (in the Vicenza area above all) which posed a threat to both agriculture and navigation due to flooding and overflowing. Da Monte estimated the costs of two canals to be dug from the Adige and Lake Garda at a good 300,000 ducats, but was convinced that the sum could be recouped from the sale of the water and the increased tax revenue resulting from the boost to agricultural and commercial activities.<sup>95</sup> For his part, Benedetto Venier estimated the cost of his project as being much lower. Whatever the truth, neither came to anything.<sup>96</sup>

In the Friuli area the only project of any importance was the canal to be drawn off the Ledra-Tagliamento; but although first proposed as early as the fourteenth century, the implementation of this scheme was put off continually. In effect, there was no real tradition of irrigation in the region, with the main causes of this continuing state of affairs from the Middle Ages onwards probably being the power of the Patriarchate of Aquileia and the low level of urban economic activity: the few channels dug in the twelfth century to draw water off the Tagliamento, the Torre dal Cellina and a few other torrents were decided solely to met domestic and craft industry needs, with irrigation being neglected entirely. When reference was made to agricultural exploitation of water resources, this was within circumscribed areas of sterile and permeable soil, so that even if the Friulan nobleman Nicolò di Maniago declared that the purpose of the Aviano and Colvera canals (1445 and 1453 respectively) was to irrigate the lands of Maniago and Aviano, the canals really served as

a means of transporting timber and as a source of water for civil and industrial uses.<sup>97</sup>

However, it would be this same nobleman who in 1457 urged the creation of a canal for the waters of the Ledra and Tagliamento at the point where the two rivers flowed down into the plain, so that the waters might be redirected towards Udine and used to irrigate the dry western area. Here again, however, commercial uses were to go together with irrigation, as it was proposed that river traffic from Germany should use the canal that would ultimately flow into the lagoon of Marano. But once more the *Consiglio Maggiore* of Udine opposed the scheme, perhaps because of insuperable distrust of such ideas amongst the local nobility.

It would be another powerful landowner however – Giulio Savorgnan – who would re-propose the Ledra-Tagliamento irrigation scheme at the end of the century, in 1592. An expert on military questions with a deep knowledge of the entire territory of the mainland state, Savorgnan had been vividly impressed by the areas of Bergamo, Brescia and Verona, where agriculture clearly profited from the presence of irrigation waters: in his own words, 'a field in the Brescia area is worth ten in Friuli'. The consequences of this fact were there for all to see: 'the areas that enjoy irrigation are becoming populated, whilst Friuli has been half deserted now for more than fifty years, because what good there was in the land has been consumed and the peasants are moving away to Germany'. Only by increasing the areas of irrigated pasture land, and thus the size of herds of cattle and horses (the latter an essential requirement in a border region such as Friuli) would there be a recovery in the agriculture and entire economy of the area. However, given that the scheme proposed by Savorgnan was to be financed by the timber merchants, they would be guaranteed three fifths of the water, whilst only two fifths would be used for irrigation. But, again, nothing was done – neither then nor in the following centuries. In spite of the fact that such illustrious scholars as Bernardino Zendrini and Geminiano Montanari championed the Ledra-Tagliamento canal, work on it would not begin until the nineteenth century.<sup>98</sup>

Given their share of property ownership, the influence of the nobility and the Church here proved to be decisive.<sup>99</sup> Largely uninterested in the introduction of new crops – especially those requiring irrigation – they would remain firmly attached to the old

system of cereal crop rotations and, above all, the use of land for vineyards. And even the small-scale landowners would, right up to the first decades of the nineteenth century, continue to dedicate only a small amount of land to the cultivation of summer crops (threatened by shortage of water), preferring instead to concentrate on the traditional rotation of wheat, oats and rye. As Antonio Zanon would note in the eighteenth century, even maize was neglected; a foodstuff that might have spared Friuli the 'undernourishment trap', this occupied no more than one quarter or at most two-fifths of total crops sown. The vast expanse of communal land within Friuli (some 41 per cent of the total area<sup>100</sup>) is another reason for the absence of those private landowners who were receptive to ideas of irrigation, drainage and land improvement in general. Nor should one overlook the real difficulties presented by the hydro-geological characteristics of the region: the wide beds of the torrential rivers meant it was almost impossible to construct safe and secure openings for the canals that were to draw water off them.

One eighteenth-century champion of irrigation in Friuli, Cortenovis, did argue that the problems of the area could be resolved by preventing the wastage of what water there was in the dry middle plain of the region, as well as making full use of the spring water available in the lower plain.<sup>101</sup> However, this could only be done if Venice itself drew up a clear plan of action and then imposed it with firmness. Here, the Friulan scholar had come straight to the heart of the problem: not only did Friuli have no independent economic forces interested in such transformations of its rural landscape, but it also came under the rule of an external government that had no unified agricultural policy for its mainland dominions.

## Conflicts Over Water: The Mainland and the Venice Lagoon

The complexity of the relations between the *Savi ed Esecutori alle Acque*, responsible for the lagoon itself, and the *Provedditori ai Beni Inculti*, responsible for land reclamation and irrigation on the mainland, was the result of more than a mere overlap of administrative duties; it reflected a more profound problem that influenced the whole definition of Venice's environmental – and, ultimately, economic – policies. The difficulties arose not solely in

delimiting areas of responsibility but also in deciding which one of the two authorities was to have final say in policies regarding the region's water resources and its hydro-geological management. Another reason for the long-lasting ambiguity between the two authorities was the fact that before the institution of the *Provveditori ai Beni Inculti*, it had been the *Savi alle Acque* who had overseen 'land reclamation' in the areas bordering on the lagoon (for example, Foresto and Santa Giustina). What is more, even as late as 1560, when the Senate elected the *Provveditori sopra i Beni Inculti* for the Treviso area, it imposed the presence of at least one *Savio alle Acque* to make sure that irrigation 'did not do any harm to our lagoon'. In addition, the *Savi* had to be informed of all the allocations of water from the Brenta and Piave (the two rivers that were the most direct threat to the Venice), because they 'had a say in everything to do with the rivers that emptied into the Lagoon'.<sup>102</sup> This subordination of the *Provveditori* to the *Savi* could still be seen in 1686, when the latter appointed themselves to check the distribution of all the waters drawn off the Brenta, with their own inspectors visiting the river and requiring that all unauthorised openings off it be sealed immediately.<sup>103</sup>

The reconciliation of land reclamation and irrigation also encountered difficulties arising from the multiple uses (military, commercial, agricultural and industrial) to which water was put.<sup>104</sup> Various kinds of machinery and plant were powered by water: mills, paper works, fulling and spinning machinery for the silk industry; hammers and bellows used in working iron; mechanical wood-saws and presses for flax oil. And, of course, given their importance as a source of food, particular attention was dedicated to water-powered flour mills<sup>105</sup>: experts and technicians were constantly being reminded that water drawn off for irrigation should in no way hamper the working of such mills, because 'diverting water from mills is against the law'.<sup>106</sup> There were undoubtedly frequent clashes over this question between private individuals and the communes who were directly responsible for the good working of mills.

Such conflicts over the use of water resources can be found throughout Europe, and inevitably led to a certain impasse. This continued throughout the Early Modern era until, with the advent of the industrial revolution, there came the emergence of water channels and canals 'dedicated' to one specific purpose; thereafter, millers no longer robbed water from farmers, the requirements of

manufacturing no longer interfered with river transport, and rural needs no longer undermined urban water supplies (as had been the case with the Brenta and Venice).<sup>107</sup>

Waterways obviously played an important role in the economic life of the Veneto as a whole, with a great deal of attention being focused on the Brenta. As early as 1611 the *Provveditori ai Beni Inculti* were expressing their concern that the quantity of irrigation water being drawn off the river was interfering with the shipping and transportation of goods.<sup>108</sup> This was why legislation was passed which required the widest possible publication of all applications to draw water from the river, even in the stretches beyond Padua and Ponte di Brenta. When for example in 1676 the Venetian nobleman Andrea Capello applied to use five *quadretti* of Brenta water to power his three-wheel mill and irrigate his estate, the *Provveditori* received a flood of protests against such a proposal. The opponents of the scheme included the community of Marostica, the Seven Communes of the Vicenza area, the bargemen of Padua and Limena, and various other private individuals, who all claimed that excessive water concessions were exhausting the river; the boatmen pointed out that drawing off another five *quadretti* would mean that the river only became navigable after heavy rains or the melting of winter snows, whilst such navigation was essential to the livelihood of the foothills populations who relied on the river to transport their timber, coal, meat, etcetera down towards Padua and Venice.<sup>109</sup>

The very opposite fears prevailed where the Adige was concerned, given that the main actions taken by the authorities responsible for the river – the *Provveditori all'Adige* and the *Savi alle Acque* – were concerned to forestall the river breaking its banks.<sup>110</sup> In such a situation, the indiscriminate creation of openings in the embankments of the river and its tributaries could, when the river was running in spate, lead to flooding in the surrounding areas. A decree of 1682 described a situation in which the embankments of the Adige 'are being increasingly undermined ... by the erection of buildings and the opening of waterways to irrigate land and rice-fields'.<sup>111</sup> Certainly, the rivers in the Verona area (and the Adige, in particular) were responsible for very serious flooding – for example, in 1677, 1679 and 1680 (on the first of those occasions, the representatives of the city of Verona estimated the damage caused at some 60,000 ducats, and even though it was in their interests to

stress the seriousness of the disaster, their figures cannot be dismissed out of hand). What is more, this was a period when around 21,000 ducats a year was spent on channelling the river, given that for long stretches the Adige has no natural banks as such and flows between man-made embankments. It is therefore perfectly understandable why, throughout the seventeenth and eighteenth century, a great deal of attention was focused on what was considered to be the main river of the Republic, with heavy penalties being inflicted upon anyone who made openings in the river banks or dug wells alongside the Adige or its tributary, the Bussé. Legislation also required that, before granting any concession of water, the *Provveditori* had to inform the *Rettori* [City Governors] of Verona, who would then consider what might be the consequences of the proposed scheme.<sup>110</sup>

## Notes

1. A. Serpieri, *La bonifica nella storia e nella dottrina*, Bologna, 1957, pp. 1–2. In Italian the term for land reclamation – *bonifica* – has a more general etymological sense of ‘bettering’, improving terrain.
2. All the dates taken from Venetian archive documents use the Venetian calendar – that is, with 1 March marking the beginning of the New Year.
3. The upper and middle plain area extends from the base of the alpine foothills to the zone of the various water springs, which obviously have a direct effect upon irrigation and the types of agriculture that could develop here. Of an average width of 3–4 kms, this zone of springs stretches from the Mincio to the Adige (feeding numerous watercourses in the lower Verona area), to then extend beyond Vicenza to the Piave and Tagliamento, and finally curve down to the coast. In the zones upstream from the springs, the terrain is generally permeable, with the water seeping through until it encounters impermeable strata. In the upper plain areas, the soil is coarse and poor; and it is difficult to harness and distribute water supplies; land in the middle and lower plain is much more fertile, even if there are the perennial difficulties of drainage and defence against flooding (F. Marzolo, ‘Le irrigazioni nelle Venezie. Aspetti idraulici’, in *Atti del convegno delle bonifiche venete* (Padova 27 May 1954), Padua, 1954, pp. 3–4; V. Ronchi, ‘Le irrigazioni nelle Venezie. Aspetti agronomici e sociali’, in *Atti del convegno delle bonifiche venete*, Padua, 1954, pp. 4 and 14–19).
4. Beltrami, *Saggio di storia dell'agricoltura*, pp. 41–43; idem, *La penetrazione economica dei veneziani in Terraferma*, p. 53 and 156; Ventura, ‘Considerazioni sull'agricoltura veneta’, p. 535; De Maddalena, *Il mondo rurale italiano nel Cinque e nel Seicento*, p. 389; Gloria, *Della agricoltura nel Padovano*, I, pp. 239–42 and 291. Venetian documents use the term *campo* –

field – as a unit of measurement. The *campo vicentino* measured m<sup>2</sup> 3,862, like the *campo padovano*; the *campo veronese* was m<sup>2</sup> 3,003 and the *campo trevigiano* m<sup>2</sup> 5,204: Martini, *Manuale di metrologia*; idem, *Manuale di ragguaglio fra le misure e pesi veronesi ed il sistema metrico decimale e viceversa*.

5. Berengo, *L'agricoltura veneta dalla caduta della Repubblica all'unità*, pp. 12–15.
6. Tucci, 'L'Ungheria e gli approvvigionamenti veneziani di bovini', p. 159.
7. Areas of land for reclamation in the Tre Venezie (in hectares.):
 

Province	Terrain for drainage	Terrain for irrigation
Padua	1.000	266.000
Verona	6.000	20.000
Rovigo	8.000	3.000
Treviso	2.000	12.000
Venice	12.000	—
Udine	36.000	59.000

(Caizzi, *Aspetti economici e sociali delle bonifiche nelle Venezie*, p. 103).
8. As has been pointed out, 'systems of irrigation cannot be created overnight; and above all, it takes time to develop the expertise required to implement irrigation' (*Bonifica e programmazione nel Veneto*, pp. 119–20).
9. Vilar, *La Catalogne dans l'Espagne moderne*, II, pp. 278–79.
10. In eighteenth-century Lombardy, it was laid down that in the absence of rain, wheat fields were to be irrigated at least every fifteen days in the period from April to June; for flax and maize fields that interval was reduced to every ten days, and for meadowlands (throughout the summer) to every week. Rice fields had to be entirely covered in water right up to August. (R. Canetta, 'L'irrigazione nella bassa pianura lombarda tra il Sette e l'Ottocento', in *Le campagne lombarde tra Sette e Ottocento*, M. Romani ed., Milan, 1976, pp. 73–74).
11. J. Jacquart, 'La productivité agricole dans la France du Nord aux XVI<sup>e</sup> et XVII<sup>e</sup> siècles', in *Troisième conférence internationale d'histoire économique. Production et productivité agricole, Section II* (Munich 1965), Paris, 1969, pp. 70–74, esp. p.71; B.H. Slicher van Bath, 'La productivité agricole. Les problèmes fondamentaux de la société pre-industrielle en Europe occidentale', *ibid.*, pp. 23–30. Slicher van Bath, however, dedicates much less space to irrigation than he does to land reclamation.
12. Vilar, *La Catalogne dans l'Espagne moderne*, II, p. 279; Braudel, *La Méditerranée et le monde méditerranéen*, I, pp. 65–66.
13. Haussmann, 'Il suolo d'Italia nella storia', in *Storia d'Italia. I caratteri originali*, Romano and Vivanti eds., pp. 90–91; Braudel, *La Méditerranée*, pp. 64–67. The development of irrigation in Emilia was equally limited: R. Tirelli, *Progetto d'estrarre acqua dal Po sopra Piacenza per irrigarne la provincia e quelle di Parma, Reggio, Modena e Bologna*, L.F. Valdrighi ed., Modena 1872, p. 3ff.; C. Brogion and G. Tocci, 'Vie di comunicazione e traffici nella Romagna settecentesca: il canal naviglio Zanelli', in *Studi Romagnoli*, 22 (1971), pp. 1–25.
14. C.M. Cipolla, 'Per la storia delle terre della 'bassa' lombarda', in *Studi in onore di A. Saponi*, Milan, 1957, pp. 667 and 671–72.

15. Romani, *L'agricoltura in Lombardia*, p. 199. Late-eighteenth-century travellers from Britain and Austria – for example, Symonds, Young and Burger – did not fail to celebrate the exceptional results achieved by irrigation in Lombardy (*ibid.*, pp. 23–24).
16. S. Pugliese, 'Condizioni economiche e finanziarie della Lombardia nella prima metà del secolo XVIII', in *Miscellanea di Storia Italiana*, 52 (1924), pp. 31–32; G. De Ricco, *Le irrigazioni dei terreni. Opere e tecnica*, Bologna, 1956, pp. 3–8; for the Lodi area, still the main dairy-product centre within Lombardy, see D. Zanetti, *Problemi alimentari di un'economia preindustriale*, Turin, 1964, pp. 31–34.
17. An enlightening example here is the case of the hemp, which from the mid-fifteenth century onwards was cultivated in the irrigated fields of the Montagnana area to provide the necessary raw materials for the Venice Arsenal shipyards, but then was later abandoned in favour of more profitable cereal crops (it should be pointed out that the hemp for the Arsenal was controlled more by public authorities and *magistrature* than by individual entrepreneurs: F.C. Lane, 'Rope Factory and Hemp Trade in the Fifteenth and Sixteenth Centuries', in *Venice and History*, Baltimore, 1966, pp. 281–84). However, the studies by Ivana Pastori Bassetto and David Celetti reveal that the situation on the Venetian mainland was not that unfavourable to the development of hemp as a crop: cf. I. Pastori Bassetto, 'La canapa nella Repubblica veneta', in *Archivio Veneto*, s.V, 141 (1993), pp. 5–65; D. Celetti, 'Il prezzo della canapa in età moderna. L'interazione del mercato, della moneta e dello stato nella determinazione del valore di una fibra strategica', in *Storia Economica*, 6 (2003), pp. 5–47.
18. Corazzol, *Fitti e livelli a grano*; *idem*, *Livelli stipulati a Venezia nel 1591*.
19. Pietro de Crescenzi's *Opus ruralium commodorum* published from the sixteenth century onwards: L. Olson, 'Pietro de Crescenzi: the Founder of Modern Agronomy', in *Agricultural History*, 18 (1944), pp. 35–37; P. Toubert, *voice* 'Pietro de' Crescenzi', in *Dizionario biografico degli italiani*, XXX, Rome, 1984, pp. 649–57.
20. Ibn-al-Awwām, *Le livre de l'agriculture*, I, pp. 117–34 and 510–36; L. Bonelli-Conenna, *La Divina Villa di Corniolo della Cornia. Lezioni di agricoltura tra XIV e XV secolo*, Siena, 1982.
21. Glick, *Irrigation and Society in Medieval Valencia*, pp. 11–15; M. Aymard, *Irrigations du midi de l'Espagne*, Paris, 1864, p. 18 n.; J. Depassa, *Voyage en Espagne dans les années 1816, 1817, 1818, 1819 ou recherches sur l'arrosage*, I, Paris, 1823, pp. XIII–XVII and 186–208.
22. Bolens, *Les méthodes culturelles au Moyen Age d'après les traités d'agronomie andalous*. In Andalusia, irrigation was not only 'a means of providing moisture for the soil but indispensable in preventing it from being scorched and dried out'. According to the author, one should not draw too sharp a line between the *secano* and *regadío*, as the two types of agriculture overlapped with each other.
23. K.A. Wittfogel, *Irrigation Policy in Spain and Spanish America*, quoted by G.L. Ulmen, 'The Science of Society. Toward an Understanding of the Life

- and Work of Karl August Wittfogel', in *Society and History. Essays in Honour of Karl August Wittfogel*, Ulmen ed., p. 481.
24. Herrera, *Libro di agricoltura utilissimo*, pp. 31v.-34v.-167r.-170v.
  25. Bruschetti, *Storia dei progetti e delle opere per l'irrigazione del Milanese*.
  26. Smith, *Man and Water*, p. 12ff.
  27. Serres, *Le théâtre d'agriculture*, II, pp. 223-24, 242, 426 and 527-58; Palissy, *Discours admirables de la nature des eaux et fontaines*, pp. 239-303.
  28. Beutler, 'Un chapitre de la sensibilité collective', pp. 1091-1122; Sereni, *Storia del paesaggio agrario italiano*, p. 176; P. Lanaro Sartori, 'Gli scrittori veneti d'agricoltura del Cinquecento e del primo Seicento tra realtà e utopia', in *Venezia e la Terraferma attraverso le relazioni dei rettori*, A. Tagliaferri ed., Milan, 1981, p. 273ff.
  29. G. Lanteri, *Della economica. Trattato di M. Giacomo Lanteri gentiluomo bresciano*, Venezia, 1560; I. Milius, *De hortorum cultura*, Brescia, 1574. On innovation in the Brescia area, see the useful bibliographical study by F. Grasso Caprioli, 'Camillo Tarello - Agostino Gallo - Giacomo Chizzola e l'Accademia di Rezzato', in *Rivista di storia dell'agricoltura*, 22 (1982), n. 2, pp. 37-122.
  30. E. Sereni, 'Spunti della rivoluzione agraria europea nella scuola bresciana cinquecentesca di Agostino Gallo e di Camillo Tarello', in *Miscellanea in onore di R. Cessi*, II, Rome, 1958, pp. 113-28; Berengo, 'Introduzione' to *Camillo Tarello*, pp. VII-XLV; Poni, 'Un privilegio d'agricoltura. Camillo Tarello', pp. 592-610; Ambrosoli, *The Wild and the Sown*, p. 119ff. However, it was only with the agricultural revolution of the eighteenth century that Tarello's teachings would become at all widespread on the Venetian mainland.
  31. Gallo, *Le vinti giornate dell'agricoltura*, p. 6.
  32. Ibid., pp. 7-8. Similar worries were voiced by the Spaniard Herrera and by the Ravenna agronomist Bussato (Herrera, *Libro di agricoltura*, pp. 31v.-32r. Bussato, *Giardino di agricoltura*, p. 2r.). To counteract the effects that prolonged irrigation might have in carrying away the topsoil, Herrera suggested that manure should also be fed through the irrigation canals, in order to provide soil nutrients and fertilisers.
  33. Berengo, 'Introduzione' to Tarello, *Ricordo di agricoltura*, pp. XXVI-XXVII; Finzi, *Monsignore al suo fattore*, pp. 29-34 and 79-113; Tarello, *Ricordo di agricoltura*, p. 100 and n.; Finzi, *Monsignore al suo fattore*, pp. 79-113.
  34. Clementi, *Trattato dell'agricoltura*, pp. 26-27.
  35. Berengo, *Africo Clementi, agronomo padovano del Cinquecento*, pp. 27-69.
  36. Derex, *La gestion de l'eau et des zones humides en Brie*.
  37. Braudel, *Civilisation matérielle. Les structures du quotidien: le possible et l'impossible*, I, p. 81.
  38. Ceredi, *Tre discorsi sopra il modo d'alzar acque*, pp. 94-95.
  39. One can see a similar problem in Northern France in the first decades of the seventeenth century: Jacquart, 'La productivité agricole', cit., p. 73.
  40. Ceredi, *Tre discorsi sopra il modo d'alzar acque*, pp. 94-95.
  41. Messedaglia, *Per la storia dell'agricoltura e dell'alimentazione*, p. 85. The lengthy list of these agronomists might include such names as Marco

- Bussato, Charles Estienne (Carlo Stefano), Africo Clementi, Giovanni Tatti, Costantino Cesare, Bernardo Sacco, Giovanbattista Barpo and Giacomo Agostinetti.
42. Falcone, *La nuova, vaga, et dilettevole villa*, pp. 253–54.
  43. Vilar, *La Catalogne dans l'Espagne moderne*, II, pp. 284–89. See also *Istruzione sulla coltura del riso*, in *Giornale d'Italia*, VII, Venezia, 1771, pp. 49–72; D. Mainardi, *Della coltivazione del riso e della coltura dei prati e degli arativi*, Padua, 1792, pp. 5–7; Pugliese, 'Condizioni economiche e finanziarie della Lombardia', cit., pp. 35–38; Zucchini, *L'agricoltura ferrarese attraverso i secoli*, pp. 134–35 and 180–81; Vivanti, *Le campagne del Mantovano*, pp. 17–158; Faccini, *I lavoratori della risaia*, pp. 545–88; idem, *Uomini e lavoro*, pp. 23–28: the other diseases and disturbances were chlorosis (green sickness), neuralgia, nephritis, imbecility, gastroenteritis and dysentery.
  44. Vilar, *La Catalogne dans l'Espagne moderne*, II, p. 285; Faccini, *Uomini e lavoro*, p. 120.
  45. Pugliese, 'Condizioni economiche e finanziarie della Lombardia', cit., pp. 3 and 38; Faccini, *Uomini e lavoro*, p. 24; P. Lemonnier, 'Acqua', in *Enciclopedia*, R. Romano ed., I, Turin, 1977, p. 184.
  46. A valuable export, rice from the Verona and Lombardy areas was often shipped from the port of Venice. (Sella, *Commerci e industrie a Venezia nel secolo XVII*, pp. 87–88).
  47. Falcone, *La nuova, vaga, et dilettevole villa*, pp. 253–54; Sereni, *Storia del paesaggio agrario*, p. 240.
  48. Some of these questions are dealt with in *Histoire d'une eau partagée. Irrigation et droits d'eau du Moyen Âge à nos jours. Provence Alpes Pyrénées*, O. Aubriot and G. Jolly eds., Aix-en-Provence (Publications de l'Université de Provence), 2002.
  49. Mozzi, *I magistrati veneti alle acque e alle bonifiche*, p. 19 n.; Aymard, *Venise, Raguse et le commerce du blé*, p. 7ff.
  50. Ventura, 'Considerazioni sull'agricoltura veneta', pp. 519–21; B. Pullan, 'The Occupations and Investments of the Venetian Nobility in the Middle and Late Sixteenth Century', in *Renaissance Venice*, J. Hale ed., London, 1974, pp. 379–408; S.J. Woolf, 'Venice and Terraferma: Problems of the Change from Commercial to Landed Activities', in Pullan ed., *Crisis and Change in the Venetian Economy*, pp. 175–203.
  51. G. Ferrari, 'La legislazione veneziana sui beni comunali', in *Archivio Veneto*, n. s., 36 (1918), pp. 29–30.
  52. The growing workload meant that in 1589 the three *Provveditori ordinari* were joined by four *Provveditori straordinari*; however, in 1655, the overall number was reduced to five. In 1700 one such *Provveditore* was raised to the rank of *Inquisitore*, to deal with the continual infringements of the law. (Mozzi, *I magistrati veneti alle acque e alle bonifiche*, pp. 5–8; Campos, *I consorzi di bonifica*, pp. 17–22; ASV, S.T., filza 32, Senate decree of 12 October 1560).
  53. *Il summario di tutte le leggi et parti ottenute nell'illustrissimo Senato in materia delli beni inculti*, Venezia, 1558; *De' privilegi de veronesi nelle acque*, in *Livellazioni fatte per M. Gieronimo Pontara [...] in proposito della regulation*

- dell'Adige, Verona, 1596, pp. 64–66. If one wants to know more about the development of irrigation in these provincial areas, one has to consult local archives, given the poverty of extant material in those of the *Beni Inculti*.
54. S.T., reg. 21, 21 July 1519, cc.43v.–45r.; S.T., reg. 40, cc. 156v.–157r., Senate decree 6 February 1556; Bruschetti, *Storia dei progetti e delle opere per l'irrigazione del Milanese*, p. 59).
  55. Romani, *L'agricoltura in Lombardia*, pp. 202–3 and n.
  56. Glick, *Irrigation and Society in Medieval Valencia*, pp. 12–13; Macías Hernández, 'Les Îles Canaries, 1480–1525. Irrigation et première colonisation atlantique: le domaine de l'eau'; Bresc, 'Les jardins de Palerme (1290–1460)'.
  57. Mozzi, *I magistrati veneti alle acque e alle bonifiche*, pp. 6–12; Bruschetti, *Storia dei progetti e delle opere per l'irrigazione del Milanese*, pp. 150–51. On the fame and importance of the Ferrara hydraulic engineers in the fifteenth and sixteenth century, see Zucchini, *L'agricoltura ferrarese attraverso i secoli*, p. 92; now the important edition of Giovanni Battista Aleotti (*Della scienza e dell'arte del ben regolare le acque di Gio. Battista Aleotti detto l'Argenta architetto del papa, et del pubblico ne la città di Ferrara*), M. Rossi ed., Modena, 2000.
  58. S.T., reg. 22, cc. 107v.–108r., Senate decree of 15 July 1522; SEA, busta 89, copy of Senate decree of 19 June 1545; S.T., filza 64, Senate decree 16 September 1574; S.T., filza 342, Document of the Psbi 18 August 1622, attached to the Senate decree of 20 February 1630; Psbi, busta 81, Dossier Sagramoso, Secret report to the Psbi, 26 June 1598, accusing the Verona noblemen of usurping for their own use the waters of the Adige and other watercourses. On the theft of water in Spain, see J. Depassa, *Voyage en Espagne dans les années 1816, 1817, 1818, 1819 ou recherches sur l'arrosage*, I, Paris, 1823, p. XVII.
  59. The use of the 'wheel' system – with a rotation in the delivery of water over a period of from one to two weeks – was less common in the Veneto than it was in Lombardy, where much greater use was made of water (Canetta, 'L'irrigazione nella bassa pianura lombarda', cit., pp. 74–75).
  60. In eighteenth-century Catalonia, too, rainwater cost half as much as river water (see Vilar, *La Catalogne dans l'Espagne moderne*, II, p. 249).
  61. The regional variations in the price of water mean that one cannot make any precise deductions on the basis of the data we have regarding such costs. One essential instrument for the Venetian State – both in outlining the general situation of its water resources and in fighting evasion of the dues to be paid for their use – was provided by the cadastral land registers, which listed all the various water concessions. Three such registers are still to be found in the records of the Psbi: one for the Vicenza area, one for the Padua, Treviso and Friuli area, and another for Verona, Cologna, Crema, Cremona, Bergamo and Istria (even if in this latter, the registrations concern Verona alone).
  62. The *piede lineare* [foot] (=0,34 metre) was made up of 12 *oncie* [inches], so that one square foot was made up of 144 square inches, which were also known as *punti*; in practice, however, a *quadretto* was divided into 12 *oncie*, which were again divided into 12 *punti*. The water was also measured in terms of *ruote* [wheels], each one of which was equivalent to one *quadretto*

- (Psbi, *busta 475*, Application by Girolamo and Antonio Morosini, 9 March 1557; V. Brunacci, *Memoria sulla dispensa delle acque*, Milan, 1927, pp. 6–25; on the Lombard unit of measurement, the 'Milanese inch', see Canetta, 'L'irrigazione nella bassa pianura lombarda', cit., pp. 75–76).
63. L.E. Harris, 'Land Drainage and Irrigation', in *History of Technology*, III. *From the Renaissance to the Industrial Revolution, c.1500–c.1750*, C. Singer et al. eds., Oxford, 1969, pp. 314–15.
  64. P. Frisi, 'Del modo di regolare i fiumi e i torrenti', in *Nuova raccolta d'autori, che trattano del moto delle acque*, Carmignani ed., VI, Parma, 1766, pp. 1–110.
  65. B. Castelli, 'Della misura delle acque correnti', in *Nuova raccolta d'autori, che trattano del moto delle acque*, Marsigli ed., III, Bologna, 1822, p. 166. Castelli had been Galileo's pupil in Padua.
  66. *Perizia intorno alla misura delle acque erogate dal Brenta [...] estesa dai matematici Ximenes e Stratico [...] nell'anno 1777*, Venice, 1844, pp. 9–10.
  67. Ibid., pp. 39–40. Bruschetti, *Storia dei progetti e delle opere per l'irrigazione del Milanese*, pp. 19–20 and 34. Bruschetti's argument appears rather weak when he claims that water speed was taken into account in such calculations within the Milan area during the sixteenth century.
  68. *Perizia intorno alla misura delle acque erogate dal Brenta*, cit., pp. 39–40; Zendrini, *Leggi e fenomeni*, pp. 142–43; Brunacci, *Memoria sulla dispensa delle acque*, cit., pp. 57–58.
  69. Museo Correr, Mss. P.D., C.975/52, Concordat between the Republic and the Duke of Mantova, 15 March 1548; *Trattato fra [...] l'imperatrice [...] e la Serenissima Repubblica di Venezia sopra l'uso delle acque del Tartaro*, Verona, 1768; *Informazione sopra gli argini, sgoli ed adacquamenti dello stato mantovano*, Mantua 1734, part II, p. 67 and part III, pp. 3–40). On the clashes between Brescia and Cremona over the waters of the Oglio, see C. Cairns, *Domenico Bollani. Devotion to Church and State in the Republic of Venice in the Sixteenth Century*, Nieuwkoop, 1976, pp. 80–117; on disputes over water between Mantua and Ferrara, see Zucchini, *L'agricoltura ferrarese attraverso i secoli*, p. 96).
  70. Canetta, 'L'irrigazione nella bassa pianura lombarda', cit., p. 78; Romani, *L'agricoltura in Lombardia*, p. 202.
  71. Psbi, reg. 312, cc.19v.–20r., concession granted 23 March 1574; Psbi, *busta 263*, Report of 8 March 1583; Boerio, *Dizionario del dialetto veneziano*, Venezia, 1856, definition of *Penello*; and the entry 'Irrigazione', in *Enciclopedia italiana di scienze, lettere ed arti*, XIX, Rome, 1951, p. 572.
  72. Almost all writers of the period agree that the best time for irrigation was the evening or the early hours of the morning (Porta, *Villae libri XII*, pp. 644–45 and 905; Stefano, *Agricoltura nuova*, pp. 120 and 341–46. On these questions see Sinclair, *L'agriculture pratique et raisonnée*, pp. 535–66; Buffon, *Des subversions fertilisantes*, p.109ff.
  73. Stratico, *Raccolta di proposizioni d'idrostatica*, pp. XLVI–LII.
  74. In effect, these wheels were just a version of the *tympanum* which, together with the *noria*, had been used for this purpose since Classical Antiquity. The literature on this subject is extensive: Bélidor, *Architecture hydraulique*, I,

- livre II, cap. IV, pp. 384–87 and *planche* 9; Agricola, *De re metallica*, pp. 131–33; Ewbank, *A Descriptive and Historical Account of Hydraulic*, pp. 109–14; Zonca, *Novo teatro di machine*, pp. 61–63 and 100–15; Besson, *Theatrum instrumentorum*, tavv. 46–52; Veranzio, *Machinae novae*, p. 10ff.
75. There are numerous examples of this to be found amongst the papers of the various Venetian *magistrature*. Galileo Galilei himself obtained a patent in this area from the Republic in 1594 (Berveglieri, *Inventori stranieri a Venezia (1474–1788)*, p. 48).
  76. The Archimedes' Screw is a cylinder around which is wrapped a spiralling tube or sloping thread; in Ceredi's model, this spiral and cylinder were contained within a second cylinder. They could be worked by a single man; whilst a horse attached to a wheel could power three. Ceredi also argued that Ferrara had no reason to fear that drawing water from the Po would interfere with navigation, because the river had more than enough water to serve both purposes.
  77. Ceredi, *Tre discorsi sopra il modo d'alzar acque*, pp. 1–90.
  78. J. Mokyr, *The Lever of Riches: Technological Creativity and Economic Progress*, New York, 1990.
  79. S.T., reg. 21, Senate decree July 1519, cit.; Grinovero, *Ricerche sull'economia dell'irrigazione*, p. 173 n.
  80. S. Bortolami, 'Il Brenta medievale nella pianura veneta. Note per una storia politico-territoriale', in *Il Brenta*, A. Bondesan et al. eds., Verona, 2003, pp. 211–33.
  81. M.C. Billanovich, *Attività estrattiva negli Euganei. Le cave di Lospida e del Pignaro tra Medioevo ed età moderna*, Venezia, 1997; Marzolo, 'L'idraulica veneta e l'apporto dell'Università di Padova nelle discipline idrauliche', p. 96.
  82. Vergani, *Brentella. Problemi d'acque nell'alta pianura trevigiana*, pp. 37–43 and 61ff.; Serena, *Il canale della Brentella*, pp. 9–22 and 43–48. The first pressure to open a canal at Pederobba had come from the citizens of Castelfranco in 1425 (*Relation scripta intorno la Brentella se ha da trasar per adacquare le campagne*, in R. Brenzoni, *Fra Giovanni Giocondo veronese*, Firenze, 1960, p. 152).
  83. 'The poor die of *dexaxio* [dehydration] and haven't enough water to drink, whilst the grand not only have water left over for their meadows and fields, but even enough to wash out their stables' (*Relazioni dei rettori veneti in Terraferma. Podestaria e Capitanato di Treviso*, Tagliaferri ed., Report by Marco Zantani, 1 October 1525; see also L. Doglioni, *Ragionamento epistolare sopra le irrigazioni del territorio trevigiano*, Bassano, 1799, pp. 10 and 21).
  84. Psbi, *Capitolare secondo*, cc. 138r.–139v., Application from the ambassadors of Treviso to the Collegio, 27 July 1572; *ibid.*, cc. 133v.–140r., Written document by Nicolò Cicogna 22 June, 21 and 29 July, 1 August 1572.
  85. Cicogna must have had a vested interest in such extensions of irrigation, given that in 1475 a certain Francesco Cicogna had bought land at Montebelluna (Serena, *Il canale della Brentella*, p. 135 n.).
  86. In June 1572 Cicogna applied for half the water, but by 1 August he was willing to settle for one quarter (S.T., *filza* 59, Senate decree 2 August 1572;

- cfr. also *filza* 60, Senate decree 3 December 1572 and attached document by Cicogna, 22 November 1572; 'Relazione Francesco Bragadin', 9 September 1537, in *Relazioni dei rettori veneti in Terraferma. Podestaria e Capitanato di Treviso*, Tagliaferri ed., p. 12; 'Relazione Francesco Diedo', 12 October 1569, *ibid.*, pp. 52–53; Psbi, *busta* 263, *Report by the expert Feliciano Perona*, 13 November 1595. This latter document provides detailed information on the development of rice-fields and their irrigation in the Friuli, Po delta and the Treviso areas).
87. In 1595 irrigation had only covered some 4–5 per cent of the consortium's agricultural land, which amounted at the time to around 23,000 hectares (Vergani, *Brentella. Problemi d'acque nell'alta pianura trevigiana*, p. 318).
  88. SEA, *filza* 85, 11 January 1550; C. Sabbadino, 'Per adacquar il Trevisan da Nervesa in zoso', in ASV, *Archivio Proprio Zendrini*, reg. 24, cc.56–59, between 1550 and 1558; Serena, *Il canale della Brentella*, pp. 132–33.
  89. S.T., reg. 21, Senate decree 21 July 1519, *cit.* The areas irrigated were Bassano, Rosà, Cassola, Rossano Veneto, Castello di Codego, Castelfranco (cfr. *Carta delle irrigazioni cit.*, p. 44).
  90. S.T., reg. 40, cc.128r.–128v., Senate decree 29 August 1556.; S.T., *filza* 1074, Report by the *rettori* of Padua, 14 September 1686 attached to Senate decree 26 September 1686. In fact, nowadays the canal is known as the Dolfina canal; it carries some 5,058 cubic metres, as opposed to the 6,744 of the Rosà (for this data, and that concerning the volume of other canals, see Grinovero, *Ricerche sull'economia dell'irrigazione*, p. 175).
  91. According to the *rettori* of Padua, there were at least 14 large and small canals drawing water off the Brenta (S.T., *filza* 1074, Senate decree 26 September 1686 and attached document; S.T., *filza* 1049, Report by Marchio Moretti, 14 August 1683, deputy expert on rivers, attached to Senate decree 19 August 1684; *Carta delle irrigazioni venete*, *cit.*, pp. 44–49).
  92. Report by the *rettori* and Senate decree of 6 September 1686, *cit.*
  93. A. Keller, *Prosciugamenti ed irrigazioni nel Padovano*, Padua, 1878, pp. 58–59 and 60–64; C. Bionda, *L'irrigazione dei prati di Bacchiglione in provincia di Vicenza e di Padova*, Vicenza, 1896.
  94. *Modo d'irrigare la campagna di Verona, e d'introdur più navigationi per lo [...] stato di Venezia, trovato fino dal 1565 da M. Christoforo Sorte [...] e anco di Antonio Magro, e del Sig. Theodoro da Monte*, Verona, 1593, pp. 16–24 and 44–48. According to Sorte's calculations, the work would have reclaimed some 7,500 hectares, increasing its value and boosting fodder production (Petition of C. Sorte, *ibid.*, pp. 5–10; see also ASV, SEA, *busta* 529, Report by A. Glisenti, 20 November 1587). Like the other parts of the Veneto mainland, the Verona area imported beef from Mantua, Ferrara, the Trento region and even the distant Hungary because of the insufficiency of local fodder (M. Lecce, 'Le condizioni zootecnico-agricole del territorio veronese nella prima metà del '500', in *Ricerche di storia economica medievale e moderna*, Verona, 1975, pp. 85–116).
  95. Teodoro da Monte, 'Breve discorso sopra l'irrigazione delle campagne veronesi e scollation sua', 21 December and 10 June 1593, in *Modo*

*d'irrigare*, cit., pp. 105–11. Teodoro da Monte took up C. Sorte's idea of drawing an irrigation canal off Lake Garda; he intended to supplement this with a further irrigation canal drawn off the Adige. He also suggested the creation of a special shipping canal between the river and lake; but the course he plotted for this was rather bizarre (see the *Compendio di tutti li raccordi et suppliche presentate da diversi [...] in proposito d'irrigar la campagna di Verona*, Verona, 1594, p. 87ff.; *Aggionta al compendio di tutti gli raccordi et suppliche [...] in proposito d'irrigar la campagna di Verona*, Verona, 1594, pp. 119–33; *Livellazioni fatte per M. Gieronimo Pontara, et per M. Bartolameo Montino [...] ad instantia del Sig. Theodoro da Monte*, Verona, 1595, pp. 5–9; 'Supplica di Teodoro da Monte al senato veneziano', in *Modo d'irrigare*, cit., pp. 98–104; *ibid.*, 'Breve discorso sopra l'irrigazione', pp. 111–21; document submitted to the *rettori* of Verona, s. d., in *Aggionta al compendio*, cit., pp. 31–51. Da Monte planned to irrigate around 25,000 *campi*; even if in another passage he does speak of 150,000 *campi*. Similarly, his estimates of fodder production vary from 60,000 to 300,000 cartloads. Clearly he wasn't above a little exaggeration when promoting his scheme.

96. Benedetto Venier, *L'unica maniera d'irrigare le campagne veronesi da due parti dell'Adige, principalmente con l'escrescenze sue facendo navigazioni, et essicationi*, Verona, 1594, pp. 5–28 and 39–40.
97. G. Valente, 'Cenni storici sull'irrigazione in Friuli', in *Atti dell'Accademia di Scienze Lettere e Arti di Udine*, Udine, XXI (1942), pp. 1–9 and 17. The city governors in their reports often stress how agriculturally backward this scarcely-populated area was, in spite of the fact that it was of great military importance as a border zone between the Venetian Republic and the Holy Roman Empire (*Relazioni dei rettori veneti. La Patria del Friuli* [Luogotenenza di Udine], Tagliaferri ed., pp. XVII, XXXI–XXXIV). The Aviano canal (after 1486 known as the 'Brentella') has been rhetorically defined as 'a monument to the hydraulics of the fifteenth century' (see *Documenti del terzo scavo del canale di San Marco o Brentella da Montereale al Musile* [Nozze Brusasco-Cossettini], Pordenone, 1884 and G.B. Bassi, *Sulla irrigazione colle acque del Cellina nella provincia del Friuli*, Udine, 1875; *idem*, *Memoria sull'antico divisamento di costruire un canale navigabile da Udine al mare*, Udine, 1829; G. Occioni Bonaffons, *Bibliografia storica friulana*, I, Udine, 1883, p. 180 and II, p. 135.
98. C. Cattaneo, 'Delle irrigazioni del Friuli in paragone al canale Cavour e ai nuovi progetti dell'Alto Milanese', in *Scritti economici*, A. Bertolino ed., III, Florence, 1956, pp. 440–42; *Scrittura di Giulio Savorgnan nel 1592 sull'incanalamento del Ledra* [Nozze Occioni Bonaffons-Criscopulo], Udine, 1876. The governors themselves commented upon the abundance of water that was practically unused (see, for example, Giovanni Moro in 1527: *Relazioni dei rettori veneti, La Patria del Friuli*, cit., p. 10). On Giulio Savorgnan, of the Osoppo branch of the family, see F. Bonati Savorgnan d'Osoppo, 'I Savorgnan d'Osoppo', in *Archivio Veneto*, s. V, 100 (1973), pp. 10–11; P. Quaglia, 'Della irrigazione di un vasto territorio alla destra del Tagliamento colle acque del Cellina', in *Bollettino dell'Associazione agraria friulana*, II, Udine, 1874, p. 1.

99. According to the cadastral register of 1661, the nobility of the 'Patria del Friuli' owned 18,131 hectares, as against the 8,003 owned by commoners, that is 66.5 per cent as against 29.5 per cent (cf. Beltrami, *La penetrazione economica*, p. 94; C. Grinovero, *L'evoluzione dell'agricoltura friulana. Monografia economico agraria*, Udine, 1966, pp. 14–16).
100. Berengo, *L'agricoltura veneta*, pp. 129–30.
101. Valente, *Cenni storici sull'irrigazione in Friuli*, cit., pp. 15–16; Biblioteca comunale di Udine, Mss. 585, Angelo Maria Cortenovis, *Sull'irrigazione del Friuli. Dissertazione accademica letta nell'Accademia di Udine*, 1772.
102. Mozzi, *I magistrati veneti alle acque e alle bonifiche*, pp. 13–16. The Savi were generally responsible for work of any complexity involving the rivers that emptied into the Lagoon – for example, the passing of a new canal bed across an existing river or canal, which could involve the construction of either a 'canal bridge' or of an underground culvert. See the Senate decrees of 12 October and 6 February 1560 (S.T., filza 32) and D. Guglielmini, 'Trattato sulla natura dei fiumi', in *Nuova raccolta d'autori, che trattano del moto delle acque*, Carmignani ed., II, Parma, 1766, pp. 255–58.
103. G.A. Pedrinelli Pissina, *Compendio dei decreti e terminazioni [...] circa gl'affari del Magistrato ecc.mo delle acque*, Venezia, 1706, p. 23. It was the Savi and not the *Provveditori* who, in 1681, gave permission for the community of Gambarare outside Padua to draw a *quadretto* of water from the Brenta *nuovissimo*; they even contributed 250 ducats to the cost of the scheme (ibid., p. 21). On other occasions they made changes in the status quo; for example, in 1559 a Ducal decree by Girolamo Priuli put an end to a concession granting three *quadretti* of water from the Brenta for irrigation because, after use, that water flowed into the Lagoon (Psbi, reg. 300, c.19r., Ducal decree by Girolamo Priuli to Psbi (copy), 21 November 1559).
104. As is well known, throughout the sixteenth and seventeenth century, 'before the time of Newcomen' the only natural sources of energy were men, animals, wind and water: cfr. A. Ruppert Hall, 'Scientific method and the progress of techniques', in *The Cambridge economic history. The economy of expanding Europe in the sixteenth and seventeenth centuries*, E.E. Rich and C.H. Wilson eds., IV, Cambridge, 1967, p. 103; D. Sella, *Contributo alla storia delle fonti di energia*, in *Studi in onore di A. Fanfani*, V, Milan, 1962, pp. 619–31.
105. On the paper industry and its location in the foothills area, see I. Mattozzi, *Produzione e commercio della carta nello stato veneziano settecentesco. Lineamenti e problemi*, Bologna, 1975, pp. 67–70; on the silk industry, C. Poni, 'Archéologie de la fabrique: la diffusion des moulins à soie 'alla bolognese' dans les Etats vénitiens du XVI<sup>e</sup> au XVII<sup>e</sup> siècle', in *Annales E.S.C.*, 27 (1972), pp. 1475–96. Hammers and bellows do not seem to have used much water (Psbi, busta 94, Report by the expert Tommaso Fiorini, 4 July 1695). By the second half of the seventeenth century, metal furnaces might be ventilated by bellows (driven by water wheels) or by hydraulic air pumps, which were introduced into Italy around the middle of the previous century (C.S. Smith-R.J. Forbes, 'Metallurgy and assaying' in *History of Technology*,

- III. *From the Renaissance to the Industrial Revolution, c1500–c1750*, cit., pp. 51–53). On Italian fulling-mills or *gualchiere*, see Malanima, *I piedi di legno. Una macchina alle origini dell'industria medievale*. On mills in general and their increase from the Middle Ages onwards, see M. Bloch, *Lavoro e tecnica nel medioevo* (Introduction of G. Luzzatto), Bari, 1974, pp.73–110; Cipolla, *Before the Industrial Revolution*, pp. 137–59; U. Forti, *Storia della tecnica. Dalla rinascita dopo il Mille alla fine del Rinascimento*, II, Turin, 1974, pp. 139–42.
106. Psbi, reg. 550, c.81r., Document by Michele Priuli, 24 September 1535; Psbi, reg. 307, cc.58v.–59r., Document by Psbi 16 March 1569.
107. On canals and rivers, see J. Day, 'Strade e vie di comunicazione', in *Storia d'Italia. I documenti*, pp. 101–2; *ibid.* U. Tucci, 'Credenze geografiche e cartografia', pp. 62–66; P. Laven, 'The Venetian rivers in the Sixteenth Century', in *Montagnes, fleuves, forêts dans l'histoire*, J-F. Bergier ed., St. Katharinen, 1989, pp. 198–217. On these issues, see also F.C. Lane, *Navires et constructeurs à Venise pendant la Renaissance*, Paris, 1965, pp. 206–7 and 213–16; *Relazioni dei rettori veneti in Terraferma, Podestaria e Capitanato di Belluno – Podestaria e Capitanato di Feltre*, Tagliaferri ed., pp. 291, 313, 318, 371, 407, 411 and 418; Sereni, *Storia del paesaggio agrario*, pp. 198–204; Cipolla (*Before the Industrial Revolution*, pp. 92–93 and 112) argues that Italy had already started to compromise its woodlands and forests very early, leading to the creation of marshland and terrain subject to flooding. From another perspective, that of mentality and sensibility, see Schama, *Landscape and Memory*, p. 75ff.
108. Psbi, *Capitolare secondo*, c.98r., 22 February 1611. Similar concerns to reconcile the needs of shipping and irrigation can often be seen in Lombardy: G. Cesare Zimolo, 'Canali e navigazione interna nell'età moderna', in *Storia di Milano. Sotto l'Austria (1815–1859)*, XIV, Milan, 1960, pp. 835–38.
109. M.C.V., Mss. P.D., C.827/37, Applications 16 September 1678, 24 March 1679, 9 September 1679. See also ASV, SEA, busta 89, Application by F. and G.B. Garzadori, 9 August 1565, regarding an opening off the Bacchiglione, opposed by Simone Da Porto of Vicenza.
110. On the responsibilities of the *Provveditori all'Adige*, first set up to supervise that river in the second half of the sixteenth century and made a permanent body in 1667, see Da Mosto, *L'archivio di Stato di Venezia*, I, p. 158. With regard to the Adige, see the numerous essays in *Una città e il suo fiume. Verona e l'Adige*, Borelli ed.
111. S.T., filza 1021, Senate decree 11 april 1687. On the course of the Bussé see the 'Carta idrografica del Veronese, Polesine e Padovano' attached to Giovanni Coi, *Ragionamento intorno ai fiumi del Veronese, Polesine e Padovano* (Padua 1777); and ASV, P. all'A., Disegni n. 28, *Corso generale delle acque da sette miglia inferiormente a Verona fino al mare*, 30 July 1784. A tributary on the right bank of the Adige, the Bussé cuts diagonally across the ample curve of the river and all the channels drawn off the upper part of the river flow into it.

112. Application by the City of Verona, 10 April 1681 and Report by the *Presidenti del Collegio dell'Adige*, 11 March 1682, enclosed with Senate decree of 11 April 1682.