The Tariff Structure in the Tagus-Segura Water Transfer

Marcos García-López *, Borja Montano and Joaquín Melgarejo

Institute of Water and Environmental Sciences, University of Alicante, 03690 San Vicente del Raspeig, Spain;
borja.montano@ua.es (B.M.); jmelgar@ua.es (J.M.)
* Correspondence: marcos.garcialopez@ua.es

Abstract: The Tagus-Segura water transfer has generated significant value in the region that receives its water resources. Despite this value, some agents seek the cancellation of this important infrastructure, arguing economic, environmental, social, and political problems. With the aim of providing information on the efficiency of the Tagus-Segura aqueduct as a water resource management measure, especially in terms of the importance of water and the tariffs paid by the users of the aqueduct, this paper presents valuable information to analyse how to improve the functioning of the infrastructure. Thus, the southeast of Spain obtains a high return on the water received from the water transfer while covering all the financial costs derived from it. However, in 2017 a modification was introduced in the tariff that forced water users to cover the construction and fixed costs of the infrastructure as if the total amount of water agreed upon had been received, when in reality a lower amount had been received. This problem was not solved by the proposed tariffs for 2021, and it is therefore essential for the efficient operation of water transfer to modify these tariffs so that they are fair and reduce existing problems, thus avoiding the cancellation of an infrastructure that has not yet been amortised and which provides many benefits to the receiving region.

Keywords: Tagus-Segura water transfer; water conveyance tariffs; amortisation of the transfer infrastructure; economic profitability of water; economic instruments against scarcity

1. Introduction

The Segura River Basin is one of the regions in Europe with the greatest pressure on its water bodies, if not the greatest. This situation is associated with various types of impact, the most significant of which are environmental due to the effect on the ecosystem, economic due to the limited access to a basic productive resource, and social due to the difficulties in obtaining a stable water supply. Thus, the Tagus-Segura water transfer, in addition to the various water policy measures carried out by the institutions of the Segura basin [1], arises from the need to address a complex and delicate situation in terms of the availability of water resources.

Water transfer is a water policy measure that has been used or proposed on several occasions to meet the water resource demands of water-scarce regions [2–6]. In the case of China, for example, it was concluded that failure to meet the water demands of the northern part of the country would hinder the sustainable development of that region, thus making water diversion from the south of the country an available alternative [6].

Of course, urban water supply is of great importance and must be guaranteed in any case, at least when it is for household consumption. In addition, in this region, there is a dynamic agricultural activity with higher returns than in the rest of the country [7–10]. Therefore, the transfer of water to this region not only allows the urban water supply to be met but also provides high productivity of the water transferred for agriculture. The agricultural sector in the areas irrigated by the aqueduct represents a very important production and employment generation in social and economic terms for the receiving region [10]. Thus, the economic losses would be high in the event of the closure of the...
aqueduct because of the good economic yield obtained from the water received and the constant situation of scarcity of resources [9–11].

In other words, there are sufficient reasons to justify the operation of the water transfer since water is a public asset and access for all citizens must be guaranteed. [12,13]. In this case, we are talking about a water transfer whose resources have been needed for urban uses due to periods of great scarcity but which, in addition, when they have been used in agriculture, have been used obtaining a significant agricultural production [14]. This is a water policy measure that allows for a redistribution of available resources to satisfy the demand, but it is not sufficient to address the serious problem in this region [15,16]. In addition to these problems, there are also those generated in environmental terms in the donor basin [17]. For this reason, other alternatives such as desalination, water reuse, or improvements in irrigation techniques are often used, activities which, on the other hand, can also be enhanced to improve the management of available resources [18]. These alternatives, although they improve efficiency in terms of water management and distribution, also entail relatively higher economic and environmental costs [19], which should be minimised, as the situation requires the use of all possible water policy techniques.

Water transfers, like any other water policy measure, have economic as well as environmental costs that must be compensated. In the case of the Tagus-Segura water transfer, the financial cost is fully covered by the users of the Tagus-Segura water transfer in exchange for receiving a basic productive element. The environmental cost is mainly that suffered in the donor basin, which should be compensated through the development of new water policies financed by the economic payments made by the receivers of the water from the aqueduct. Since the transport of water requires an important infrastructure, there are high construction costs and, therefore, a large initial investment is required, which must be recovered in the long term [20]. Once the works have been completed and the infrastructure is in operation, water transport has both fixed and variable costs. These costs, including the gradual recovery of the investment, are financed through tariffs that are borne by the receivers of the water. Thus, the case of the Tagus-Segura water transfer is a particular case of Spanish water management, as it achieves financial cost recovery, which is not the case for most water services [21]. In fact, the total amount invoiced for this transfer represents more than 20% of all the income from fees and tariffs produced in all the Hydrographic Confederations of Spain, despite the fact that the water from the transfer only amounts to 3% of the total amount of water used for irrigation in Spain [19].

The central question of this paper is the influence of a structural feature of the Tajo-Segura water transfer tariffs introduced in 2017. This modification meant that water users must pay a series of fixed payments regardless of the quantity of water transferred, which implies a very high financial cost per cubic metre when this quantity is low. For this reason, it is of great importance to design a water transfer properly [22] and that it is carried out in a context of understanding, cooperation, and mutual benefit, thus avoiding conflicts, and carrying out the activity in an efficient manner [23,24]. This is of great interest, as a water transfer can have various types of impact, including environmental impacts due to the outflow of water from one river basin and its inflow into another and economic impacts derived from the loss of a valuable asset in the transferring basin and its reception in another [25,26]. This may compromise water supply in the donor basin in the long term or in periods of scarcity if the transfer is not properly designed. In this regard, the possibility of transferring water between two regions has been considered in England, but it has been estimated that it would generate a deficit in the supply of the donor basin in the long term [3]. This is also the case in China with the Yangtze River, from which water is extracted, compromising the security of supply of the city of Shanghai during periods of scarcity [4]. Therefore, we cannot consider the development of a water transfer to be efficient and sustainable if the environmental and social problems are not solved. To these impacts should be added the social impacts if, for example, water is given a cultural value, and political impacts, as different social agents may seek to control the available resources, thus generating disputes [25]. This is a major problem in the case of the Tagus-Segura water
transfer, as the environmental situation of the Tagus River has worsened significantly due to its unsustainable management and the transfer of water to the Segura River [17]. This requires all stakeholders to collaborate with the aim of designing the water policy of both regions based on the relevant geographical and economic data and in a way that benefits all [27]. In the absence of this collaborative situation between stakeholders, problems often arise even despite the benefits that the transfer may generate in the receiving basin, as in the case of the Sao Francisco transfer in Brazil [5].

In short, the Tagus-Segura water transfer provides available resources to a region suffering from severe shortages. For this reason, and taking into account that there are prospects of a reduction in the amount of water transferred [19,28], this paper will analyse the current economic situation of the Tagus-Segura aqueduct, with special emphasis on the payments made by the users of transferred waters, to contribute to better economic functioning of the aqueduct. At present, water transfers have tariffs that water users feel disadvantaged by, so it is highly advisable to study them. This may also help in the design of tariffs for other water transfer projects. This would help to improve the capacity of the water transfer as a tool to distribute water resources and to maintain the social and economic benefits in the receiving basin. In order to achieve this goal, the next section will explain the importance of the Tagus-Segura water transfer and the payments derived from it, then the discussion generated will be presented and, finally, the conclusions obtained will be shown.

2. Study Area

The Tagus-Segura water transfer is one of the largest hydraulic engineering works carried out in Spain. Since 1979, this 292-kilometre-long infrastructure has been supplying water to the Segura basin, which suffers from severe shortages. The surface area of the Segura basin that can receive water from the aqueduct is 200,000 hectares, while the total size of this basin is 1.887 million hectares. The area irrigable by the aqueduct amounts to 147,255 hectares, which is a large part of the 262,000 irrigated hectares of the entire river basin district [29]. The areas irrigated by the aqueduct belong mainly to the regions of Murcia and Alicante and, to a lesser extent, to the region of Almeria. The water received from the aqueduct is a major source of water resources for the regions irrigated by the aqueduct, but it is also of relevance at basin level, as each year, on average since it came into operation, 295 hm$^3$ arrive [30]. This quantity is an important part of the total usable resources in the Segura basin, a figure that amounts to 1662 hm$^3$ [30]. The amount of water transferred depends on the amount of water between Entrepeñas and Buendía (two points on the Tagus river). Thus, four levels are established according to this quantity, with level one being the situation in which the most water would be transferred as there is an abundance in the Tagus and level four being the point at which no water would be transferred as there is less than 400 hm$^3$ between Entrepeñas and Buendía [31].

Figure 1 [32] shows the route taken by the water through the water transfer infrastructure to reach its destination. As can be seen, the infrastructure follows a single path until it reaches the southeast of the peninsula, at which point it splits to give access to the different areas entitled to the transferred water.
3. Materials and Methods

In order to achieve the proposed objectives, data has been obtained from various sources so that the information used is complete. Based on this information, an analysis of the importance of the Tagus-Segura water transfer and the tariff aspect has been carried out.
3.1. Materials

The data obtained come mainly from the Central Irrigation Union of the Tagus-Segura Aqueduct (SCRAMT by its Spanish acronym), from other research articles that have previously focused on these issues, and from the official state bulletins [33–35] through which the tariffs of the Tagus-Segura aqueduct have been published. Thus, we have information about the agricultural production of the areas irrigated by the aqueduct, the amount of water transferred, and the different tariffs that have been applied to the use of water from the aqueduct. Therefore, we have complete information about the water from the aqueduct, its use, and the cost that this entails.

3.2. Methods

The methodology followed consists of the search for and analysis of bibliographic material. The Tagus-Segura aqueduct is an infrastructure that has always been under debate and about which a great deal of information has been generated, which we will use for this analysis. To meet our objective, the information obtained is explained in an orderly manner. Firstly, the available data on the relevance of the transferred waters are worked out. Specifically, we show the total amount of water transferred over time and the relevance of this water in terms of the total resources used by the irrigators receiving the water. Secondly, the information related to the production and economic profitability of agriculture in the areas irrigated by the aqueduct is shown. Once the importance of the aqueduct water in the receiving region has been discussed, the evolution of the aqueduct tariffs is presented, as well as details of the most recent tariffs, so that the adequacy of the current tariffs and the economic operation of the Tagus-Segura aqueduct can be assessed.

In this paper, tariffs are calculated based upon the tariffs published by the Spanish government and the quantities that could be transferred. For each of these quantities, we have multiplied the variable part of the tariff by the quantity transferred and added the fixed part multiplied by the maximum quantity that could be transferred (421 hm$^3$). This is due to the structural modification introduced by the Spanish government in 2017 and conditions the final average price per cubic metre. Tariffs without the above-mentioned structural modification have a constant unit cost. Finally, it should be noted that these calculations are made without taking into account the toll rate, as this is only applied to water outside the aqueduct, which flows through its infrastructure.

4. Results

This section includes information on the quantity of water transferred, its importance, the yield obtained from it, and the tariffs that users have to pay for receiving it. In general terms, the water transferred is of great value for the receiving region, not only because of the economic yield obtained from it, but also because it is a very important part of the available resources. In terms of tariffs, this is an aspect that has evolved over time and is currently designed in such a way that the initial investment and fixed costs are guaranteed regardless of the quantity of water transferred, which has a negative impact on the financial situation of water users.

4.1. The Importance of the Waters of the Tagus-Segura Aqueduct

Once the key points of the current situation of the Tagus-Segura water transfer have been explained, we will proceed to show a series of data on the functioning of this infrastructure. These data will consist of figures and tables obtained both from institutions directly related to the Tagus-Segura water transfer and from researchers interested in this issue. The existence of a variety of this type of material is reasonable, as the economic, social, and environmental importance of the Tagus-Segura water transfer is very important for the region receiving its waters.
4.1.1. The Relevance of Transferred Water to the Total Available Resources

Firstly, data will be presented on the amount of water transferred and what proportion of the available resources it represents in order to show its high importance in the water services of south-eastern Spain. In this regard, Figure 2 [36] shows the volume of water transferred to southeast Spain up to 31 December 2020, differentiating between water for irrigation and water supply. As can be seen, the 421 hm$^3$ that was agreed to be transferred for irrigation is only reached in 2000–2001. It can also be easily seen that the volume transferred for irrigation is very irregular. Within this irregularity, the decreases in the quantities transferred for the periods 2005–2008 and 2015–2017 stand out. This was due to the drought suffered in those years, which limited the amount of water that could be transferred [37]. On the other hand, the amount of water transferred has been reduced in recent years and is likely to be further reduced as a result of the implementation of the ecological flow regime set out in the Provisional Scheme of Important Issues in the Tagus River Basin Confederation [23,32]. This recent proposal would mean raising the ecological flow of the Tagus river from the current 365 hm$^3$ to 443 hm$^3$, which would reduce the amount of water that could be transferred. This modification has not yet been approved, so we cannot take it into account for historical data. Until this proposal, the ecological flow of the river Tagus had no great influence on the amount of water to be transferred, but this flow is currently under discussion.

![Figure 2](https://via.placeholder.com/150)

**Figure 2.** History of water transfers (hm$^3$) to south-eastern Spain up to hydrological year 2019–2020. Source: [36].

However, Figure 2 only shows the total amount of water transferred, so it does not express the importance of this quantity of water. In order to complement the information in this figure, Figure 3 [36] presents the water use originating from the Sindicato Central de Regantes del Acueducto Tajo-Segura (SCRATS). These sources include the Tagus-Segura water transfer, the drought wells, which are wells that are only accessed in times of drought, surface water from the Segura river, desalinated water, groundwater, and purified water. Thus, the great importance of the resources from the aqueduct for irrigators in the areas receiving these resources is evident. Water from the aqueduct is always the main source of resources, followed by water from the Segura basin. The data show lower resource utilisation in the periods 2005–2008 and 2015–2017 due to drought, which not only reduced available resources but also led to a decrease in water transfers [37].
farmers adapted to the scarce resources available. After 2017, although the amount of water transferred partially recovered, the resources available for agricultural use did not return to the pre-drought level and, due to the latest published exploitation rule, it is very complicated for this to happen [31]. This significantly affects agricultural activity in the areas irrigated by the Tagus-Segura aqueduct. Regardless of the amount of water transferred, at all times this resource is essential for irrigators in the area irrigable by the Tagus-Segura Aqueduct. This information is general for the areas irrigated by the aqueduct, but we can also comment on cases such as Albatera or Riegos de Levante M.D., where this water is a fundamental resource [15]. Finally, it should be noted that SCRATS is continuously working to develop alternative sources of water resources, as well as to maximise the efficiency of its water consumption [36].

![Figure 3. Comparison of water use by hydrological year (hm$^3$). Source: Approximation of [36].](image)

4.1.2. The Financial Performance of Agriculture Linked to the Tagus-Segura Aqueduct

Therefore, we have seen the great importance of the water received from the Tagus-Segura aqueduct for south-eastern Spain, at least in terms of available resources. However, it is also of great interest what use and yield are obtained from the water received. In this sense, part of the water is destined for urban consumption, which is fundamental as this includes household consumption, so this water is satisfying an essential demand. The other main use of the water received is agricultural, as agriculture is an important and dynamic economic activity in Spain and in the areas irrigated by the Tagus-Segura water transfer. Spanish agriculture represents 13% of the agricultural production of the entire European Union and, specifically, the activities linked to agriculture in the areas irrigated by the aqueduct contribute more than 3013 million euros to GDP and generate 106,566 jobs [10]. This includes agriculture and the activities or businesses that can be carried out largely due to receiving water from the aqueduct. Furthermore, the agricultural competitiveness of the areas irrigated by the aqueduct makes it possible to fix the population in rural areas, achieve a significant volume of exports, and balance the economy in phases of recession, as it is less linked to the economic cycle than other economic activities [10]. In order to express this issue more clearly, Table 1 [8], in addition to the available references, shows the
important and efficient agricultural production in south-eastern Spain that receives water from the aqueduct. In particular, the production of some agricultural products in the areas irrigated by the aqueduct is very important in the national context, as, for example, these areas produce around 30% of the lemons, 34% of the table grapes, 81% of the pomegranate and 53% of the loquat in the whole country [38].

Table 1. Productivity and profit per hectare and cubic metre of water consumed of the main crops in the irrigable areas of the Tagus-Segura water transfer. Source: [12].

| Product       | Production (kg/ha) | Benefit (€/ha) | Production (kg/m³) | Benefit (€/m³) |
|---------------|--------------------|----------------|--------------------|----------------|
| Orange        | 36,000             | 5695.25        | 5.23               | 0.83           |
| Lemon         | 42,500             | 5513.18        | 4.78               | 0.62           |
| Mandarin      | 34,000             | 4717.27        | 4.92               | 0.68           |
| Almond        | 2500               | 3380.31        | 0.30               | 0.40           |
| Tomato        | 120,000            | 40,271.80      | 21.10              | 7.08           |
| Artichoke     | 26,000             | 7670.91        | 5.50               | 1.62           |
| Pepper        | 105,000            | 52,384.31      | 13.49              | 6.73           |
| Potato        | 35,000             | 4940.43        | 7.58               | 1.07           |
| Cauliflower   | 36,000             | 7663.76        | 9.19               | 1.96           |
| Pomegranate   | 21,500             | 8306.17        | 2.62               | 1.01           |
| Lettuce       | 55,000             | 4859.16        | 14.53              | 1.28           |
| Vineyard      | 36,000             | 6369.21        | 4.53               | 0.80           |
| Green broad beans | 14,000          | 3103.64        | 3.50               | 0.78           |
| Melon         | 52,000             | 2342.05        | 9.37               | 0.42           |
| Peach         | 28,000             | 11,045.23      | 3.30               | 1.30           |
| Apricot       | 24,000             | 10,423.38      | 3.00               | 1.30           |
| Cucumber      | 42,969             | 11,042.25      | 9.32               | 2.40           |
| Courgette     | 42,969             | 11,042.25      | 9.32               | 2.40           |
| Watermelon    | 81,830             | 6332.46        | 10.22              | 0.79           |
| Aubergine     | 63,636             | 3390.27        | 13.81              | 0.74           |
| Green beans   | 9091               | 5941.18        | 1.97               | 1.29           |

Table 1 shows the production and profit per hectare and cubic metre of water consumed of the main crops in the areas irrigated by the Tagus-Segura aqueduct. We can see a high production that obtains profits. It should be noted that these financial results are pre-tax profits, so they already include costs but not taxes. These data are of great importance if we consider the context in which they are produced. Specifically, 54.90% of the irrigated agricultural area in the Region of Murcia corresponds to the areas irrigated by the aqueduct, while in Alicante this value rises to 61.65% [8]. In addition to the surface area occupied by these areas, the agricultural income from these regions accounts for 62.18% in the case of Alicante and 58% in the case of Murcia of the total income from provincial agriculture [8].

Agricultural activity in the Region of Murcia is a strategic sector due to its economic, social, and environmental implications. The economic importance of agriculture in Murcia is very high in terms of production and employment generation, which is why the reduction of water transfers would affect the region significantly [39]. Moreover, within Murcia, the case of the Campo de Cartagena is particularly relevant, a region that suffers from a scarcity of resources, but whose contributions to regional output, employment, and exports are of great relevance and reflect the dynamism of the activity [40]. In the case of Almería, both the surface area occupied and its contribution to provincial agricultural income are reduced to 1.74% and 3.57%, respectively. These numbers are lower, but even so, they express the yield obtained from the water received from the aqueduct. Therefore, it can be seen how the importance of the water from the aqueduct is very high for the receiving regions and, moreover, how the use given to it generates a significant production.

However, these data on agricultural profitability must be assessed within the context in which they are produced. On average, the profitability obtained from water in the Segura basin was estimated at €0.97/m³, compared to €0.88/m³ in the Tagus basin [41]. The
difference is not particularly high, but it is an indication of the yield obtained from water in the Segura, without forgetting that the aqueduct enables the creation of a significant number of jobs [10]. Therefore, the aqueduct enables the areas irrigated by its waters to develop in economic and social terms because of employment generation [42]. The transfer should not be carried out at the cost of not satisfying the demands of the donor basin, as in that case, the social impact could be too high. It cannot be affirmed that no water yield is obtained in the Tagus basin, nor can it be denied that the outflow of water to the Segura has an environmental impact [17]. Since a water transfer project cannot be considered sustainable if the negative impacts are not addressed, the efficient economic functioning of the water transfer is very important as it would allow funds to be allocated to correct the negative impacts derived from the outflow of water.

4.2. The Tagus-Segura Water Transfer Tariffs

Once commented on the great importance and profitability obtained from the water of the aqueduct by its receivers, it is essential to show the financial cost of the aqueduct and the payments that its users make in compensation. Thus, the receivers of the water cover all the costs, which include both the construction/investment made at the beginning of the project and the fixed and variable costs of operating the infrastructure [33–36]. Therefore, in order to present the situation in this sense, Table 2 [43,44] and Figure 4 [32,45] contain different aspects of the transfer tariffs for agriculture. It should be noted that these tariffs are divided into two parts, the water supply tariff, and the toll tariff. The water supply tariffs are the transfer’s own tariffs, as they are applied to the water from the Tagus that flows through the transfer with the Segura basin as its destination. On the other hand, the toll tariffs are the tariffs applied to water that is not part of the Tagus-Segura water transfer as such, but it is water that needs the infrastructure of the aqueduct to reach its destination.

### Table 2. Tariffs for the Tagus-Segura water transfer in 2013, 2014, 2017 and the alternatives for 2021. Source: [43] and own elaboration based on information from [44].

| Year       | 2013                  | 2014                  | 2017                  | 2021 (a)                | 2021 (b)                |
|------------|-----------------------|-----------------------|-----------------------|-------------------------|-------------------------|
| Period of validity | 29 November 2013 to 28 November 2014 | 29 November 2014 to 17 June 2017 | 18 June 2017 to 7 August 2021 | 8 August 2021 | Discarded |
| Irrigation Water Transfer Tariff | € cents/m³ | € cents/m³ | € cents/m³ | € cents/m³ | € cents/m³ |
| Construction cost | 1.4774 | 1.5388 | 1.4264 | 1.075 | 1.075 |
| Fixed costs | 1.8707 | 1.213 | 1.6321 | 1.66568 | 2.25111 |
| Variable costs | 6.4964 | 6.98 | 8.7308 | 10.64354 | 8.299326 |
| Total Irrigation Tariff | 9.8445 | 9.7318 | 11.7893 | 13.41609 | 11.65794 |
| Construction cost | 4.1568 | 4.2796 | 4.0548 | 3.417 | 3.417 |
| Fixed costs | 1.2354 | 0.0628 | 0.8913 | 2.498792 | 4.044107 |
| Variable costs | 6.1846 | 5.5739 | 8.4276 | 14.48059 | 8.299326 |
| Total Urban Supply Tariff | 11.5768 | 9.9163 | 13.3737 | 20.39638 | 15.76043 |
| Toll rate Irrigation |                |                |                |                |                |
| Construction cost | 0.5611 | 0.5597 | 0.5129 |                |                |
| Fixed costs | 0 | 0.4481 | 0.5803 |                |                |
| Variable costs | 4.4142 | 0.9786 | 1.2196 |                |                |
| Total Irrigation Toll | 4.9753 | 1.9864 | 2.3178 |                |                |
| Urban Supply Toll Tariff |                |                |                |                |                |
| Construction cost | 2.3242 | 2.3214 | 2.2378 |                |                |
| Fixed costs | 0 | 0 | 0.5803 |                |                |
| Variable costs | 2.6882 | 3.1314 | 2.4391 |                |                |
| Total Urban Supply Toll | 5.0124 | 5.4528 | 5.2572 |                |                |
4.2.1. The Evolution of the Tariffs of the Tagus-Segura Aqueduct

First of all, Figure 4 presents the time evolution of the supply tariff of the Tagus-Segura water transfer and the toll rate for irrigation with its water. Figure 4 contains the individual tariffs, of which we can observe that they do not follow a pattern, i.e., the evolution of the tariffs is not regular. It can be observed that the trend reflects growth in tariffs over time, with the trend being higher in the case of the supply tariff. Before going into detail, it should be noted that these data are not corrected for inflation, so that part of the tariff increases could be due to this issue, which is natural if we take into account that this transfer has been in operation for more than 40 years. As far as the supply tariff is concerned, price variations are indeed significant in a large number of periods, although it is also true that in most cases it takes several years of tariff operation before the change occurs. It can be seen how the tariff grew continuously from 1981 until 1997, after which it was reduced for some time. Years later, the 2005 modification led to an increase in the tariff after years of stability. However, the most important variation is found in 2009 with a tariff increase of almost 75%. After this tariff increase, two reductions softened the price for receivers until the 2017 tariff was published, which not only increased the average water price but also introduced the toll tariff, with the trend being higher in the case of the supply tariff. Before going into detail, it should be noted that these data are not corrected for inflation, so that part of the tariff increases could be due to this issue, which is natural if we take into account that this transfer has been in operation for more than 40 years. As far as the supply tariff is concerned, price variations are indeed significant in a large number of periods, although it is also true that in most cases it takes several years of tariff operation before the change occurs. It can be seen how the tariff grew continuously from 1981 until 1997, after which it was reduced for some time. Years later, the 2005 modification led to an increase in the tariff after years of stability. However, the most important variation is found in 2009 with a tariff increase of almost 75%. After this tariff increase, two reductions softened the price for receivers until the 2017 tariff was published, which not only increased the average water price but also introduced the toll tariff.

As for the toll rate for irrigation, the evolution is more stable, as this rate was increasing until 1998 and decreasing until 2005. However, since the 2009 modification, it has followed a completely different evolution to the one it had experienced until then. Thus, the 2009 tariff was more than three times higher than the previous one, which, together with the large increase in the main tariff that year, meant that the 2009 tariff was a large increase in the price of the water from the aqueduct. In contrast to the water supply tariff, which was reduced in 2012, this tariff increased significantly at this time. From here, the modifications of 2013 and 2014 significantly reduced the toll rate and 2017 meant only a slight increase. In other words, in recent years, both types of tariffs have undergone very different evolutions,
and, in both cases, we can find significant variations. Currently, the most interesting fact is that in 2017 an increase in the average price of water and the modification of the payment for the cost of construction and fixed costs of the water transfer came together.

Analysing the tariff variations in more depth, we can find that there are four moments in which the price to be paid by the user is reduced. Specifically, 1998, 1999, 2012, and 2013 tariffs led to a reduction in the amount to pay. The 1998 tariff was reduced as a result of the public sector’s agreement with the energy supply company [21]. The agreement meant that this company provided the energy supply service to the water transfer without financial profit in exchange for favourable conditions in other activities. A year later, two rulings by the Supreme Court led to a reduction in the tariff due to the imposition of the withdrawal of several of its components as they were contrary to law [21]. On the other hand, the reductions in 2012 and 2013 have their origin in the economic viability studies of the water transfer carried out by the users of its waters [46]. This led to an initial reduction in the tariff in 2012 and a second reduction in 2013 as a result of complaints from the receivers of the water. On the other hand, tariff increases are more common, which is logical considering that some of them come after several years of tariff operation and that the economic system is based on constant growth. However, some increases are striking, especially the one that took place in 2009 and continued until 2012, which significantly affected both the supply tariff and the toll tariff. This tariff change had effects on the competitiveness of farms in the areas irrigated by the aqueduct and, therefore, on the economic viability of agricultural activity. This increase was the result of an estimate that the energy cost of the transfer was going to increase by 120% [47], which would have a major impact on the operation of the infrastructure. This estimate is made every time tariffs are to be changed, but this energy cost increase was an isolated case. However, this large increase occurred at a time when the Spanish economy was going through a difficult period, so the effect on users of the aqueduct water was significant.

The 2017 increase, on the other hand, and as will be detailed below, attracted attention because of its structural modification rather than the increase itself and led to complaints from users of the water from the aqueduct [48]. The aim of this change was to obtain full payments for construction and fixed costs with independence to the quantity transferred, which resulted in a significant price increase as the quantity transferred became smaller. Thus, the 2009 and 2017 modifications entailed an important change in the payments made by users of the Tagus-Segura water transfer.

4.2.2. The Current Situation of the Tagus-Segura Water Transfer Tariffs

On the other hand, and with the aim of showing the recent situation in greater detail, Table 2 presents the transfer tariffs published in 2013, 2014, 2017, and 2021, with the 2021 tariff being the current one [35]. However, for the year 2021, two different tariffs will be shown because two different alternatives were assessed, which will be explained below. In general, important changes can be observed between these tariffs, highlighting that the 2013 tariff presented a high toll rate for irrigation that was reduced by 3 cents per cubic metre in the tariff published in 2014. In addition, there was an increase in the toll tariff for urban supply and an increase in the transfer tariff for the same use. From the 2013 tariff to the 2014 tariff, there was a decrease in the final cost of water for water users. However, the 2017 tariff did entail major changes in the payments made by users of the water from the aqueduct. Firstly, the toll tariff increased for irrigation and decreased for water supply. Secondly, the transfer tariff for both uses increased significantly, mainly due to the increase in variable costs. But, in addition, as mentioned above, this new tariff made a fundamental modification that greatly affects the payments made. This change meant that the construction costs and fixed charges were to be paid regardless of the quantity of water transferred. This implies that the 2017 tariff presents prices per cubic metre that are the result of dividing a fixed amount, which would be the sum of the cost of the construction and the fixed costs, by the total amount of water that was agreed to be transferred, which would be 421 hm$^3$. Therefore, this change implies that the payments in these concepts
become fixed amounts independent of the quantity of water transferred and that, of course, the unit payments are higher as the quantity of water decreases. The effect is very important and implies an increasingly higher average cost as the amount of water received decreases, becoming high in the lowest quantities. In other words, since the 2017 tariff, in the case of receiving a lower quantity of water than agreed, the unit price of that water increases above that established in the tariff. Bearing in mind that there is currently a prospect of a reduction in the amount of water transferred [19,28] this structural change in the tariff in 2017 would lead to an increase in the average cost of water for receivers of water from the Tagus-Segura aqueduct.

However, the 2017 tariff has just given way to the 2021 tariff. Two alternatives were proposed for this new tariff, which we will explain below. These two alternatives presented an important difference, as the first one maintains the same structure as the 2017 tariff (2021 a) while the second one transfers part of the amount so far located in the variable costs to the fixed costs (2021 b). Thus, since this second tariff maintains that the fixed costs are paid out of the agreed 421 hm³, its approval would have accentuated the fact that the transferred water presents, for its users, a relatively high average cost when the quantity transferred is small. The tariff that would entail this modification presents the highest unit cost for irrigators at the lowest quantities transferred but gradually decreases as the quantity of water transferred increases. In fact, in the event that the quantity of water transferred was the same as originally agreed, this tariff would not imply a large variation in the cost for users. The other proposed tariff, which has already been approved, represents precisely the opposite change, as it implies a reduction in the unit cost when the quantity transferred is low. However, this reduction is only present until the amount of water transferred reaches 80 hm³, as from this point onwards there is an increase compared to the 2017 tariff (grey bars), which amounts to 1.63 euro cents per cubic metre if the full amount is transferred. Had this structural feature been included in 2014, payments would have changed significantly. Specifically, in 2014 the amount of water transferred for irrigation decreased to 183 hm³. If the aforementioned modification had been introduced at that point, the final price would have increased by almost 4 Euro Cents per cubic meter, that is, it would have meant an increase of approximately 38%. Nevertheless, in 2013 the amount transferred for irrigation amounted to 363.10 hm³, which would not have meant a high price increase. Finally, if the change had not been introduced in 2017, the 123 hm³ transferred would have meant a saving of more than 7 Euro Cents for each of the hm³ transferred.

As can be seen, the quantity of water transferred is of fundamental importance in determining the unit cost to be paid by the users of the transferred water. In the context of reduction of the amount of water to be transferred, the current structure of the rates can significantly increase the average price paid by users of the transfer water. In summary, tariff (a) maintains the 2017 structure, softening the cost in the lower amounts, but increasing it significantly in the higher amounts, while tariff (b) would make the opposite modification, increasing the fixed costs, but maintaining the average cost in the higher amounts. All this considers only the water supply tariff, as no toll tariffs have been published for the proposed tariffs in 2021.

With regard to the transfer tariffs for urban supply, we can find some aspects worth commenting on. Again, without taking into account the toll tariff, as none has been published and they do not apply to the waters of the transfer, large differences can be observed between the two tariff options for 2021. Thus, as with irrigation tariffs, there is one tariff with a greater emphasis on variable payments and another with higher fixed payments. However, in this case, the situation is striking as both tariffs imply a significant increase in the price of the water transferred. In the case of tariff (b), the increase in fixed costs is high and represents a high cost for low quantities transferred, although it is softened as the quantity transferred increases compared to tariff (a). This other tariff has very high variable costs compared to the other tariffs. The fixed costs are lower compared to tariff (b), but the high variable costs mean that this tariff represents a significant increase in the cost
of water for its users. The structural issue between the two 2021 tariffs is the same, but in this case, both involve a significant price increase compared to the 2017 tariff. In particular, tariff (a) implies a price increase in both fixed and variable costs, which largely outweighs the decrease in construction cost payments. Tariff (b) implies an increase in fixed costs, but modifies the variable costs to a lesser extent, so that, although in any case it entails an increase in the tariff, this will be greater in the lower quantities transferred. Since tariff (a) has been approved, an increase has been introduced in the tariff for urban supply, which will be determined according to the tariff chosen and the quantity of water transferred. This is of great importance, as it increases the cost of access to water for the citizens of the areas receiving water from the Tagus-Segura water transfer.

5. Discussion

Given the current situation of conflict surrounding the Tagus-Segura Aqueduct, the need for water resources in southeast Spain, and the economic-financial situation of the aqueduct, it is clearly necessary to analyse the problems and introduce modifications. The situation, as it could not be otherwise, is complicated, as economic, environmental, social, and political aspects are connected.

The economic issue focuses mainly on the amount paid by the receivers of the water, as well as on the recovery of the investment made in the past. In this sense, the infrastructure has not yet been amortised and requires more operating time to do so, without forgetting that, as less water has been transferred than agreed at source, this amortisation is being delayed [20,21,49]. Therefore, the cancellation of the transfer would mean a waste of financial resources due to the non-utilisation of the investment. On the other hand, and despite the need to cover the full costs of investment and operation of the infrastructure, the change of concept introduced in 2017 leads to a situation that could be considered unfair and directly affects the users of the water from the aqueduct. The investment must be recovered, however, this way of doing it entails high payments by the receivers of the water, payments that do not correspond to the amount of resource received. In 2021, a modification of the tariff has been introduced, for which two different options were available. One of them would have implied a greater emphasis on fixed payments, which is particularly relevant when the quantity of water transferred is low. The one that has been approved, on the other hand, involves a decrease in fixed payments and an increase in variable payments, so that the unit cost of water would be reduced in the reduced quantities, but would increase considerably as the quantity of water transferred increases. Of course, these tariffs respond to the need to cover the costs of the transfer. However, this tariff structure, in a context in which a reduction in the quantity of water transferred is foreseen, may lead to an excessive financial cost for the users of the transferred water. This adds an element of uncertainty to the functioning of the water transfer that penalises the receivers of the water [50], who must constantly take the necessary actions to avoid excessively high prices or aspects contrary to law, as happened in the tariff reductions of 2009 and 2012. In fact, the 2021 reform implies both a cut in the amount of water transferred and an increase in prices. Specifically, in August 2021, although the amount of water transferred remained the same as in July, the cost of water for irrigators increased by 14% [51]. Thus, the problem is not only the tariff structure, which penalises users as the quantity of water transferred is lower, nor the amount they have to pay for receiving the water, but also the uncertainty associated with prices, which forces users to defend their rights. To this end, the irrigators will ask the Supreme Court to annul the cut in the water transfer [52].

If we compare this structural issue with a nearby transfer such as that of the Negratin-Almanzora, we find that the rate paid by the users of this other water transfer amounts to 25 Euro Cents per cubic meter [53]. This is a number that is clearly higher than that of the Tagus-Segura transfer when the amount of water transferred is high, but it lacks the structural component that we refer to in this work and that can make the cost of water grow excessively for its users. In addition, in 2015 there was a decrease in the rates for users of the Negratin-Almanzora waters [54]. The exploitation rule is also different in this
water transfer. As we can see, two transfers that are geographically close and supervised by the same government show a big difference in terms of exploitation rules. If we make an international comparison, the two exploitation rules discussed above differ from those proposed for the Dahuofang-Biliu transfer in China [2]. For this project, a more advanced methodology was proposed than simply assessing the volume of water in the basins involved in the water transfer. These are just a few examples of how a water transfer project can be managed and we have already seen that there is no single way of doing it and that management can be adapted to specific situations. In the case of the Tagus-Segura transfer, the constant need in the receiving region for additional water resources and the high productivity obtained from the water, as well as the more than 42 years of operation of the aqueduct, constitute an important guarantee that the users of the aqueduct will continue to demand this water and be willing to cover all the costs, as they have been doing so far. That is, given such a willingness to pay, it is feasible to consider the option of designing other tariffs that address the current problems. In the event that the water from the aqueduct is not available, the current users of the aqueduct water would have to look for additional sources of water resources. Part of the transferred water is used for urban supply, which is a priority use, so non-conventional sources would be necessary to provide water to irrigators in the region. Otherwise, economic activity in the area would be seriously affected, compromising an important production for the country, which is also linked to a significant number of jobs [55–57]. Of course, before reaching this point, other possible activities such as desalination or the reuse of wastewater would be attempted. However, this entails a number of problems that make the Tagus-Segura water transfer a valuable alternative in comparative terms. The most important economic aspect would undoubtedly be that the infrastructure of the water transfer is already in place so that the investment cost of the other alternatives is a problem for its development. On the other hand, the water quality is also an aspect of great interest when the water has an agricultural use, as the transferred water does not have the problems associated with desalinated water (low quality because of the presence of boron) or reclaimed water (possible problems due to the presence of diverse pollutants). The energy cost is of particular importance, as it is not only a financial cost but also an environmental cost in terms of greenhouse gas emissions, as the main source of energy used is fossil fuels. In this aspect, the transfer of water is associated with an energy cost, but this is significantly lower than that of desalination [58] and, although it is higher than that of water reuse, this is a resource with limited capacity to increase the available resources [57]. In addition, both non-conventional sources would imply a higher economic cost of water supply [28].

The energy issue is a major indicator of the environmental impact that water resources management can have because this energy comes mainly, at least in Spain, from fossil fuels. One of the objectives must be, without doubt, to minimise the environmental impact of our activities so that we maintain the natural environment, as well as the valuable services it offers us, in good condition. Thus, it is important that the Tagus-Segura water transfer has been operating for a long time and that the investment and infrastructure are already in place, so that it is not an alternative as such, but simply the continuation of an activity that has brought great value to south-eastern Spain. In other words, the development of other alternatives in order to increase the resources available in the event of the cancellation of the aqueduct would not only entail a financial investment, but also a new environmental impact. This effect would be avoided by maintaining the good functioning of the water transfer, since the damage has already occurred and, in this sense, the best alternative would be to make the impact profitable instead of generating a new one.

Finally, from a social point of view, the water transfer has generated conflicts and is a topical issue almost continuously. Therefore, it is important that alternatives to the cancellation or reduction of the water transfer are assessed and that decisions are taken in a context of mutual understanding, cooperation, and benefit, thus avoiding conflicts and guaranteeing economic, environmental, and social efficiency [23,24]. In other words, given the financial and environmental cost of other alternatives, the Tagus-Segura water
transfer is a great option for guaranteeing water supply in the Segura basin. Tariffs play a very important role in this decision, as they are the main indicator of the cost to be met by water users. Therefore, if the transfer tariffs are not adequate, there is a possibility of losing its benefits and having to resort to other sources of water resources, which have significant costs. The information on the case of the Tagus-Segura transfer, constantly under debate, can be very useful for the design of transfer projects, in the same way that other projects can serve as a reference for this case. One of the fundamental pillars of a transfer consists of financial compensation from the receivers of the water. This compensation must, as a minimum, cover all the costs derived from the transfer. The economic cost is easy to determine but, since there are other types of costs, and the water policy depends on each hydrographic confederation, it is difficult to determine if the compensation is sufficient to satisfy the environmental and social costs. In the case of the Tagus-Segura transfer, the users of its waters cover all the economic costs derived from the operation of the infrastructure. However, as a result of the constant complaints about the state of the Tagus River, it seems that the environmental impact of the transfer is not properly compensated. Transfer projects have also been carried out on many occasions in other countries, such as China, the United States, Australia, India, and Mexico, among others, to redistribute the scarce resources available [59]. When developing this type of project, the design of the economic aspect is fundamental and is correlated with the rest of the aspects of a transfer, so that this work, focused on the design of the tariffs of the Tagus-Segura transfer, can be useful for the design of other transfer projects. Efficiently designing the economic component of a transfer makes it possible to maximize the benefits obtained by the different agents involved. Thus, the objectives are to minimize costs, maximize the benefits of the water receivers, and that the compensation paid to the donor basin is useful to improve its water policy and minimize the environmental impact of the water leakage from the river basin.

6. Conclusions

This paper has presented a series of data on the functioning and economic relevance of the Tagus-Segura water transfer in order to analyse the current development of the activity and whether it constitutes an efficient water policy measure in comparison with other alternatives. The available information clearly shows the high economic value of the water from the aqueduct, as the receivers of this water obtain high profitability from it, thus contributing to a highly productive and competitive agricultural sector that generates a significant number of jobs both directly and indirectly. Furthermore, part of the water from the aqueduct is used for water supply, which is of enormous value as it is a priority use.

Having confirmed the high value of the Tagus-Segura water transfer, it is worth highlighting the existence of a series of problems in its operation. In this sense, there are several key aspects to be taken into account. Firstly, the recovery of the investment only takes time, as each year the transfer is profitable due to the willingness to pay for these resources. However, since less water is transferred than originally planned, the recovery of the investment is taking longer than expected [56]. In this sense, it should be noted that the Tagus-Segura transfer is a very special case within the water services of Spain where the water users satisfy all financial costs. In other words, while the water services are under-financed, the users of the waters of this transfer are constantly fighting to pay a fair price for the waters received. Secondly, the problem with the tariffs stems from their design, which currently, and since 2017, could be considered to penalise the receivers of the water undeservedly. Thirdly, the environmental impact is strongly related to energy consumption from fossil fuels, so the search for energy alternatives is also an activity that could bring major improvements to the functioning of the water transfer. In particular, the introduction of energy efficiency improvements or the use of alternative energy sources could contribute to reducing the environmental impact and the financial cost of the water transfer. The latter would also make it possible to reduce tariffs by reducing the variable costs associated with water conveyance. Finally, the social problem can be easily detected in the efforts made by certain actors to close the infrastructure or limit its operation, as well
as in the activities made by the users of the water transfer to keep it running in a fair and efficient way. The presence of all these problems makes the experience of the Tagus-Segura transfer useful for the design of other transfer projects. The Tagus-Segura transfer forms a very complete experience due to the combination of issues such as the environmental impact derived from the discharge of waters from the Tagus River, the social and political problems derived from it, and the constant debate about the design of the payments to be made by the receivers of the waters. This transfer presents problems of the four types that we have commented on in the introduction, so it is a very valuable experience for the proper design of other projects of this type. Other water transfer projects show differences in the price formation mechanism [2,53], so the information on the tariffs of the Tagus-Segura water transfer, in the context in which they are placed, joins the data already available on other water transfers with different policies, which is very useful to improve the design and maximise the efficiency of other water transfer projects.

It is therefore always appropriate to consider the various alternatives available in order to determine which would be the best water policy option in each situation. However, in the current situation, considering the high value obtained from water in the receiving region and the investment cost that the other alternatives would require, as well as other economic and environmental problems that would arise from them, maintaining the Tagus-Segura water transfer in operation is the most appropriate and simplest option. This is mainly due to the fact that the investment and environmental impact of the construction have already taken place and it would be more appropriate to make both aspects profitable instead of generating new financial costs and environmental damage.

Since not even the financial costs of Spanish water services are usually recovered, the possibility that the tariffs of the Tagus-Segura water transfer could be partially subsidised by some public entity to complete the financing without overburdening water users could be considered. Nevertheless, it would be advisable to maintain it to ensure the financial sustainability of the infrastructure. If the infrastructure is to be kept in operation its amortisation will come sooner or later, so increasing the payments to be made by the receivers of the water is unnecessary and negatively affects the businesses that use it, as well as the urban users who need the water to satisfy basic needs. Therefore, the structural modification introduced in 2017, which led to a significant price increase for all types of water users of the aqueduct, should be reconsidered.

In this sense, an in-depth analysis of the tariffs with the aim of introducing improvements would be highly desirable. Currently, due to the current tariff structure, the average cost of water for receivers depends on the quantity received, which has a negative impact on the profitability obtained and competitiveness with respect to other regions. The return on investment is slow due to the small quantities of water transferred (small compared to the initially agreed volume). If we force this recovery through tariffs, it is the users of the transferred water who suffer the consequences of not transferring the agreed quantity, mainly through facing a higher average cost. The financing of such infrastructure will be achieved as long as it remains in operation, although this is conditioned by the quantities of water transferred.

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