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Teaching Floods in the Context of Climate Change with the Use of Official Cartographic Viewers (Spain)

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Abstract: Floods are the natural hazard that have the greatest economic impact and cause the most deaths in the Mediterranean region. The objective of this study is to present different proposals for teach the risk of flooding using the GIS viewers offered by the NFZMS (National Flood Zone Mapping System) and the PATRICOVA (Spain). The idea is that, based on the selection of the same area of study (the mouth of the Júcar River—Valencia—and the mouth of the Segura River—Alicante), students determine the similarities and differences, for educational purposes, of these two geographical viewers. These proposals are aimed at the 2nd year of the Baccalaureate (17–18 years; optional subject of Geography). The objective is to enhance the skills of the students for understand the territory, especially their immediate environment, in the learning process. Furthermore, it also seeks to expand the knowledge of students with regard to these extreme phenomena experienced by society. This proposal shows that these types of tools are important for students to understand the social and territorial part of flooding events (vulnerability and exposure), which is the most salient part in terms of finding solutions to minimise their effects.

Keywords: climate change; impacts; floods; proposals; teaching; adaptation

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1. Introduction

Floods are the natural hazard that claims most victims and causes economic losses on a global level [1]. Moreover, flood episodes have been displaying an increasing trend over the last decade due to the increase in vulnerability and exposure (increase in the population and urbanised areas in risk zones) [2,3]. To this, we should also add the manifestation of the global warming process, which is increasing the frequency of intense rainfall events (extratropical storms and tropical cyclones) [4].

In Europe, floods accounted the 44% of the economic damage caused by natural hazards in the period between 1980 and 2022 (509.437 billion euros) [5]. In Horizon 2100, the JRC calculated that floods could cause annual losses of 16 billion euros for an increase in temperature of 1.5 °C and 40 billion in the "non-adaptation" horizon (>3 °C) [6]. In the Spanish case, as indicated by Olcina [7], two million people live in places of high flood risk. Between 2000 and 2020, a total of 215 deaths were recorded caused by floods in Spain, which represents 20% of total victims of natural hazards in this period, with the Mediterranean coastal regions being those most affected by these events [8].

In the Region of Valencia (study area), the Territorial Action Plan on the Prevention of Flood Risk in the Region of Valencia (PATRICOVA) indicates that 600,000 inhabitants (12% of the region's population) reside in floodable zones. Of those, 30,000 reside in areas with a high risk. With respect to the educational field, one aspect which highlights the importance of contemplating these phenomena is that 327 educational centres are affected by this risk (having some element or construction within the floodable area), with six centres located in "Very High Risk" areas [9].

In the education domain, the teaching of climate change and its effects is a complex task, as indicated by Olcina [10]. Authors such as Ozdem et al. [11] argue that even the scientific community has difficulty in finding a simple explanation for the evolution of the climate features on a planetary scale and its current status due to the amalgam of factors that intervene. To these factors, we should add: (1) the stereotypes and false news created by the media [12]; (2) the lack of scientific rigour in this topic observed in the school textbooks [13,14]; and (3) the lack of training of current teachers [15].

Education is one of the most important actions to combat climate change and natural hazards. However, this subject has scarcely been contemplated in political action, even by teachers [16]. The 5th Climate Change Report of the IPCC [17] promoted the teaching of climate change and the associated atmospheric hazards, underlining the necessity of rigorous teaching about natural hazards. This need has been endorsed in recent years by the United Nations with its promotion of education about climate change and extreme weather events as a basic action to achieve the so-called Sustainable Development Objectives (SDOs) (2030 Agenda), specifically Objective n. 13, "Climate Action" [18]. Furthermore, it should be noted that, in Spain, and from 2021, with the passing of the Climate Change Law, a specific part is dedicated to the teaching of this phenomenon (Title VIII "Education, Research and Innovation in the fight against climate change and energy transition").

On an international level, different research conducted over the last decade has revealed the importance of the study of flood risk in education. Some of these studies have been carried out in the USA [19,20], Europe [21–25], Asia [26,27], Africa [28,29], and South America [30–33]. In Spain, the majority of the scientific production on this topic (from an educational perspective) has been carried out in the discipline of Experimental and Natural Sciences [34–36]. However, in Geography and/or Social Sciences Teaching (the object of this study), these types of publications are infrequent [37,38]. For the case of the Region of Valencia, some studies have recently been conducted on the social representations of trainee teachers [39,40] and proposals for activities [41] and field trips [42].

Our interest in studying this issue in the educational level is due to several reasons: (1) it is a Geography topic (natural hazards) which should be taught in the subject "The Geography of Spain" in the 2nd year of the Baccalaureate in accordance with the current Spanish curriculum (Royal Decree 243/2022 of 5th April); (2) Spain, and more specifically the Mediterranean region, has become a high-risk region due to its atmospheric conditions in the current context of climate change and also to the increase in urbanisation (waterproofing) and the occupation of floodable areas [3]; (3) there is a misperception in society regarding the supposed dominance of nature which would ensure "zero risk" to natural hazards, which has been proven to be highly improbable [43]; and (4) the effects of climate change mean that these extreme weather phenomena (episodes of intense hourly rain) will be more intense and frequent in the future, which is already being witnessed [44]. Therefore, education is decisive for training the youngest cohorts in how these extreme phenomena work, generating major economic damage and the loss of human lives. The use of cartography to teach flood risk based on official web viewers (Ministry of Ecological Transition and the Autonomous Regions in Spain) has unquestionable advantages, given that it enables students to relate physical and human aspects that intervene in the territory object of study and obtain an immediate knowledge of the level of risk that exists (Figure 1).

The objective of this study is to propose different didactic activities to teach flood risk with the use of two GIS (Geographic Information Systems) viewers; the one provided by the National Flood Zone Mapping System (NFZMS) and the Territorial Sectorial Action Plan on Flood Risk Prevention in the Valencian Community (PATRICOVA). The idea is that based on the selection of the same area of study (the mouth of the Júcar River—Valencia—and the mouth of the Segura River—Alicante), students determine the similarities and differences, for didactic purposes, of flood cartography. These proposals are aimed at the subject of "The Geography of Spain" (optional) of the 2nd year of the Baccalaureate and seek to promote the capacities among the students to understand the territory, particularly in their most immediate environment, in the learning process. The aim is for students to gain greater knowledge of these extreme phenomena, which will lead to territories and societies that are more prepared to withstand extreme events as a measure of adaptation to the current process of global warming.

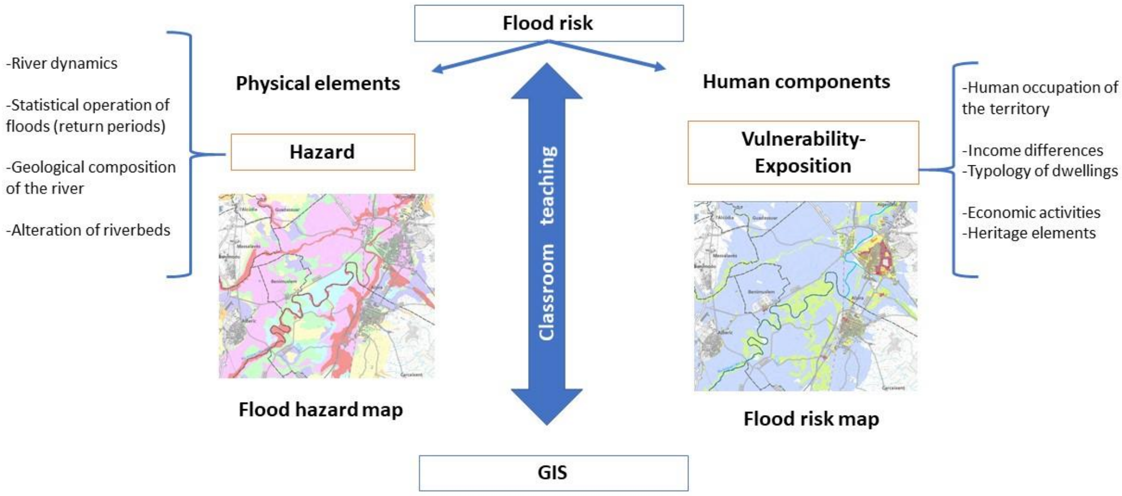

Figure 1. Physical and human factors that intervene in flood risk. Source: own elaboration.

2. Materials and Procedure

In order to fulfil the objectives, different documents and viewers were consulted: (1) the national curriculum for the Baccalaureate (Royal Decree 243/2022 of 5th April); (2) National Flood Zone Mapping System (NFZMS); and (3) the Territorial Sectorial Action Plan on Flood Risk Prevention in the Valencian Community (PATRICOVA).

2.1. Curriculum and Regulations with Respect to Climate Change in Schools

First, the national curriculum for the Baccalaureate currently in force has been consulted (Royal Decree 243/2022 of 5th April), and, more specifically, the subject "The Geography of Spain" (see Table 1). One of the novelties of these new regulations is that they establish working on skills. Therefore, the contents related to floods and ITC resources (Information Technology and Communication) are framed within the specific competencies n.2, n.3, n.4, and n.5 (see Table 1). In Spain, the responsibility for teaching educational content is transferred to the autonomous regions, which include them in their own curricula. Although this study refers to specific areas in the Region of Valencia (mouths of the Júcar and Segura rivers) (see Figure 2), it seeks to serve as a model and guide for other areas. Therefore, the national regulations have been taken into account in the design of the activities. It is a general proposal which can be adapted to Secondary Education (12–16 years) and even Primary Education, particularly the third cycle (years 5 and 6; 10–12 years). And, if the means exist (risk cartography), it can also be used on an international level. Therefore, teachers must adapt it to their school year and region.

Table 1. Specific skills related to floods and ITCs (subject of "The Geography of Spain").

Specific skill n.2. Understanding the complexity of the geographical space through the interpretation of visual information sources in order to appreciate the richness of the natural and humanised landscapes and to value sustainability as the basis of the relationship between natural ecosystems and human action.
Specific skill n.3. Analysing the natural diversity of Spain and its geographical uniqueness within Europe by comparing common and specific characteristics of relief, climate, hydrography and biodiversity in order to reflect on the personal perception of the space.

Table 1. *Cont.*

Specific skill n.4. Applying Geographical Information Technologies (GITs), methods and own techniques or those of other sciences, locating natural and human phenomena and formulating rigorous arguments regarding their limits or categories in order to efficiently resolve the problem of scale in any analysis or action proposal.
Specific skill n.5. Assuming globalisation as the context within which the recent evolution of economic systems and social behaviours has taken place, investigating their cause and effect relationships and creating own products that show the interconnection and interdependence on all levels in order to promote respect for human dignity and the environment as a basis for citizenship.

Source: Ministry of Education and Professional Training [45].

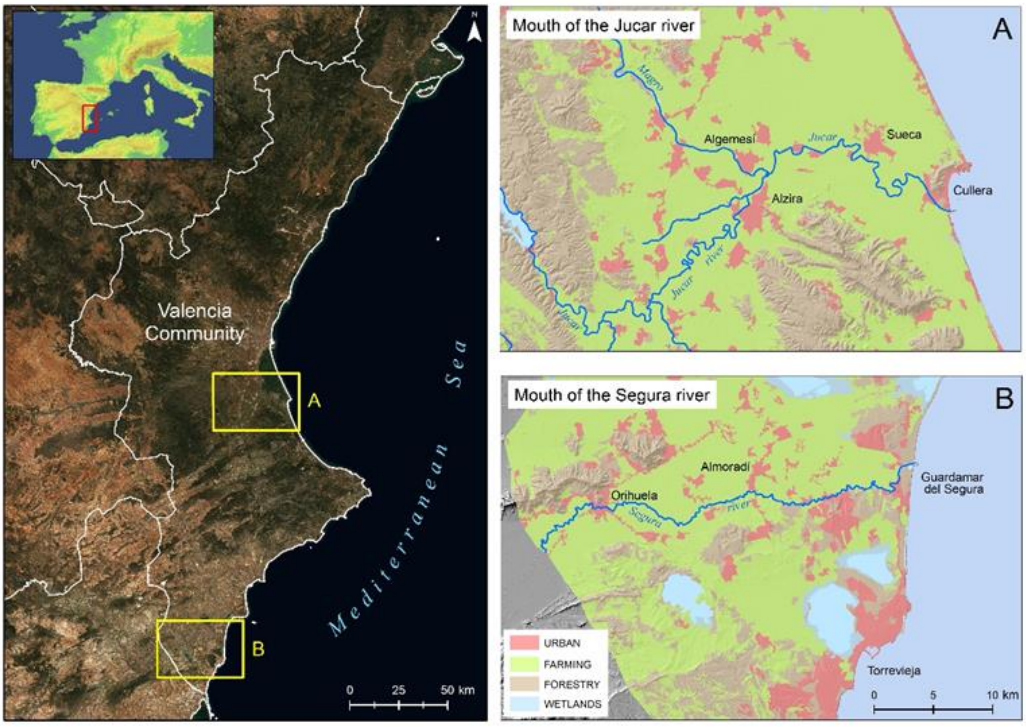

Figure 2. Study area (mouth of the Júcar River—Valencia) and the mouth of the Segura River—Vega Baja district). Source: own elaboration.

The Spanish Climate Change Law (approved in May 2021) has also been consulted, which, for the first time on a national level, has dedicated a section to the teaching of climate change (Title VIII "Education, Research and Innovation in the fight against climate change and energy transition"). This section includes two Articles: Art. 31. "Education and training in climate change", and Art. 32. "Research, development and innovation on climate change and energy transition". The former includes different motivations justifying the execution of this study (see Table 2).

Table 2. Points 1, 2 and 5 of Art. 31 of the Climate Change Law (2021).

Point 1. The Spanish education system will promote the involvement of Spanish society in the responses to climate change, reinforcing the knowledge on climate change and its implications, providing training to ensure low carbon technical and professional activity and resilience to climate change and the acquisition of the necessary personal and social responsibility.

Table 2. *Cont.*

Point 2. The Government will review how climate change and sustainability are addressed in the basic teaching curriculum, which transversally forms part of the Education System, including the necessary elements to make education for sustainable development a reality. Furthermore, the Government, in the scope of its competencies, will promote actions that guarantee the appropriate training of the teachers in this subject matter.
Point 5. The Government will take into account the influence that informal education has together with formal education and non-formal education and will make use of it to implement campaigns to raise awareness among the citizens about the effects of climate change and the impact that human activity has on it. Furthermore, the Government and the different Public Administrations will acknowledge and provide the necessary means and resources for the entities to carry out non-formal educational activities, which are understood as a further way to promote the involvement of particularly vulnerable groups such as children and young people in the fight against climate change.

Source: Government of Spain [46].

2.2. National Flood Zone Mapping System (NFZMS) A GIS Resource with Great Educational Potential for School Geography

Secondly, for the teaching proposal, the National Flood Zone Mapping System (NFZMS) was consulted. The NFZMS is an official cartographic portal on flooding, which was created in 2017 by the Ministry of Ecological Transition and Demographic Challenge in compliance with the requirements included in Directive 60/2007 on flood management. This Directive (transposed into Spanish legislation through Royal Decree 903/2010) established that the member states of the European Union had to elaborate flood hazard and risk maps (Arts. 8 and 9, Royal Decree 903/2010), with a series of recommendations for their elaboration (Art, 10, Royal Decree 903/2010). The novelty of this Directive resided in the fact that, for the first time, the European countries defined a common policy for reducing the risk of a natural hazard (floods) based on the elaboration of risk maps and flood risk management plans with implications for territorial and urban planning actions.

In Spain, for the first time, the river basin authorities elaborated the Preliminary Flood Risk Assessments (PFRA) based on the selection of areas of potential significant flood risk (APSFRs). This first step constituted an advance in the preparation, from 2013, of the cartographic portal of the National Flood Zone Mapping System, which officially began operating in 2019. In parallel with the elaboration of the flood hazard and risk maps, the river basin authorities approved their Flood Risk Management Plans within the framework of the second Hydrological Planning Cycle (2015–2021).

The cartographic portal of the NFZMS (https://sig.mapama.gob.es/snczi/index.html?herramienta=DPHZI, accessed on 24 October 2022) has some distinct advantages. For the first time in Spain, a mapping of floods for the whole of the national territory has been created. A legal hierarchy has been established for the use of these maps in relation to other existing flood risk cartographies in certain autonomous regions, which had elaborated maps to apply in their territorial and urban planning. From now on, the NFZMS maps will take priority in their determinations over other existing cartographies, which are complementary to the NFZMS maps.

Furthermore, the hazard maps of the NFZMS, together with the determinations established by Directive 60/2007, have incorporated the criteria to delimit flood zones included in the modification of the Regulation of the Public Water Domain (Royal Decree 638/2016), which defines in detail the flood hazard areas (floodable area, preferential flow area).

The central pillar of the freely accessible NFZMS is the cartographic viewer of floodable areas, which enables the studies of the delimitation of the Public Water Domain (PWD) to be viewed, together with the cartographic studies of floodable areas, elaborated by the Ministry and those conducted by the autonomous regions. Furthermore, the viewer provides information to the basin organisations with the issue of reports on authorisations in the PWD and restricted use area on flood management in connection with the AHIS (Automatic Hydrological Information System) and on the planning of flood defence actions.

It also facilitates the flood planning and management of the Civil Protection services, the transmission of information about floodable areas to the authorities responsible for territorial planning and promotion companies and enables citizens to learn about the hazard and risk existing in a particular area.

2.3. Territorial Action Plan for the Prevention of Flood Risk in the Region of Valencia (PATRICOVA)

Thirdly, the PATRICOVA was consulted. The PATRICOVA is a sectorial territorial plan which has the objective of reducing the risk of floods in the Region of Valencia (see Figure 2). This region is one of the Spanish and European territories with the highest level of flood risk due to: (1) the confluence of a high level of natural hazards (torrential river courses, atmospheric situations favouring the development of intense rainfall, the configuration of landforms prone to the effects of episodes of air instability); and (2) an also significant vulnerability, particularly on the coastal strip, where there are activities with a tourist and residential value with a network of communication infrastructures and large urban nuclei [47].

The PATRICOVA came about due to the flood episodes suffered by the Region of Valencia in the 1980s (1982, 1987, 1989). The effects of these extreme events led to the elaboration of the first flood risk cartography (although it was, in fact, hazard cartography) in 1995, as a preliminary step to the elaboration of a risk reduction plan based on territorial planning, in line with the regional legislation of Valencia related to territorial planning of 1989 (Law 6/1989), subsequently modified (Law 5/2014., mod. Law 1/2019). This plan adopted the form of a sector territorial action plan, as previously indicated, with the objective of incorporating a series of urban and territorial determinations in order to reduce the risk of flooding. The first version of the PATRICOVA was passed in 2003, including, together with the flood hazard cartography and urban planning determinations, a series of hydraulic infrastructure and hydrological and forest restoration actions.

The application of the plan revealed some weaknesses leading to an update and improvement in 2015. This new version has incorporated certain novelties that are worth mentioning. For example, in order to establish the six levels of flood risk (from "very high" to "very low"), together with the flood hazard map, geomorphological risk cartography has been incorporated, which takes into account the hydraulic function in different landforms (principally wadis and ravines). With respect to the determination of the flood hazard, the PATRICOVA defines these six levels based on two variables: the period of return and the height of the water (see Table 3). This combination is based on the idea that the damage caused by river floods increases significantly when the water exceeds a height of 80 cm.

Table 3. Hazard levels of the PATRICOVA (from 1 to 6).

	Height of the Water (<80 cm)	**Height of the Water (> 80 cm)**
Return period <25 years	3	1
Return period 25–100 years	4	2
Return period 100–500 years	5	6

Source: PATRICOVA [9].

Furthermore, there has been an updating of the human factor (vulnerability) in the determination of risk based on the study of the following variables: (1) the total population of the municipality; (2) the weight of the production sectors (according to the total employment of the municipality); (3) the proportion of the active population connected to agriculture; (4) the value and composition of the housing stock; (5) the percentage of the area affected by the flood; and (6) the population density.

The 2015 version of the PATRICOVA is more complete when determining flood risk due to the new criteria (geomorphological risk and vulnerability) and the improvement of the cartography incorporated (Table 4). Furthermore, an own viewer has been incorporated, which is accessible from the Valencian Cartographic Institute (VCI) (https://visor.gva.es/visor/, accessed on 24 October 2022) for consulting flood cartography which enables a more detailed scale to be contemplated for urban planning. This makes it a tool that is easy to access and highly useful, not only from a territorial perspective but it can also be used as an educational resource to explain the topic of risk in the classroom at different levels of school and university education, as proposed in this study.

Table 4. Characteristics of the flood risk cartography viewers.

Characteristics	NFZMS	PATRICOVA
Scope	National (Spain) (Water Basins)	(Regional, Region of Valencia)
Regulations	Directive 60/2007 (RD. 903/2010).	Agreement of 28th January 2003 (modified Decree 201/2015)
Legal form	Instrument of mandatory consultation Complement to the Flood Risk Management Plans of the Water Basins.	Regulatory plan of territorial planning.
Year of implementation	2017 In the implementation phase	2015
Hazard maps	Yes Three levels (High, Medium and Low) according to the return period (less than 100, more than or equal to 100 and equal to 500 years).	Yes Six hazard levels in accordance with the return period (25, 100 and 500 years) and two depth levels (<80 cm. and >80 cm.) The geomorphological risk parameter in wadis and ravines is included (historical floods).
Risk maps	Yes Number of inhabitants Type of economic activity. Special treatment for industrial zones in danger of contamination and protected areas.	Yes Relationship between hazard and updated land uses.
Legal hierarchy	Priority.	Complementary.

Source: Ministry for Ecological Transition and the Demographic Challenge [48]; Regional Department for Territorial Policy, Public Works and Mobility [49]. Own elaboration.

3. Educational Proposals for Teaching Flood Risk Activities Based on Digital Competence and Territorial Interpretation

In this work, five sessions are proposed with a duration of 55 minutes each, in accordance with the school stage (2nd year of the Baccalaureate) and the national curriculum (Royal Decree 243/2022). With respect to the geographical framework, two at-risk territories have been proposed in the Region of Valencia: the mouth of the Júcar River (Valencia) (Territory A) and the Vega Baja district of the Segura River (Alicante) (Territory B) (see Figure 2). These two study areas have been chosen since they are the two territories of the Valencian Community with the highest risk of flooding [50]. Besides, within these two study areas, the two most important cities have been chosen to carry out a detailed study: Cullera (22,708 inhabitants; Júcar River) and Orihuela (78,940 inhabitants; Segura River).

The interest in analysing the risk cartography of these two areas of study is due both to physical-ecological and human reasons. The lower sections of the Júcar and Segura rivers, the object of this study, constitute two of the principal flood risk areas of the Spanish Mediterranean seaboard and the whole of the western Mediterranean basin. The territory within which the section below the Júcar River (Territory A) is located forms part of a floodplain which has a very slight incline, which favours the development of meanders in the course of the Júcar River and its tributaries. It is an area which has historically suffered from serious floods (1884, *Pantaná de Tous* 1982 [see Figures 3 and 4], 1987 and 2000), all in autumn and which have barely been addressed with structural actions on the river course, contrary to the lower basin of the Segura River (Territory B). The annual rainfall is higher than that of the district of Vega Baja, with its observatories recording levels of over 450 mm.

Figure 3. The flood called "Pantaná de Tous" (Júcar River), October 1982. Source: Diario Las Provincias [50].

Figure 4. The flood called "Pantaná de Tous" (Júcar River), October 1982. Source: Diario Las Provincias [50].

With regard to the district of Vega Baja del Segura, this territory forms part of the climatic region of the southeast of the Iberian peninsula, which has one of the lowest rainfalls in Spain and Europe (see Figure 5). The common denominator of its observatories is the scarcity of rain, with hard and long droughts, notwithstanding sporadic deluges of highly and even exceptional hourly intensity [51]. An example of this was the episode of the 12th and 13th of September 2019 with the cold front or cut-off low (DANA), which generated high intensities and volumes of rainfall, characteristic of the torrential rains of the Mediterranean, which exceeded the average rainfall values. For example, in the observatory of Orihuela, 500 mm were recorded for the whole of the episode (12–13th September) with intensities of up to 200 mm per hour (12th of September). The annual period of least rainfall is in the summer season, which is long, beginning in the spring and ending in the autumn (5–6 months), and intense. The average annual rainfall is below 300 mm (Orihuela, 317 mm; Guardamar del Segura, 287 mm; Torrevieja, 271 mm).

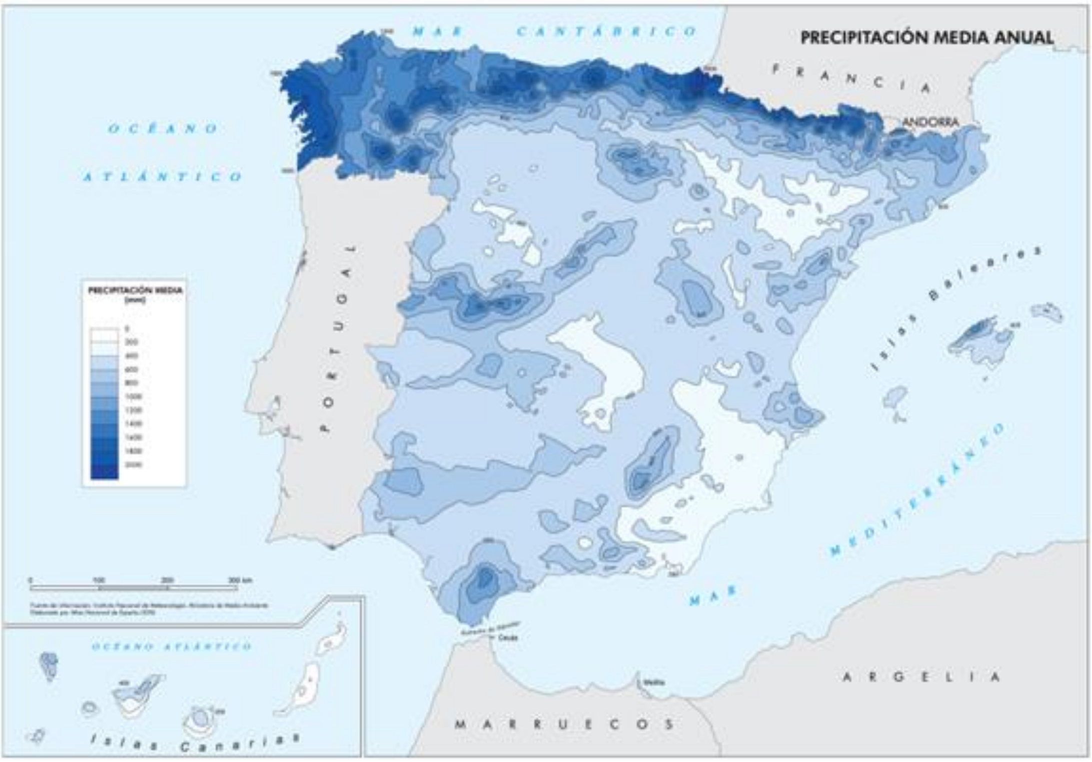

Figure 5. Annual average rainfall in Spain (1980–2010). Source: The National Geographic Institute [52].

With reference to the human factor, these two territories have a high natural risk, with a historical anthropogenic occupation, but profoundly altered from the second half of the twentieth century with the implementation of land uses in areas where extreme natural behaviour exists. In this geographical space, the following factors converge: (1) traditional agriculture based around the course of the Segura and Júcar rivers, implemented since the Muslim era; (2) modern, technical agriculture, which has expanded since the 1970s, thanks to the arrival of the waters from the Tajo-Segura Aqueduct (ATS) for the case of the Vega Baja district; and (3) extensive tourism activity on the coastal strip, which has taken the form of a residential model, distorting the traditional urban structure of the population nuclei of the district.

With respect to the educational proposal (see Table 5), the objective of the first and second sessions is for the students to diagnose the risk areas of the mouth of the Júcar River by consulting the NFZMS (Session n.1) (Figure 6) and the PATRICOVA (Session n.2) viewers (Figure 7). In this territory, there is a double analysis: (1) the general scale of the mouth of the Júcar River; and (2) the local scale (the city of Cullera) (Figure 8).

Table 5. Educational proposal for teaching flood risk.

Session n.1 Analysis of the territory of the mouth of the Júcar river (NFZMS viewer)
Exercise n.1. Using the NFZMS GIS viewer, which municipalities are affected by flood risk? Record all of the municipalities in the area of study affected, considering the different risk levels assigned by the NFZMS. Exercise n.2. Use the NFZMS SIG viewer. Load the land use layers and the highest risk layers (levels 1—High- and 2—Medium-). What do these risk layers coincide with? Are there urban areas within these risk layers? Exercise n.3. Find the city of Cullera and analyse the current situation in relation with the risk of flooding. Take note of the most exposed areas to this phenomenon. Source: NFZMS viewer: https://sig.mapama.gob.es/snczi/index.html?herramienta=DPHZI, (accessed on 24 October 2022).
Session n.2 Analysis of the territory of the mouth of the Júcar river (PATRICOVA viewer)
Exercise n.1. Using the PATRICOVA GIS viewer, which municipalities are affected by flood risk? Record all of the municipalities in the area of study affected, considering the different risk levels assigned by the PATRICOVA. Exercise n.2. Use the PATRICOVA SIG viewer. Load the land use layers and the highest risk layers ("Very High" and "High"). What do these risk layers coincide with? Are there urban areas within these risk layers? Exercise n.3. Find the city of Cullera and analyse the current situation in relation with the risk of flooding. Take note of the most exposed areas to this phenomenon. Source: PATRICOVA viewer: https://visor.gva.es/visor/, (accessed on 24 October 2022).
Session n.3 Analysis of the Vega Baja district (Segura River) (NFZMS viewer)
Exercise n.1. Using the NFZMS GIS viewer, which municipalities are affected by flood risk? Record all of the municipalities in the area of study affected, considering the different risk levels assigned by the NFZMS. Exercise n.2. Use the NFZMS SIG viewer. Load the land use layers and the highest risk layers (levels 1—High- and 2—Medium-). What do these risk layers coincide with? Are there urban areas within these risk layers? Exercise n.3. Find the city of Orihuela and analyse the current situation in relation to the risk of flooding. Take note of the most exposed areas to this phenomenon. Sources: NFZMS viewer: https://sig.mapama.gob.es/snczi/index.html?herramienta=DPHZI, (accessed on 24 October 2022).
Session n.4. Analysis of the Vega Baja district (Segura River) (PATRICOVA viewer)
Exercise n.1. Using the PATRICOVA GIS viewer, which municipalities are affected by flood risk? Record all of the municipalities in the area of study affected, considering the different risk levels assigned by the PATRICOVA. Exercise n.2. Use the PATRICOVA SIG viewer. Load the land use layers and the highest risk layers ("Very High and "High"). What do these risk layers coincide with? Are there urban areas within these risk layers? Exercise n.3. Find the city of Orihuela and analyse the current situation regarding the risk of flooding. Take note of the most exposed areas to this phenomenon. Source: PATRICOVA viewer: https://visor.gva.es/visor/, (accessed on 24 October 2022).
Session n.5. Comparison of risk mapping at the local scale
Exercise n.1. Based on the previous exercises (Sessions n.1 and n.2 from the Júcar River; and Sessions n.3 and n.4. for the Segura River) compare the flood hazard risk layers of the NFZMS and PATRICOVA viewers. Can you find any differences at the local scale? What implications can it has for territorial planning and emergency planning for the population in case of a flood?

Source: own elaboration.

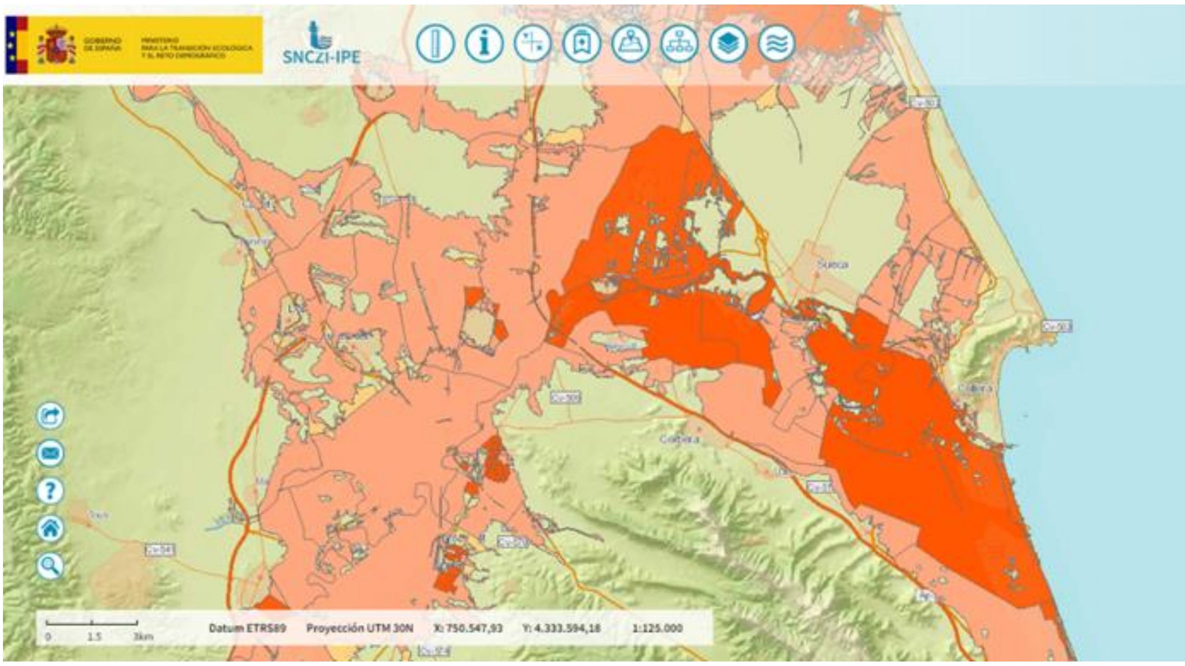

Figure 6. Image capture of the risk layers of the NFZMS viewer (mouth of the Júcar river). Source: Ministry for the Ecological Transition and Demographic Challenge [48]. Own elaboration.

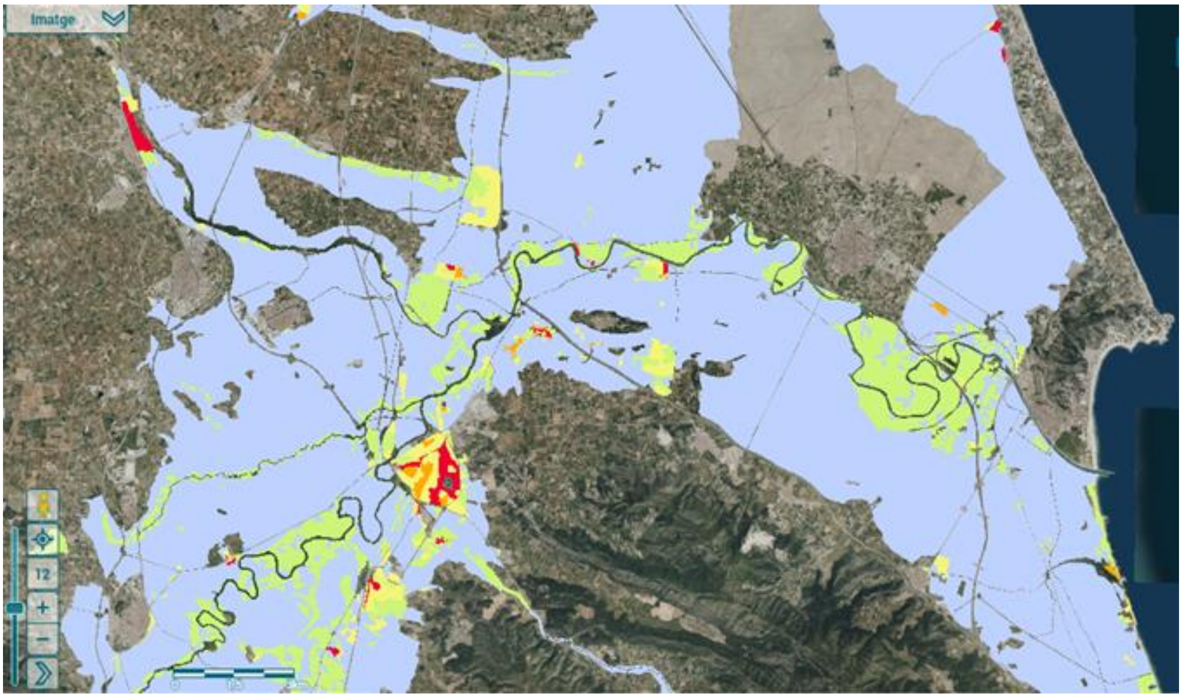

Figure 7. Image capture of the risk layers of the PATRICOVA viewer (mouth of the Júcar river). Source: Valencian Cartographic Institute [53]. Note: Levels of risk: red ("Very high"), orange ("High"), yellow ("Medium"), green ("Low"), blue ("Very low"). The red area coincides with the principal population nuclei. Own elaboration.

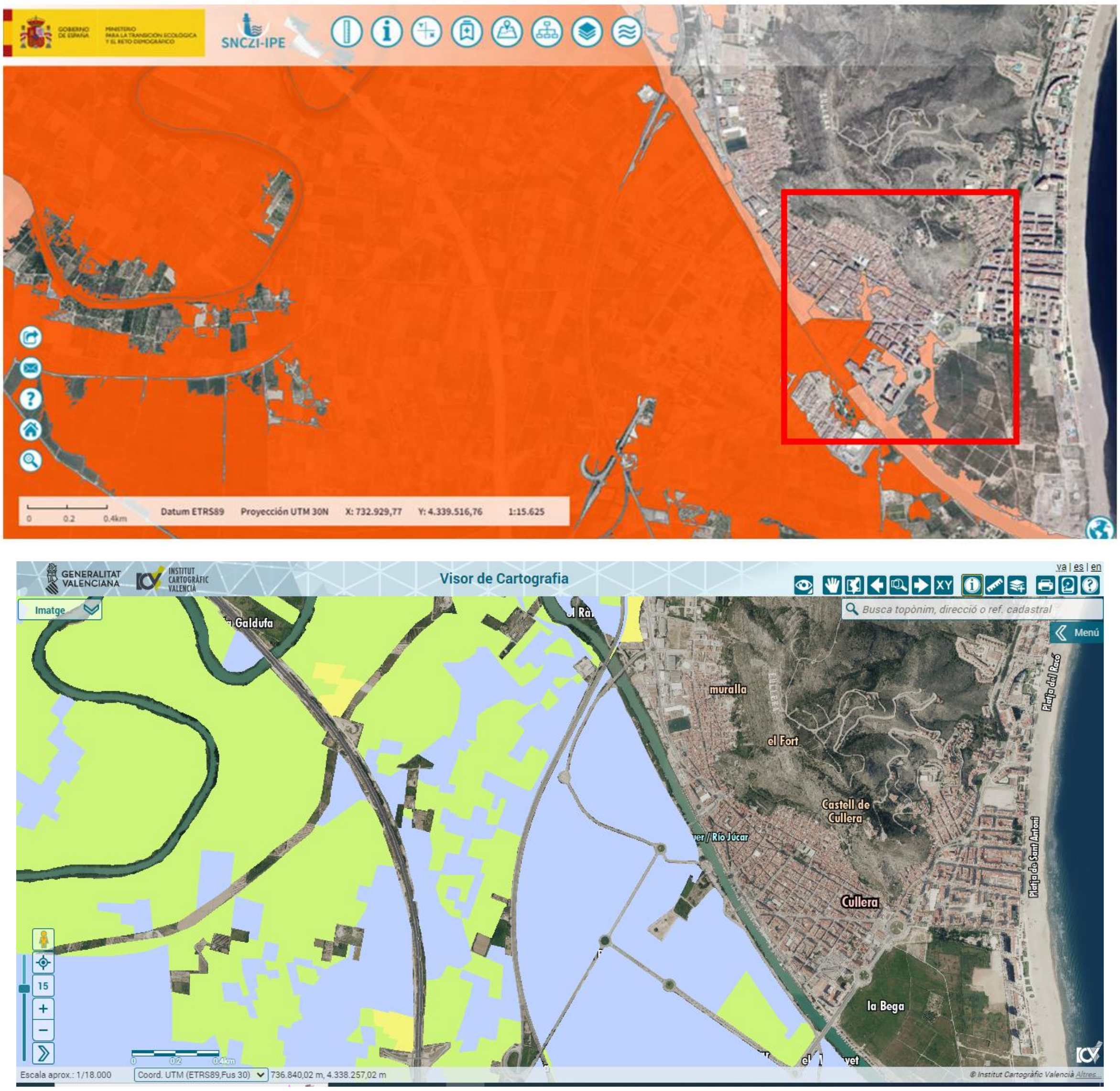

Figure 8. Local-scale. Image capture of the risk layers of the NFZMS (flood risk; return period 500 years) and the PATRICOVA viewer (city of Cullera; Júcar River). Note: the red box corresponds to where the main differences are located at the local scale. Source: Ministry for the Ecological Transition and Demographic Challenge [48]; Valencian Cartographic Institute [53]. Own elaboration.

Sessions n.3 and n.4 are dedicated to the district of Vega Baja (Segura River). In these proposed activities, the students learn to recognise the municipalities that are affected by flood risk. In this territory, there is a double analysis: (1) the general scale of the Vega Baja region; and (2) the local scale, where the city of Orihuela will be taken into account (Figure 9).

The students fill out a table (provided by the teacher) and record all the municipalities affected in these two territories, and indicate the types of the risk level that affect them according to the two viewers (see Table 6). Therefore, the objective is for the students to determine the state of exposure of these two regions in relation to the urban uses implemented.

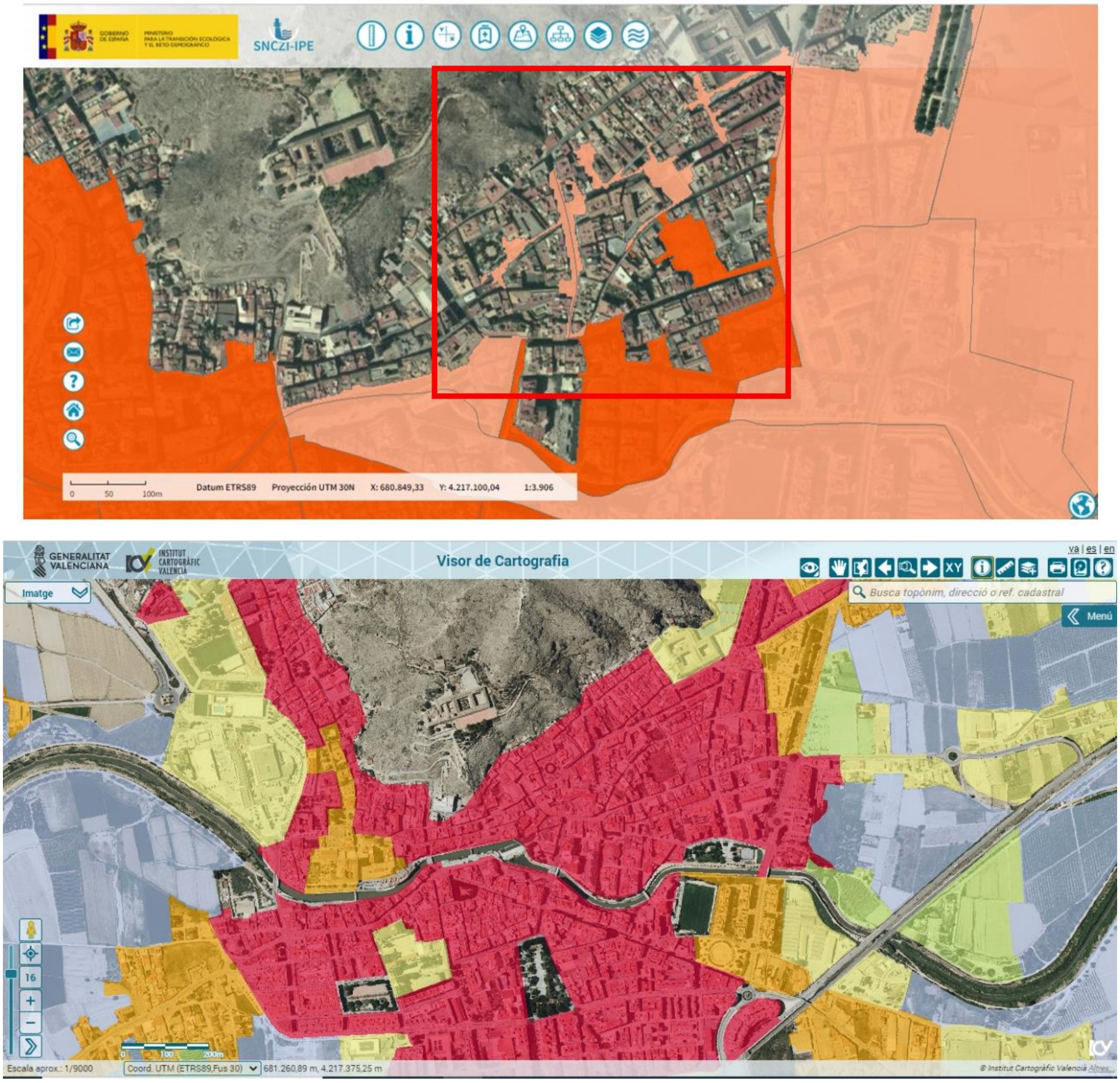

Figure 9. Local-scale. Image capture of the risk layers of the NFZMS (flood risk; return period 500 years) and the PATRICOVA viewer (city of Orihuela; Segura River). Note: the red box corresponds to where the main differences are located at the local scale Source: Ministry for the Ecological Transition and Demographic Challenge [48]; Valencian Cartographic Institute [53]. Own elaboration.

Table 6. The table shows the municipal information related to flood risk.

Municipality	Risk level (NFZMS)	Risk Level (PATRICOVA)	Are There Differences between the NFZMS and PATRICOVA Cartographies?
Municipality X			
Municipality X			
Municipality X etc.			

Source: own elaboration.

Finally, to conclude this proposal, a class debate is held on the differences existing between these two viewers in order to: (1) determine which viewer offers the most detailed cartography; and (2) ensure that the students know that the consideration of risk, at least in terms of risk cartography, depends on the organisation that has elaborated it. The idea of these activities, and especially Session n.5, is to verify that, in general, the NFZMS cartography has greater precision when it comes to mapping flood zones. For example, in Figure 8 (Cullera), it can see that there are flood zones in the urban nuclei by the NFZMS but not in the PATRICOVA viewer.

Therefore, the students can verify that, depending on which viewer they are working with, there will be some areas more exposed to floods than others. This is the case in the city of Orihuela (Figure 9), where the urban nuclei are exposed to floods. The Cullera analysis has more detail in the National Flood Zone Mapping System (NFZMS) because the hydraulic model it uses has more precision. It should be taken into account that in terms of the hierarchy of use of these cartographies for urban purposes, the NFZMS predominates over the PATRICOVA. In this regard, Cullera was declared an area of Significant Potential Risk; hence, it has more detailed cartography in the NFZMS. On the other hand, Orihuela has more detail in PATRICOVA because the new version (2015) incorporates a layer of "geomorphological hazard" that the NFZMS does not have. That is why hillside areas are represented as risk zones on the risk map.

4. Discussion

The objective of this study is to underline the importance of teaching climate risks and, more specifically, flood risks, which, as explained by Pérez-Morales et al. [2], constitute the principal risk affecting the Mediterranean area. Furthermore, the educational field plays a considerably important role, as generating a more educated society aware of these hazards would help to reduce social vulnerability and increase territorial resistance [54]. We should not forget that the proposal presented in this study is aimed at the school population.

The activities are proposed to improve the understanding of flood risk within the context of the subject “The Geography of Spain” in the 2nd year of the Baccalaureate (17–18 years). We achieve this by choosing two areas of study based on the consultation of several GIS viewers (free software) of the Spanish administration. Furthermore, it seeks to familiarise students with these types of tools (development of digital competence) and help them to learn and interpret their most immediate territory, as established in the new curriculum. Furthermore, this proposal can be adapted to the international level and has already been implemented in the educational field in different European countries (France, United States, the Netherlands, Ireland, etc.), and follows the guidelines established by Directive 60/2007 [55], or in the United States [56] and Japan [57] (see Table 7).

Table 7. Links of the different web viewers on an international level.

USA https://www.fema.gov/es/flood-maps (accessed on 9 October 2022).
Japan https://www.jma.go.jp/bosai/en_risk/#zoom:5/lat:35.173808/lon:139.020996/colordepth:normal/elements:land (accessed on 9 October 2022). https://www.jbarisk.com/news-blogs/japan-flood-map-update-2022/ (accessed on 9 October 2022).
France https://www.georisques.gouv.fr/cartes-interactives#/ (accessed on 9 October 2022).
Ireland https://www.floodinfo.ie/map/floodmaps/ (accessed on 9 October 2022).
The Netherlands https://www.atlasleefomgeving.nl/kaarten?prv=zuid-holland (accessed on 9 October 2022).
United Kingdom https://www.gov.uk/check-long-term-flood-risk (accessed on 9 October 2022).

Source: own elaboration.

The NFZMS and PATRICOVA viewers are efficient and simple tools for classroom use, and this proposal can even be adapted to other lower educational levels (Primary and Secondary Education). With respect to the contents proposed here, we should not forget that this is a recurrent topic in the university entrance exam. For example, in the exam for the Region of Valencia (July 2019), one of the exercises was to "explain the principal natural risks related to the rivers that affect Spain" [58].

The activities proposed in this study should also serve to broaden the training of the teachers of the subject of Geography in the 2nd year of the Baccalaureate. In this respect, it has recently been found that in the majority of the classes, a technical methodology is used based on master classes and reproduction and memorisation activities [59]. This learning method is not particularly motivating and is not based on problem-solving [60]. It reflects the classic image of school Geography, as explained by Murphy [61]:

"Many people consider Geography as the simple memorisation of places and the location of facts. In other words, merely knowing where certain places are and some of their distinctive characteristics. The knowledge of these things does not completely lack value, as it provides us with a basic understanding of the earth's surface and how we are placed with respect to other places and people. However, if all the arguments in favour of Geography were reduced to the knowledge of selected geographical facts, it would, in fact, be a weak defence, particularly in an era when thirty seconds on the internet is enough to find the answer to the majority of the questions relating to the location of facts and places" (p.24).

However, as this author argues, "Geography is an academic discipline and subject of study that explores—and promotes critical thinking about—how the world is organised, the environments and patterns that exist on the ground or that humans create in their minds, the interconnections that exist between the physical and human environment, and the nature of places and regions". In this respect, Murphy [61] (p. 20) expresses that "Geography offers an important critical view into natural diversity and the nature of the planet that houses humankind".

Educational proposals on the topic of flood risk have been particularly prominent in the Latin-American context, for example, in Brazil with the research of Valdanha and Jacobi [33]. These authors present a case study carried out in the river community of São Carlos do Jamari (Brazilian Amazon) in order to interpret what the members of the community did during the flood of 2014 and analyse the changes brought about by the social learning processes. The data reveal that there is a prevalence of critical understanding of risk, as it is related to the implementation of the hydroelectric plants in the area. Furthermore, three spheres of change in the community were identified based on the learning processes: (1) the community-community relationships, (2) the community-territory relationships, and (3) the community-state relationships. In the case of Argentina, Lozina and Pagliaricci [32] analyse how environmental problems have increased significantly in urban spaces together with the scarcity of solutions. The authors of this study have shown society the importance of the impact of floods and the need to raise awareness and educate the population.

In other international contexts, for example, in Taiwan, we can refer to the study by Tsai et al. [62] on a proposal for gamification for teaching about floods. These authors highlight that teaching about these phenomena (causes, consequences, forms of addressing them, etc.), is one of the best ways to raise awareness and prepare a society more resilient to the effects of climate change. However, the traditional approaches, as explained by these authors, do not motivate school students, hence the need to search for new strategies and resources, such as teaching based on gamification.

One resource that increases the motivation of the students to learn is field trips. We can refer to different proposals and educational experiences based on field trips to teach the risk of flooding in the Mediterranean area. For example, Morote [63] presents the La Marjal Floodable Park and its surroundings (city of Alicante, Spain) as a high-risk territory for teaching these phenomena (causes and consequences) from a historical perspective and explaining how human beings have increased the risk. This proposal also explains the solutions that have been implemented in the territory (adaptation measures). Furthermore, Morote and Pérez-Morales [42] propose and describe the experience of a field trip in a territory that, a priori, historically has not been considered a high-risk zone. However, the human action of the last few decades (urbanisation of former agricultural areas, the abandonment of traditional rural practices, etc.), has brought about the creation of a territory exposed to floods. This, as the authors explain, is because society has shifted from considering floods as a resource to a risk. These are reflections that have been expressed for decades by authors who are experts in natural risks as they consider that society has become a society at risk [64–66].

The exercises proposed in this study are based on problem-solving and the practice of critical Geography, breaking away from the stereotypical teachers [15] and the lack of scientific rigour which sometimes characterise the principal resources used in the classrooms (textbooks) [14]. With respect to these resources, even though their use has diminished in the last decade, they continue to play a decisive role in school education, despite the introduction of new digital media [67]. In Spain, with the COVID-19 pandemic, online classes and blended learning have not led to a decrease in the use of textbooks [68].

The scarce information in the textbooks about flood risk may cause teachers to omit this topic in the classroom or not teach it thoroughly. This is defended in the study by Morote and Souto [40] for the case of the social representation of floods by future Primary Education teachers. These authors have shown how only 12.1% of the participants received training on the risk of flooding during their school education. Other researchers have also reached these conclusions [69], finding that the majority of teachers do not feel sufficiently prepared to address this topic due to the low level of training received. Therefore, this proposal constitutes an example of teaching flood risk using ICT. Furthermore, it can be extended to other international contexts with the ultimate objective of improving territorial resilience to present and future scenarios of climate change.

5. Conclusions

This study presents different educational proposals based on digital competence and the interpretation of the territory with respect to water risks (floods) associated with climate change. Furthermore, it is worth highlighting the need to introduce these ICT tools to enhance the understanding of these phenomena in their social and territorial aspects (vulnerability and exposure). The ultimate objective is for students to know and interpret their most immediate territory with respect to flood risk. We must address climate change and the actions of human beings in order for students to understand the increase in risk in this region. This proposal shows that these types of tools are important for students to understand the social and territorial part of flooding events and exposure, which is the most salient in terms of finding solutions or minimising their effects.

The growing mobilisation of students in aspects related to the climate crisis seems to indicate a greater awareness among the population of this age group, which, undoubtedly, will be fundamental for achieving a society better adapted to the future scenarios of climate change. However, these mobilisations should be based on a sound knowledge of environmental and climate aspects, which should be learnt in the classroom. The development of materials on climate change and its atmospheric extremes contemplated in the new Education Law (LOMLOE; Law 3/2020 of 29th December) can constitute an ideal framework for learning about this topic at pre-university levels. As indicated by Morote and Olcina [13], we should not forget that the information on this subject matter is still scarce, and perhaps it is necessary to rethink the Social Sciences and Geography curriculum in order to dedicate more attention and scientific rigour to these contents in order to ensure more and better training of the teachers (current and future).

With respect to the limitations of the study, the implementation of these proposals in the classroom could be hindered by: (1) the lack of training of the teachers in the subject of Geography (it should be noted that in Spain, many of the teachers of this subject are trained in History); (2) the lack of training of the teachers in digital competence [70]; (3) the reticence of teachers to use this technology [71]; and (4) access to the internet in the classrooms and the availability of computers.

Finally, and as a proposal for the future, we would recommend: (1) an analysis of the learning results through the implementation of this proposal in class; (2) the proposal of similar activities on an international level; and (3) the promotion of these educational proposals, among both active and trainee Geography teachers (Master's Degree in Secondary and Baccalaureate Teaching). In short, this teaching material based on knowledge of the affected territories has the objective of promoting a risk culture and an awareness of the different hazard and vulnerability elements. Therefore, it is an important challenge, which should enable, through education in territorial and environmental values, the creation of societies that are more resilient to natural hazards, whose future effects are predicted to be more damaging within the framework of the current process of climate change.

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