Improving Knowledge and Awareness and Contributing to Policy Making on River Pressures through a Citizen Science Approach: Tagus Web Viewer Case (Spain)

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Abstract: Citizen science is considered one of the most appropriate tools to raise public awareness of environmental issues. With the aim of improving knowledge on river environments, this article presents a web application for mobile phones and other portable devices that allows, through the active participation of society, the collection of detailed and systematic information on the main problems facing rivers. The initiative uses a web viewer (Tagus Web Viewer—TagusWV) developed as a pilot project in the Tagus River basin (Spain). This web viewer allows information on river pressures to be collected and the aggregated data to be visualised and extracted for interpretation and analysis. Pressure is defined as any use or activity, legal/illegal, authorised/unauthorised, that has an impact on water quality, morphology, river dynamics or the ecosystem. The data are mainly collected by different groups of citizens. In addition to contributing to the environmental education of citizens involved in a river environment, the data provided in the TagusWV are of particular interest to river managers. The tool is designed to be relevant for any river basin in the world, by simply loading the map, the names of the rivers and the corresponding locations.

Keywords: citizen science; discharges; hydromorphological alteration; pressures; public water domain; river space; Tagus River; web application

1. Introduction

Citizen science projects began to emerge more than two decades ago as a way of involving non-scientific members of the public in scientific research. This contribution consisted mainly in collecting data that would later be used by scientists [1]. An early example of this collaboration is seen in the field of ornithology, with the invaluable collaboration of bird watchers for the progress of the discipline [2], although at the time, this type of collaboration was not recognised as a citizen science project. The term citizen science has become popular in recent years. However, there is no single definition that encompasses all projects. For this reason, Eitzel et al. reviewed the different terms and multiple definitions of citizen science, in different contexts and geographical areas [3]. For these authors, a project can be considered citizen science if there is public participation in a part of the project, but not if data, samples or citizen labour are used without indicating the purpose of this participation. Bonney et al. focused on collaboration between the scientific community and society, and included as citizen science activities such as collecting, categorising, transcribing or analysing scientific data [4]. In order to narrow down and define what is considered citizen science, the European Citizen Science Association (ECSA) established “The 10 principles of citizen science” as the basic criteria with which to understand the concept [5]. Compared to other forms of citizen participation and scientific dissemination,
citizen science initiatives are characterised by their generation of new knowledge and citizen participation, all within the framework of a research project [6].

One of the advantages of these projects is that they provide a forum in which participants engage in thought processes similar to those involved in scientific research [1]. In this way, citizen science brings society and the scientific community closer together. Bonney et al. report on how citizen science fosters this interrelationship in that the active participation of society fosters a sense of contribution to scientific endeavours, increases their scientific knowledge, provides them with educational materials, and fosters direct contact between scientists and the public [7]. In short, citizen science enables participants to understand and engage with the scientific method, while giving deeper meaning to their hobbies [8].

In the field of ecology and environmental science, citizen science has been highlighted as contributing to improving the environmental awareness of participating citizens. One example is CoastSnap, a project that increased opportunities to engage with the public to improve awareness, interest and, where appropriate, support for coastal management [9]. Similarly, the CoCoRaHS project has served to foster a sense of environmental responsibility and awareness of the effects of climate change through the collection of rain, hail and snow data [10]. These projects have generated consistent, representative and long-term biophysical data, providing high societal value, while at the same time reducing resource investment at the institutional level. These advantages are highlighted by Snyder et al. for citizen science air quality monitoring projects [11], and even through the involvement of school children in data collection, with Varaden et al. highlighting the importance of early participation and awareness-raising [12]. In the same vein, Nath and Kirschke [13] reviewed 33 groundwater monitoring projects, highlighting participants’ positive impacts during problem solving, while valuing the benefits of the projects on the participants and the good quality of the data collected, with special emphasis on the importance of good project design for achieving the desired objectives.

Given that data collection is carried out with the support of volunteers, there is some fear among the scientific community of the insufficient quality or inconsistency of the data, an issue for which Burgess et al. find little evidence to support [14]. These authors propose greater transparency and availability of methods and data attributes. Kosmala et al. propose addressing this scepticism through several techniques: methods to increase data accuracy and account for bias, iterative project development, the training and testing of volunteers, expert validation, replication among volunteers, and statistical modelling of systematic errors [15]. For example, the Big Data approach improves data quality in eBird, a global citizen science project that collects bird observations [16]. Cardoso et al., in the context of a citizen science project on invasive alien species in Europe, proposed the implementation of robust validation flows with automated mechanisms and expert validation and specific training for database managers and citizen scientists to improve quality assurance and decrease data bias [17]. However, government authorities remain sceptical about citizen science, although this could be addressed by publicising successful projects and initiatives.

In addition to citizen participation, data quality or project design, the importance of scientific communication should be highlighted. Authors such as Thiel et al. consider this an essential element for success, where the communication strategy must strike a balance between the learning objectives and knowledge generation [18].

During this boom in citizen science, everyday access to technological advances has had particular relevance, especially through the use of mobile devices [19–25]. These devices offer the possibility of having georeferenced data (GPS location data) and a camera and microphone to hand and being able to collect and upload information in real time; the only thing missing onsite is validation of the information by an expert.

There are many successful cases of citizen science projects. Two of the more current cases of interest are (i) citizen science data, for the first time in Italy, have been used to investigate the niche space of the largest protected saproxylic beetle species and to analyse
the distribution of their suitable habitat [26] and (ii) Marine Litter Trackers have allowed for the processes driving the movement of macroplastics in the sea to be studied and interpreted from a citizen science perspective, allowing for improved Big Data collection and education/awareness-raising on issues related to anthropogenic marine litter from rivers [27].

Given the vast data collection and interpretation needed for environmental projects, citizen science projects are often found within the natural and environmental science fields. Among these, those citizen science projects related to river environments are becoming indispensable, since water quality, quantity and access to water are crucial for human well-being [28]. Taylor et al. state that the human-created problems that are compromising our water resources require human-centred solutions, and have explored responses such as citizen science and participatory learning as more sustainable alternatives through a project that enables citizens to participate in local-scale water quality monitoring [29]. This project is based on biological indicators—on families of macroinvertebrates present in most of the world’s perennial rivers. However, it is also very important to be aware of the issues that may be causing these water quality problems, such as pressures and impacts. These include point and diffuse source pollution, water abstraction for different uses, flow regulation, morphological alterations and other types of anthropogenic impacts on a river space.

This article presents the results of the project TagusWV, a citizen science project which involves the creation of a web viewer of the state of conservation of the rivers of the Tagus basin (www.catedradeltajovisor.org, accessed on 1 May 2024). The project is an example of how citizens can contribute, by way of an easy-to-use tool on mobile devices, to the control of discharges in our rivers and other management issues which affect their proper functioning. The project has a bottom-up, co-creation approach based on the need for local communities to address a common challenge, such as in the case of the Tagus River, which shows a poor state of conservation in its middle section in the Spanish demarcation. This river is intensively used for human activities (urban and industrial supply, irrigation, hydroelectricity, refrigeration, transfers, etc.), with environmental, social and economic consequences [30], and thus makes for an ideal candidate for the development of this citizen science project.

This challenge and the project itself fall within UN Sustainable Development Goal 6 (safe drinking water and sanitation for all) and, to a large extent, achieving the objectives of the project depends on the commitment and participation of stakeholders, as well as education [28]. In addition, citizen science reinforces Goal 17 by fostering collaboration between different actors (scientific institutions, NGOs and citizens) to achieve the other development goals. This participation related to water management is enshrined and guaranteed in European legislation through the Water Framework Directive [31].

The aim of this paper is to present to the scientific community the design of an application for mobile devices which allows, on the one hand, the collection of pressures and impacts on the river environment by citizens and, on the other hand, the analysis of the results by the scientific community and stakeholders, including those responsible for water management and local and regional authorities.

TagusWV is a citizen science project in one of Spain’s river basins, characterised by the great pressure this river is under from various demands. The project aims to fill a gap in the awareness of the pressures that affect the river through the participation of citizens from sectors active in its conservation, thereby seeking to involve and raise public awareness of the main problems of river conservation.

The origin of this web application lies in the web viewer created in 2013 for rivers around Madrid by citizen groups responding to water quality problems and the multitude of abandoned obstacles [32]. This idea has been improved, thanks to the use of new technologies, and extended in this project to the whole Spanish part of the Tagus basin. The primary objective of the project is to collect detailed and systematic information on the main problems of the rivers in the Tagus basin through the active participation of the local people. This information is compiled and deposited in a web viewer, which makes it possible to
visualise and extract aggregated data for interpretation and analysis. TagusWV has been developed with the collaboration of the Spanish Foundation for Science and Technology (FECYT), a public foundation dependent on the Spanish Ministry of Science and Innovation. Firstly, it is a tool that citizens can use to participate in the collection of research data on the pressures affecting the conservation of the rivers of the Tagus basin. Secondly, it is a web interface in which the information collected is displayed, openly accessible to the public, and allows filtered information searches for viewing statistical information and generating reports.

The rest of the paper is organised as follows: Section 2 describes the study site (Tagus River basin); Section 3 explains the methodology used; Section 4 presents the results and Section 5 concludes with the final discussion.

2. Study Site: Spanish Tagus River Basin

The scope of the study is the river courses of the Spanish part of the Tagus River basin district (see Figure 1). Within each watercourse, the sampling area is the fluvial space, made up of the public hydraulic domain (riverbed) and the police zone (100 m on each side of the riverbed).

The Tagus is the longest river in the Iberian Peninsula, with a length of 1007 km. It has its source in the Montes Universales and flows into Lisbon, depositing its waters in the Atlantic Ocean. Its hydrographic basin has a surface area of 80,925.85 km², making it the third largest basin on the Iberian Peninsula. It is an international hydrological basin, being 68% in Spanish territory and 32% in Portuguese territory. The Tagus is the most populated basin of the peninsula, with more than 10 million inhabitants, including the two capitals, Madrid and Lisbon. The Spanish part of the basin has a population of 7,821,601 inhabitants [26].

The climate in the region is mostly Mediterranean-continental, with rainfall being more abundant in the sub-basins that flow into the middle part (end of the Spanish demarcation) than those that flow into the headwaters and upper reaches [33]. It has a well-defined dry season accompanied by high temperatures for at least three months in summer, which leads to markedly low water levels.

The Tagus basin has a very marked asymmetrical character in terms of the contributions of its network of tributaries. Those on the right bank (which drain the contributions from the southern sector of the Central System and part of the Iberian Mountains) provide the most abundant flows. However, those on the left bank are, in general, short and of low flow [34].
Although agricultural and forestry uses predominate in land use, urban uses have a great influence [33], especially in the metropolitan area of Madrid. The Madrid region, with 82.58% of the population of the basin, represents only 14.37% of the territory. This fact has significant influence on the deterioration of the rivers on the right bank of the Tagus River due to both its high regulation for supply and the contribution of wastewater. Taking into account the geographical situation of Madrid and its metropolitan area in the upper-middle zone, 85% of the water consumption of the entire basin is produced in an area where only 45% of the resources are available [30].

According to the status assessment provided in the Water Framework Directive (WFD) of the river-type bodies of water of the Tagus, 53% of the Spanish part of the Tagus River basin district reaches a good final status, with 47% having a final status of “worse than good” [35] (Annex 9). The pressures affecting the river environment are high, as outlined in San-Martín et al. [24]. Among the problems pointed out by the hydrological plans of the first and second planning cycle [34,36] are the impact on flows caused by the Tagus–Segura transfer, the urban pressure coming from the Community of Madrid (generating high levels of discharges that the system cannot cope with), and the general over-regulation of the basin, in particular with respect to the Extremadura section of the Tagus River and the supply system of Madrid. These problems generate serious socio-economic consequences in the riverside populations, such as depopulation of the municipalities bordering their headwater reservoirs as a consequence of the Tagus–Segura water transfer, as discussed by Larraz and San-Martín [37], or the existence of a collective memory of the Tagus in Toledo during the 50’s and 60’s of the 20th century, which highlights the importance of an environment being in good condition for the well-being of the citizens as opposed to its current deterioration, as discussed by Aguilar et al. [38].

3. Materials and Methods
3.1. Design of the Web Application

This research follows the stages for the design and implementation of a citizen science project in ecology and environmental sciences [39]: (i) in Stage 1, we identify the need for a viewfinder that would collect and show the pressures and impacts on a river which divert it from its natural behaviour; (ii) in Stage 2, we affirm that citizen science is the best way to conduct this research because of the many kilometres of riverbank that one person or a team would have to cover to achieve this; (iii) in Stage 3, we design A web application for mobile devices (TagusWV); (iv) in Stage 4, we build a participant community, considering environmental groups, students and the general public; (v) in Stage 5, citizens collect data and researchers analyse the data and (vi) in Stage 6, we evaluate the results.

As a central element of the project (Stage 3), a web application of a responsive nature is developed for mobile devices, tablets and desktop computers, i.e., it allows a website to automatically adjust to the size and layout of its users’ devices. The double development of a website associated with a mobile app was ruled out due to accessibility issues (the app would have to be downloaded) and the cost involved. The technology and possibilities offered were considered to be the same using the web application.

A fundamental element of the development was the web application’s design, creating an attractive and intuitive application which avoided the need for tutorials or user manuals that could discourage users in the first instance. The design and development of the application was programmed in LINUX and pHp. The databases were created in mySQL and htm15, while the design was carried out with uX.

TagusWV was designed with four work areas: (i) create pressures, where users enter the pressures; (ii) the viewer where the registered pressures are reflected, which allows for measurements of areas and lengths and loads different layers; (iii) queries, where users can make filtered queries of the different fields of each pressure (for example, river, municipality, province, type of pressure), as well as consult the pressures input by themselves and (iv) explorer, which provides statistical information on the pressures in the viewer (see Figure 2).
Data collection through fieldwork was carried out by people from different citizen and environmental groups. The recommended method was to cover distances of no more than 5 km, by groups of between 2 and 5 people, normally walking along the public water domain, easement area or public paths, where appropriate. In some cases, the collection of pressures with private vehicles was supported. On a few occasions, pressures were incorporated by the office using available official information. Also in the office, relevant data from official sources was added to the pressures, such as data related to protected areas, involvement in flood zones, links to registers of authorised discharges or dams, etc.).

Pressure is understood as any use or activity, whether legal or illegal, authorised or unauthorised, that generates an impact on water quality, morphology, river dynamics or the ecosystem. Following Spanish regulations, the characterisation of the Hydrological Planning Instruction [40] was used as a basis, although a typification was made based on the most common incidences encountered through experience. The following data was collected for each pressure: coordinates, province, municipal district, river bank, place name, type of main pressure, type of secondary pressure, observations, possible corrective measures and photograph. The information collected, in order to be displayed in the viewer, must be previously validated by one of the authorised administrators.

To validate a record, a check is made to ensure that there are no inconsistencies in the information provided or that the information actually involves pressure. First of all, the data provided are related to the photographic evidence. Next, a verification of the pressure on the orthophoto is carried out, where it is possible to detect it (for example, activities in the fluvial space such as roads, power lines, bridges, dams, gravel pits, crops, constructions, etc.). Additionally, for pressures affecting uses and activities in the river space, as well as spillages and longitudinal and transversal barriers, the information is verified in the map of flood zones of the Ministry for Ecological Transition, in the census of authorised spillages of the Tagus Hydrographic Confederation and in the census of barriers of the same body, respectively. In the event of any doubtful information or a lack of relevant information, the administrators communicate with the participants by e-mail. In some cases, direct visits to the field are even made to resolve any doubts. If the information provided does not pass all these filters, the incident is not recorded.

The development of the project has included communication and dissemination activities. These have consisted of public presentations, face-to-face and online workshops,
accompanying visits with volunteers and various educational and informative materials. Volunteers have been able to participate in the implementation of these activities.

3.3. How It Works

The TagusWV has four areas offering different possibilities to the user: creating new pressures; viewing pressures; making queries and exploring statistical data.

3.3.1. Creation of Pressures

In this space users can enter field data: the location of the georeferenced pressure, municipality, province, name of the affected river, photograph, type of pressure, as well as a free field for a description and to propose possible improvements (Figure 3). Figure 4 shows the type of pressures. To access this space, a registration must be completed beforehand, which is automatically validated.

To avoid possible noise and heterogeneity in the data collected by volunteers, which is one of the potential disadvantages of citizen science, online learning tutorials have been designed and training programmes and informative conferences developed. In addition, each of the entries registered in the application follows an expert validation process.
3.3.2. Visualisation of Pressures

A map shows all occurrences grouped by number and proximity. By zooming in, the incidents can be separated out into individual incidents, identified by a menu of icons that give information on the type of pressure (spillage, barrier, construction, etc.). Clicking on the icon displays a window that gives basic information on the pressure and allows access to a larger window with all the information collected (Figure 5).

This work area also allows basic operations such as measurements and various map layers.

3.3.3. Queries

The aim is to be able to obtain reports using the existing information (see an example in Figure 6). The user can make combined searches and download the information in PDF format. Another important element is the possibility of visualising the query in the TagusWV.

Figure 5. Tagus Web Viewer (TagusWV). Source: www.catedradeltajovisor.org, accessed on 1 May 2024.

Figure 6. An example of a query: Pressures in Henares River. Source: www.catedradeltajovisor.org, accessed on 1 May 2024.
3.3.4. Explorer

The website offers basic statistical information on pressures: percentage of occurrences, territorial distribution by province, distribution by river and temporal distribution (Figure 7).

![Figure 7. Explorer showing statistics by pressure type. Source: https://www.catedradeltajovisor.org, accessed on 1 May 2024.](image)

The personal information of the participants is not made public, with the privacy of personal data in TagusWV being guaranteed. This research was developed following the ethical principles of the Cátedra del Tajo UCLM-Soliss. The results of the pressures collected and described are published in https://catedradeltajovisor.org, and are freely accessible.

4. Results

The main result obtained so far is the creation and implementation of the cartographic Tagus Web Viewer (TagusWV) for free access and consultation, with 3450 incidents collected so far (January 2024). Information is available for 36 rivers (out of nearly 200 rivers in the basin), although the rivers with the most systematised information are the Jarama, the Guadarrama, the Guadalix, the Tajo (Madrid section and some sections in Toledo), the Tajuña, the Henares and the Manzanares, among others. The number of pressures detected per river can be seen in Table 1. Data are available for rivers in all the provinces of the Spanish part of the Tagus basin, although Madrid is the province which has the greatest number of rivers crossing it and also has the highest percentage of pressures (82% of the total), followed by Toledo (14%).

Table 1. Number and percentage of total pressures detected in different rivers of the Tagus Basin.

<table>
<thead>
<tr>
<th>Rivers</th>
<th>Location</th>
<th>Pressures</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jarama</td>
<td>Madrid/Guadalajara</td>
<td>879</td>
<td>25.3</td>
</tr>
<tr>
<td>Tajo</td>
<td>Guadalajara/Madrid/Toledo/Cáceres</td>
<td>635</td>
<td>18.3</td>
</tr>
<tr>
<td>Tajuña</td>
<td>Madrid/Guadalajara</td>
<td>395</td>
<td>11.4</td>
</tr>
<tr>
<td>Manzanares</td>
<td>Madrid</td>
<td>335</td>
<td>9.6</td>
</tr>
<tr>
<td>Guadarrama</td>
<td>Madrid/Toledo</td>
<td>294</td>
<td>8.5</td>
</tr>
<tr>
<td>Henares</td>
<td>Madrid/Guadalajara</td>
<td>161</td>
<td>4.6</td>
</tr>
<tr>
<td>Alberche</td>
<td>Ávila/Madrid/Toledo</td>
<td>152</td>
<td>4.4</td>
</tr>
<tr>
<td>Lozoya</td>
<td>Madrid</td>
<td>149</td>
<td>4.3</td>
</tr>
<tr>
<td>Guadalix</td>
<td>Madrid</td>
<td>144</td>
<td>4.1</td>
</tr>
<tr>
<td>Others</td>
<td>Guadalajara/Toledo/Cáceres</td>
<td>329</td>
<td>9.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>3473</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: Data from January 2024.
The overall figures on the types of pressures found give a clear idea of the situation of the rivers studied (see Table 2). There is a predominance of pressures that affect the police zone (100 m on each side of the riverbed, an area in which activities and uses are conditioned). It is common to find that, except for a small strip close to the riverbed, the banks are occupied by different uses and anthropogenic activities. Pressures affecting water quality are also common, i.e., direct discharges into the riverbed from different sources, or indirect discharges through polluted tributaries such as uncontrolled landfills and occasional rubbish deposits. Morphological alterations, due both to transversal barriers (dams, weirs, overpasses) and to different types of bank protection, are very frequent pressures and appear, almost without exception, in urban stretches, periurban stretches and stretches with the presence of agricultural activity. The occupation of the public water domain and of the easement zone (i.e., the watercourse and the 5 m nearby reserved for public use, where activities and uses are restricted) continues to be a recurrent phenomenon in the watercourses analysed, with no distinction being made between urban and rural stretches. Finally, it is worth noting the high frequency with which different obsolete infrastructures appear in the fluvial space, whether in the form of hydraulic installations or in constructions or other elements in the riparian space.

Table 2. Types of pressures found.

<table>
<thead>
<tr>
<th>Type of Pressure</th>
<th>Number</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities affecting the police zone (gravel pits, forestry operations, farms, enclosures, power lines, recreational areas...).</td>
<td>1070</td>
<td>30.8</td>
</tr>
<tr>
<td>Pressures on water quality (discharges and waste)</td>
<td>838</td>
<td>24.1</td>
</tr>
<tr>
<td>Morphological alterations (dams, dykes, bank protection, canalisations)</td>
<td>492</td>
<td>14.2</td>
</tr>
<tr>
<td>Occupation of the DPH and easement area</td>
<td>317</td>
<td>9.1</td>
</tr>
<tr>
<td>Disused infrastructure</td>
<td>128</td>
<td>3.7</td>
</tr>
<tr>
<td>Flow abstraction (pumping and abstractions)</td>
<td>123</td>
<td>3.5</td>
</tr>
<tr>
<td>Other alterations</td>
<td>505</td>
<td>14.5</td>
</tr>
<tr>
<td>Total</td>
<td>3473</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: Data from January 2024.

By river and by stretch, very different situations are encountered. In general, in rivers crossing large urban areas, the number of pressures and their importance in terms of environmental deterioration increase as the river flows from the headwaters to the middle and lower reaches. Despite the rivers being heavily affected by urban and agricultural activity, they maintain natural areas in some parts of their middle and lower reaches. The lower courses of the Jarama, Manzanares, Guadarrama, Henares, all of those in Madrid, the Tagus River as it passes through Toledo, etc., have similar characteristics (transformation of the fluvial space by urban, industrial and agricultural activities, longitudinal morphological alterations, poor water quality, presence of invasive exotic species, uncontrolled waste, concentration of transport infrastructures, poor quality of the riverside woodland, etc.). However, watercourses running through a predominantly rural territory show a greater number of alterations linked to agricultural activity (occupation of the public domain, transformation of riverbanks, alteration of riverbank vegetation, water extraction, dams, etc.).

From the outset, the project was defined as a citizen science project so that citizens could connect with science. Accordingly, 45 people registered on the website, with a majority profile of inhabitants of the Community of Madrid (the biggest province in the basin, with almost 7 million people), with the most active people in the collection of data belonging to the citizen and environmental movement in defence of rivers.

As part of the communication and dissemination activities, four public presentations were made in different cities, an online meeting, three face-to-face workshops, two field visit accompaniments and a final evaluation and analysis meeting between the scientific community and citizens. These communication activities have been recognised by the Spanish Foundation for Science and Technology (FECYT) in the catalogue of excellence and
innovation in science communication: “Selection of Projects of the Call for grants for the promotion of scientific, technological and innovation culture 2021. Edition 2024”.

It is important to emphasise that the project is in continuous development and that the number of incidents varies, normally increasing over time. In second and third visits to the same areas, the pressures detected in previous samplings are checked and eliminated from the viewer if they no longer exist, so the intention is that the information is adapted to the real situation of the rivers at any given time.

5. Discussion and Conclusions

The usefulness of the web viewer, TagusWV, developed for the collection and subsequent analysis of environmental data on rivers shows itself to be an ideal tool for raising public awareness and improving knowledge of the pressures and impacts these rivers are experiencing. Having its origin in the viewer developed by an environmental group in defence of the rivers of Madrid, its transformation into a web application for mobile devices has meant a great advance in the methodology used, making it a valid and easy-to-use tool for citizen science for the entire Tagus River basin. The tool can also be used by public administrations to update their pressure catalogues in their respective areas of competence. The proposed citizen science data can complement and add to official records. In fact, it appears that the official information even lacks some of the information that is included in the viewer, certainly in the case of the Tagus basin.

As for the rivers studied, it can be concluded that the middle and lower courses of the main rivers analysed (for example, Manzanares, Jarama, Guadarrama, Henares, middle section of the Tagus) are suffering from significant degradation that affects both the quality of their waters and the conditions of their fluvial space. Most of the data have been obtained from the Community of Madrid and adjacent areas, as well as from the central stretch of the Tagus River, so future research could focus on collecting information related to the remaining rivers in the basin in order to also raise environmental awareness of river care in less populated areas. The tool is designed to be relevant to any river basin in the world, by simply loading the map, the names of the rivers and the corresponding locations.

This tool serves as a source of first-hand information for academic issues, dissemination, reports in public participation processes, etc. In this sense, it has been one of the main sources used by citizen groups in the public participation process of the third cycle of hydrological planning in the Tagus basin [41] (Annex 12), as well as in the new National River Restoration Plan [42] (Annex 3). In addition, some of the incidents recorded in TagusWV (which could be contrary to environmental regulations) have been brought to the attention of the authorities so that they can take appropriate action. In this respect, the public presentation of the pressures in the municipality of Toledo has led to the commitment of the local authorities to tackle several points of irregular discharges.

In this way, this co-engaged citizen science and action learning project is in line with more inclusive, participative and effective channels for social change (Taylor et al.) [7,29,43,44]. The fact that it is such an easy-to-use tool means that it is user-friendly for all ages, including older adults. This latter group represents a significant proportion of the participants, and yet using this new technology has not been an obstacle for them, showing advances in this respect on the results previously presented by Martellos et al. [25]. The three sets of factors that were identified by San Llorente et al. [45] to evaluate the success of citizen science projects are clearly incorporated in the Tagus VW project: (i) participation by volunteers who have contributed a significant level of data, which demonstrates their knowledge and experience and, since they come from a background of environmental action, their environmental awareness and motivation; (ii) coordination between the promoting organisation (Catedra del Tajo) and the co-financing organisation (FECYT), which has made it possible to develop the project in terms of resources, materials and activities; (iii) application of materials, activities and tools that have enabled constant interaction between volunteers and the scientific community. The Tagus VW project mostly complies with the ECSA principles of citizen science [5] (see Table 3).
According to Thiel et al. [18] the project should encompass communication, dissemination and outreach activities as important elements for citizen science.

Table 3. Relationship of ECSA’s citizen science principles to Tagus WV.

<table>
<thead>
<tr>
<th>ECSA</th>
<th>Tagus WV</th>
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<tbody>
<tr>
<td>1. Involvement of citizens in scientific endeavours that generate new knowledge</td>
<td>1. Citizens and NGOs are involved in the whole scientific process</td>
</tr>
<tr>
<td>2. Production of a new scientific results</td>
<td>2. New results have been generated on the pressures on the rivers of the Tagus basin that can help management decisions</td>
</tr>
<tr>
<td>3. Mutual benefit between professional scientists and citizen scientists</td>
<td>3. The UCLM-Soliss Tagus Chair has acquired new knowledge on the state of the basin; citizens can see their work in TagusWV and access the results</td>
</tr>
<tr>
<td>4. Involvement of citizen scientists in multiple stages of the scientific process</td>
<td>4. The research design starts with organised citizen groups: citizens participate in data collection and contribute knowledge during learning workshops</td>
</tr>
<tr>
<td>5. Citizen scientists can receive information about the project at any time</td>
<td>5. Through the TagusWV, where data is updated in real time, continuous feedback is received on the progress of the project and its social and political implications</td>
</tr>
<tr>
<td>6. Citizen science has its limitations and biases, which need to be monitored and considered</td>
<td>6. The data must undergo a validation process, which has its logical limitations; the river basin is of considerable geographical size</td>
</tr>
<tr>
<td>7. Public data and metadata and open access results</td>
<td>7. Research results are public and accessible, providing different formats for their understanding and analysis</td>
</tr>
<tr>
<td>8. Recognition of results input by citizen scientists in publications</td>
<td>8. The results are always visible in publications, public events and communication channels</td>
</tr>
<tr>
<td>9. Assessment by scientific output, quality of data, expertise of participants and social and political outreach</td>
<td>9. See results section</td>
</tr>
<tr>
<td>10. Legal, ethical and rights aspects must be taken into account</td>
<td>10. Through compliance with the UCLM’s principles of scientific ethics in research</td>
</tr>
</tbody>
</table>

The limitations of citizen science projects noted by Fraisl et al. [39] have mainly been overcome, in that the transdisciplinary research team displays a wide range of necessary competencies outside the research topic. The maintenance of citizen engagement has been achieved mainly by the environmental groups themselves, and biases related to data collection have been overcome by communication and monitoring activities and an expert validation process. However, it is worth noting some of the biases encountered: (i) participation basically of volunteers with a high interest in river conservation; (ii) a small number of volunteers providing a significantly high amount of data and, conversely, a significant number of volunteers providing data on an ad hoc basis over time; (iii) most of the volunteers (and, therefore, the data provided) are geographically located in the Madrid region; (iv) the collection of information requires an effort to travel, sometimes to not very accessible places and (v) despite the accessibility efforts, the use of the tool requires a minimum of attention and knowledge on the part of the volunteers. However, as these limitations were considered in the design phase, they did not affect the achievement of the objectives set.

In line with Echeverria et al. [24], the next step could be to introduce this application to secondary students in an educational context, since this age group is particularly open to engaging in learning activities that incorporate mobile devices.


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Conflicts of Interest: The authors declare there to be no conflicts of interest.

References
5. ECSA. Ten Principles of Citizen Science; European Citizen Science Association: Berlin, Germany, 2015; Available online: https://ecsa.citizen-science.net/2016/05/17/10-principles-of-citizen-science/ (accessed on 16 June 2023).
6. Oltra, A.; Piera, J.; Ferrando González, L. Breve Guía Sobre Ciencia Ciudadana CSIC; CSIC—Vicepresidencia Adjunta de Organización y Cultura Científica: Madrid, Spain, 2022. [CrossRef]
9. Elrick-Barr, C.E.; Clifton, J.; Cuttler, M.V.; Perry, C.D.; Rogers, A.A. Understanding coastal social values through citizen science: The example of Coastsnap in Western Australia. Ocean Coast. Manag. 2023, 238, 106563. [CrossRef]


26. Zan, L.R.D.; de Gasperis, S.R.; Andriani, V.; Bardiani, M.; Campanaro, A.; Gisondi, S.; Romiti, F. The Big Five: Species Distribution Models from Citizen Science Data as Tool for Preserving the Largest Protected Saproxylic Beetles in Italy. *Diversity* 2023, 15, 96. [CrossRef]


30. San-Martin, E.; Larraz, B.; Gallego, M.S. When the river does not naturally flow: A case study of unsustainable management in the Tagus River (Spain). *Water Int.* 2020, 45, 189–221. [CrossRef]


44. Pocock, M.J.; Roy, H.E.; August, T.A.; Kuria, A.; Barasa, F.S.; Bett, J.; Sithuru, M.; Kairo, J.G.; Kimani, J.; Kinuthia, W.; et al. Developing the global potential of citizen science data as tool for preserving the largest protected saproxylic beetles in Italy. *Diversity* 2023, 15, 96. [CrossRef]

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