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Using the Impact-WEB_GIS Platform to Assess the Impacts of Environmental Sustainability Public Policies in the Lisbon Metropolitan Area

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Abstract: Urban environmental sustainability is a growing concern within the United Nations and the European Union's ongoing policy agendas to fight climate change. This paper contributes to this debate by presenting the main impacts of the Operational Programme for Sustainability and Use of Resources (POSEUR 2014–2020) in the Lisbon Metropolitan Area (NUTS II). The analysis was completed using the Impact-WEB_GIS platform, specially developed for this study, supported by a territorial impact assessment methodology. In addition to the production of general impact scores, five analytic dimensions were further analysed, supported by state-of-the-art (i) low-emissions economy, (ii) adaptation to climate change, (iii) risk prevention and management, (iv) environmental protection and (v) resource efficiency. At a strategic level, the research created awareness of the need to adjust regional policy to the region's characteristics on environmental sustainability matters.

Keywords: sustainability; environmental impacts; public policies; Impact-WEB_GIS; POSEUR; Lisbon Metropolitan Area

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1. Introduction

The growing concern with sustainable development has resulted in a substantial investment by the European Union (EU) to fight climate change since the Brundtland report was released [1]. The EU Cohesion Policy is a tool that works toward fomenting environmental quality and improved sustainability [2,3]. The aim is to reach the goals proposed by the United Nations 2030 Agenda [4], which include 'grow affordable and clean energy', 'improve clean water and sanitation', and 'organise climate action' [4]. The EU is working towards adopting measures that follow this environmental protection policy rationale. One of the most critical moments in the EU movement towards sustainability was achieved within the EU Green Deal [5], which looks forward to accomplishing structural changes in clean technology evolution in the energetic efficiency of buildings or the public transport sector.

To achieve these goals, the Portugal 2020 (EU Cohesion Policy Framework for Portugal 2014–2020) supported an Operational Programme (POSEUR 2014–2020) to foster a transition to an economy with lower CO_2 emissions. This will promote initiatives that can contribute to mitigating the risks created by the climate, protecting the environment and promoting the efficient use of available resources [6]. This analysis focuses on the Lisbon Metropolitan Area (LMA) (NUTS II) since it is known to face several environmental challenges (pollution, rising sea levels, etc.), exacerbated by high levels of population densities

(above 1000 inhabitants per km^2). This Portuguese region has different geographic and morphologic features compared to the other four mainland NUTS II, since it mainly comprises densely populated urban settlements, including Lisbon—the country's capital [7]. Hence, adaptation to climate change in the LMA has significantly different dynamics compared to the rest of the country [8], since most citizens have full access to sanitation, an effective waste management cycle, and capable infrastructures for water treatment. Consequently, POSEUR adapted its investment to the region's needs, which makes the LMA an interesting case study for analysing the significant impacts of the EU Cohesion Policy.

This study aims to understand the most significant impacts of POSEUR 2014–2020 in the LMA in five main analytical dimensions: (i) low-emissions economy, (ii) adaptation to climate change, (iii) risk prevention and management, (iv) environmental protection, and (v) resource efficiency. These five dimensions are related to the state of the art and the goals defined by the POSEUR 2014–2020 action in mainland Portugal. From a methodological standpoint, it is supported by quantitative and qualitative data used in a territorial impact assessment (TIA) methodology (TARGET_TIA) [9] to produce impact scores in all analytical dimensions. This TIA methodology was designed to produce policy impact scores for selected territories and analytical dimensions, at several implementation stages (ex-ante, mid-term, and ex-post), in a sound yet simple manner. Until the creation of the Impact-WEB_GIS platform, a mainstream Geographical Information System software was used (ArcGIS 10) to visualise the obtained scores via the produced cartography. This follows from similar TIA methodologies which make use of a GIS software, like the Tequila and the QUICK-TIA [9].

The quantitative data (statistics and project databases) were obtained through online open data. The qualitative data were collected via interviews with stakeholders who worked directly with POSEUR during its period of activity, and literature reviews: quantitative and qualitative data were inputted into the Impact-WEB_GIS platform.

The novel contribution of the Impact-WEB_GIS platform via an analytical Graphical Information System, specially developed to depict the mentioned impact scores in all the analytical dimensions, can play a crucial role in future research about regional policy using GIS technology. Therefore, this study provides a valuable contribution to the existing literature with an interdisciplinary approach between sustainability and public policy studies, specifically, the implementation of EU cohesion policy in a specific European urban region.

2. Literature Review

Globalisation processes raise socioeconomic and environmental pressures in urban areas, which forces sustainability policies to adapt at all territorial levels, following a place-based approach [10,11]. It is also essential to understand the difference between developing and developed countries concerning the pursuit of sustainability practices since the socio-economic features of the different regions require a distinct approach [12]. Various studies in the urban sustainability field have chosen to analyse environmental sustainability in urban areas. Several examples focus on Lisbon [13–16]; nonetheless, the literature has a clear gap regarding establishing a causal relationship between EU funds and positive or negative environmental sustainability trends in the LMA. This article contributes to filling this gap and also can be used for other regions suffering from the same conditions.

As Sachs [17] emphasises, sustainable cities should be efficient on a productive, socio-political, and environmental level. The primary goal is their citizens' well-being [17]. The ecological burden of activities in Lisbon outweighs the urban capacity for an environmental regeneration process [15]. This poses environmental sustainability problems. Constant environmental harm influences citizens' quality of life. Moreover, the physical structure of cities is essential for their sustainability. For instance, an efficient public space can only be obtained by promoting partnerships between the national and local powers, and the stakeholders that gravitate around them (private entities, communities, and civil society) [18]. Here, some stakeholders, such as corporations, are significant consumers of the

city's resources, which is why the citizens and other stakeholders need to hold corporations accountable for the sustainability of the urban environment [19]. This accountability is vital when the consumption footprint can accurately measure an urban centre's sustainability level [20].

On another level, population growth negatively impacts the urban ecosystem, not only in the water sector but also in waste, energy, and public transport [21]. Hence, the topic of the circular economy is one of the most recent trends in the literature related to sustainability and is presented as a long-term solution to the waste management issues that have the potential to impact citizens' well-being [22,23]. The waste management cycle can also influence levels of soil contamination, which are reaching unprecedented levels in cities worldwide due to the greenhouse emissions caused by heavy traffic and construction sites [24]. Likewise, access to fresh drinking water is also one of the most decisive factors related to sustainable urban development and public health [25].

In a nutshell, urban sustainability includes the principles of policy integration, ecosystem thinking cooperation, and partnership [26]. Besides that, it is fundamental to have different stakeholders to find new solutions to urban issues such as energy, natural resources, and waste production [26]. The most recent debate on urban sustainability policy is focused on the importance of innovation in building intelligent cities [27,28]. The use of technology as a tool to fight environmental deterioration is fundamental if the policy guidelines aim to keep the mitigation of climate change as its top priority [29]. The sustainable development of cities should not include only environmental development concerns. Implementing new policies should consider the "equity to the provision of basic services, housing, employment, social infrastructure and transportation" [30] (p. 34). Hence, to reduce carbon footprints, the literature mentions the benefits of using renewable energy sources [31,32] as it "allows an optimal supply of the electricity network while emitting little or no pollution" [33] (p. 5). This adherence to energy from new sources can only be guaranteed by creating new "customer-centric services and innovation" [31] (p. 38) in urban environments.

Recently, the EU has been keen to launch agreements to further the sustainability agenda in European cities. The new circular economy action plan [34] builds on the results obtained in the previous action plan that ensures that the value of products is kept in the economy with long-term solutions [35]. A climate-neutral economy is also one of the EU goals for the following decades, with its most significant initiatives being 'Towards a climate-neutral economy' and 'Sustainable industry low carbon initiative' [35]. These two documents are part of a larger strategy (EU Green Deal) to implement carbon neutrality in Europe until 2050 [5]. The EU Green Deal incorporated concern for energy labelling that will work as a tool for improving the energy efficiency of products.

This labelling excludes products that do not achieve the required level of energy efficiency from the market. The strategy for a sustainable built environment is fundamental for the urban management dimension; it defines four areas in which the EU must improve to prevent environmental degradation: (I) circularity, (II) the climate, energy and resource efficiency, (III) management of construction and demolition waste, and (IV) accessibility, digitalisation, and skills. The EU Cohesion Policy is one of the main tools (with a significant investment) that contributes to implementing programmes that guarantee the pursuit of the goals mentioned above.

As Park and Eissel pointed out, "the energy policy of the EU aims to promote energy efficiency and renewable energy" [36] (p. 323). These EU priorities explain why it is fundamental to understand the impact of POSEUR 2014–2020 in these fields. Did the changes implemented by the projects under POSEUR induce a systemic change and turn LMA into a smarter urban area with more efficiency regarding its resources?

3. Methodology

3.1. Obtaining Territorial Impact Scores via TARGET_TIA

The TARGET_TIA model obtains its scores using a mix of quantitative and qualitative data. The qualitative data for this research were obtained via interviews with five stakeholders who implemented POSEUR projects in the Lisbon Metropolitan Area. In addition, the authors conducted a literature review on five selected analytical dimensions—the low emissions economy, climate change adaptation, risk prevention and management, environment protection, and resource efficiency. These dimensions were collected to analyse the methodology's regional sensibility element (the region's needs in the investment).

The (five) interviews with involved stakeholders are vital to understanding the effects of the investment made by the EU cohesion policy in the LMA since they provide detailed information on the implementation of POSEUR. The interviewed stakeholders work in different areas concerning the ecology of the LMA, including public water systems services, regional development associations, municipal governments, and green energy enterprises. The selection of heterogeneous entities to be interviewed was deliberated to depict this research's different analytical dimensions, allowing a more complex and complete portrayal of the LMA sustainability reality.

The quantitative data were collected in national and regional statistics related to the five analytical dimensions for two periods, before 2014 and after 2020, to verify territorial development trends and potential causality. The first period captures the region levels before the implementation of POSEUR; on the other hand, the period after 2020 considers the levels of the analytical dimensions after the effects of the POSEUR projects. Moreover, the POSEUR project database was again divided into five analytical dimensions to analyse the methodology's policy intensity (the weight of the investment—Table 1) element. Ultimately, the methods used produce a general impact score and specific (for each analytical dimension) impact scores (from −4 'very significant negative impacts' to +4 'very significant positive impacts'), translating the impact of POSEUR in the LMA.

Table 1. POSEUR (2014–2020) investment per analytical dimension in the LMA.

Analytical Dimension	**€ (×1000)**
Low-Emissions Economy	39,570
Climate Change Adaptation	1560
Risk Prevention and Management	37,670
Environment Protection	64,238
Resource Efficiency	270,433
Total	413,472

Source: own elaboration based on the Portugal 2020 database.

3.2. Impact-WEB_GIS, an Analytical Web-Based GIS Platform for the Interactive Visualisation of Impact Scores at All Territorial Levels

To support the analysis of impact scores computed via the application of the mentioned territorial impact assessment (TIA) methodology (TARGET_TIA), an Analytic Geographic Information System (GIS) system was developed featuring a web user interface with a responsive design so that users can access the system using a computer or a smartphone. Our design followed Kimball's reference model [37] for the development life cycle and computing architecture of this type of system, with the integration of a Data Warehouse in the backend and a front end with an interface to a web-based geographic information system (Table 2).

Table 2. High-priority user requirements of the Impact-WEB_GIS platform, regarding policy interventions.

Requirement Id	Description
VIS1	The system needs to support georeferenced interactive visualisation of TARGET_TIA impact scores, related to arbitrary analytical dimensions of a given policy intervention, in ex-ante, mid-term or ex-post phase, in standard European territorial units, namely NUTS 0 to III (in all versions since 2013)
VIS2	The system needs to support georeferenced interactive visualisation of TARGET_TIA impact scores, related to arbitrary analytical dimensions of a given policy intervention, in ex-ante, mid-term or ex-post phase, in standard Portuguese territorial units: District, Municipality and Parish (in all versions since 2013)
TIA1	The system needs to create/manage/delete impact analysis policy interventions under the framework of the TARGET_TIA methodology. That includes arbitrary, user-defined analytical dimensions and the estimated impact vectors of this methodology, as depicted in Figure 1
TIA2	The system needs to upload pre-computed TARGET_TIA impact scores data in .CSV file format, per each analytical dimension, territorial unit and phase of the analysis (ex-ant, mid-term or ex-pos), of a given policy intervention
RESP1	The system needs to adopt a responsive design so that users can access the system using a computer or a smartphone.
USERS1	The system needs to support the following users' profiles: 1. Public with access to selected policy interventions in an interactive visualisation-only mode 2. User with access to all policy interventions in interactive visualisation-only mode 3. Data scientist that can create/manage/modify policy interventions following the TARGET_TIA methodology, in addition to interactive visualisation-only mode to such interventions 4. Administrator that has full access to the platform, including the privilege to delete policy interventions

Source: Own elaboration.

Figure 2 presents the logical architecture of the technological solution of the Impact-WEB_SIG Platform. Crucially, this Platform serves as a facilitator to present the results (impact scores) produced by the Target_TIA methodology. The system, available at https://websig.iscte-iul.pt/, comprises a backend module (see 2 to 10 in Figure 2) deployed in the ISCTE Data Center, that currently retrieves geometry data (shapefiles) from EUROSTAT and Instituto Nacional de Estatística (INE) sources and TARGET_TIA impact scores data in .CSV file format. It performs a full ETL (Extract, Transform, and Load) process on the data, and creates a data integration layer via developing a Data Warehouse based on a relational database (PostGresSQL Server 13). Mapping data are managed via the integration of the OpenStreetMap open-source system. The system was developed using the following open-source technologies and programmed with Javascript and Python:

- Postgresql 13 Database Engine, for the Data Warehouse system;
- Apache 2 Webserver, for provision of the web service;
- Several Python 3 programming language libraries: Cherrypy WSGI application, PsycoPG database library, Jinja2 templating library;
- Leafletjs map library.

The novelty of this platform and its contribution to this paper are based on the user-friendly features of the technology. Any researcher can access this innovative tool for policy assessment, and, by inputting the collected data into the platform, users can obtain a graphic display of its evaluation of policy at regional, national, or international levels. Users (regular End User, including the public, Data Scientist, or Administrator) can access the platform via a web frontend (see 1, 10, 12 in Figure 2). Figure 3 depicts a view of the graphical user interface of the current version of the Impact-WEB_GIS platform, showing the ex-post POSEUR 2014–2020 policy intervention impact scores described in this paper regarding the NUTS II territorial units in Portugal (2021 NUTS II version).

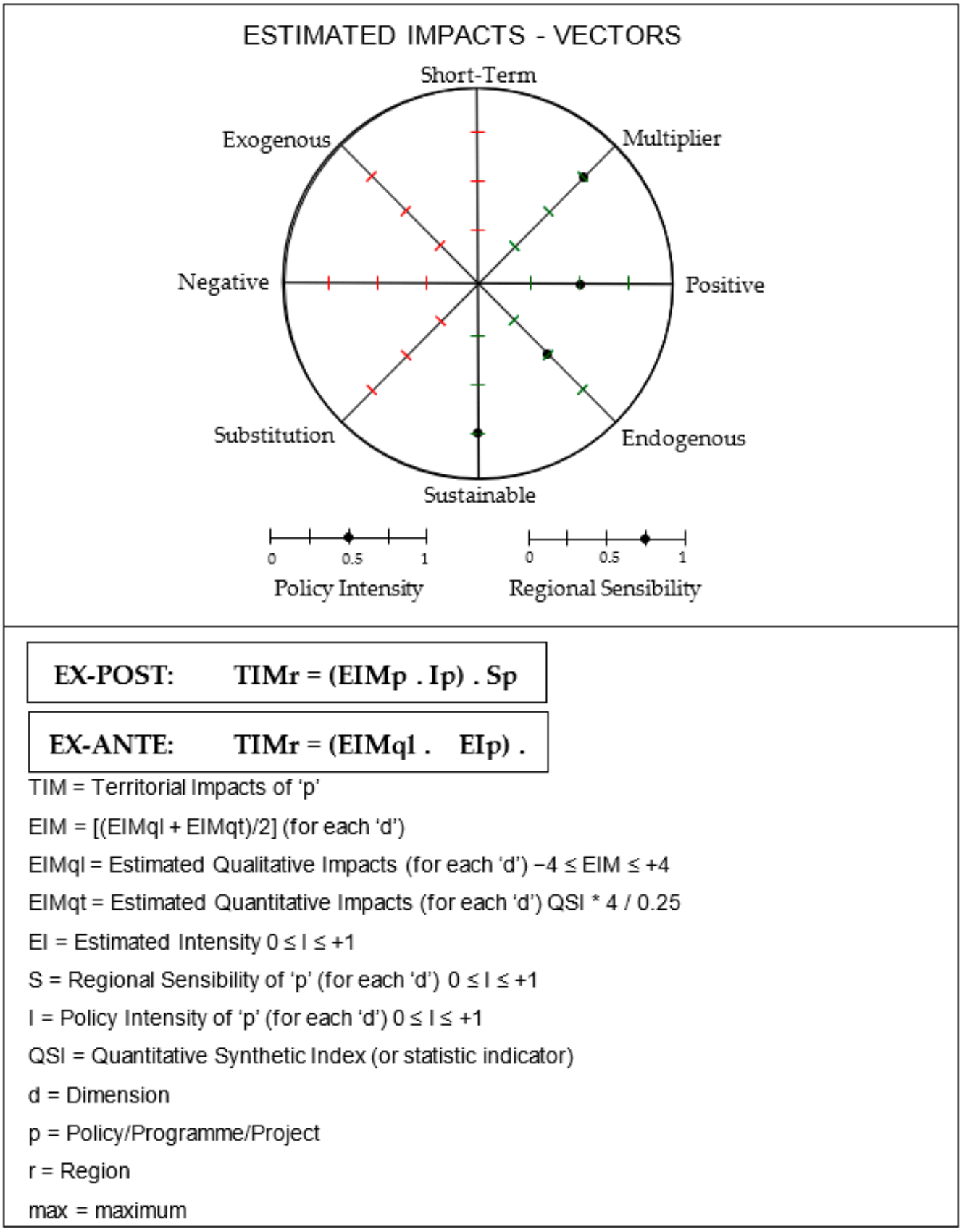

Figure 1. The Target_TIA methodology. Source: [9].

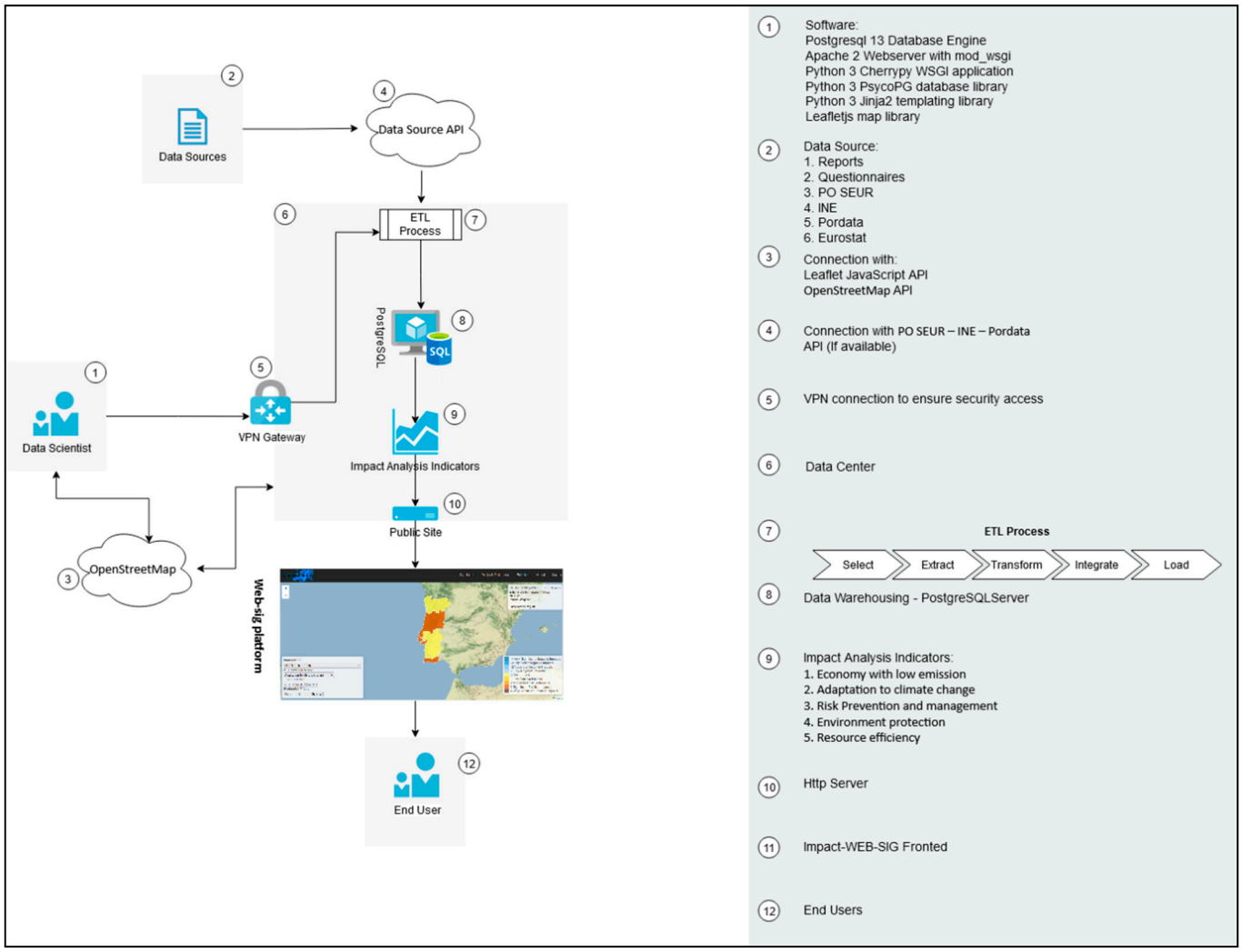

Figure 2. The logical architecture of the Impact-WEB_GIS Platform. Source: own elaboration.

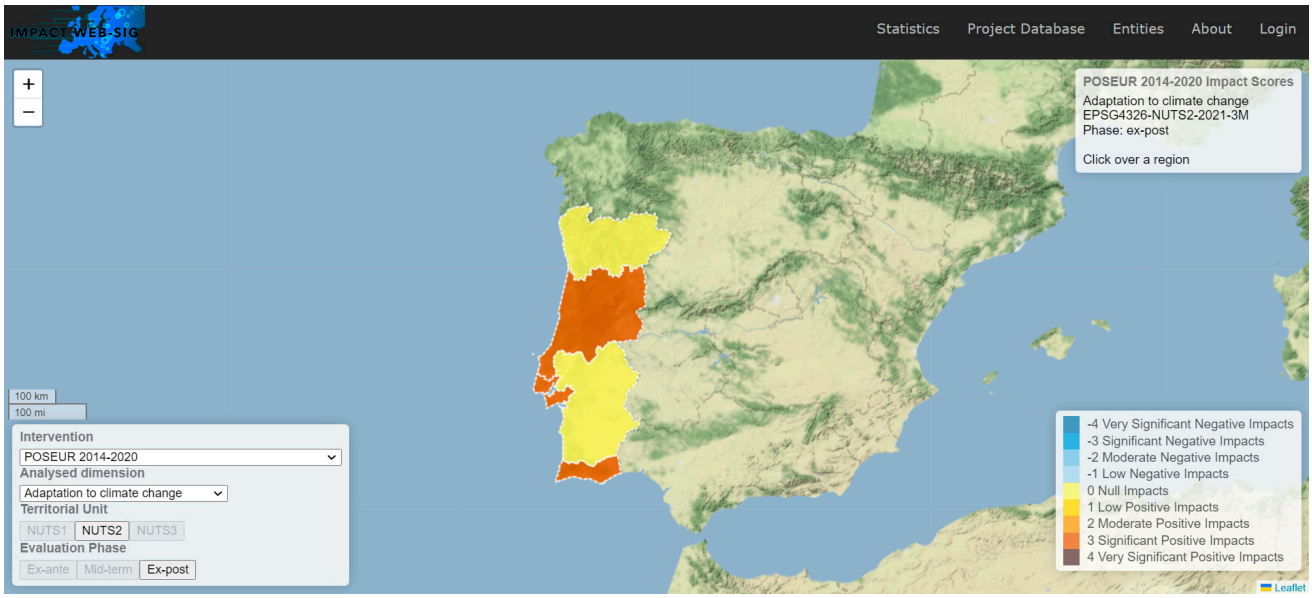

Figure 3. Impact-WEB_GIS Platform graphical user interface. Source: own elaboration.

4. Results

The principal impact scores of the POSEUR are presented in Table 3 and can be interactively visualised in the Impact-WEB_GIS Platform. In the platform, researchers can select the typology of intervention (bottom left corner—Figure 3) and the dimension they want to consider. Following that, together with the definition of the territorial unit in analysis and the type of evaluation, the results will be presented in the form of graphical info based on a colour scheme. The positive impacts have a yellow or brown colour (depending on the grade of the results); simultaneously, negative impacts are represented by a blue colour graded based on the obtained results.

Table 3. POSEUR Evaluation Impact Matrix—Lisbon Metropolitan Area.

Dimensions	Impact Scores (−4/+4)/Contrafactual					Tuning Elements (0–1)		Causality—Territory Features (0–1)		Impact (Score)
	Pos/Neg	End/Exo	Sus/Cur	Mul/Sub	Mean	Int/Pol	Sen/Reg	2014	2020	(−4/+4)
Low-Emissions Economy	4	4	4	4	4	0.25	0.75	0.5	0.75	0.750
Climate Change Adaptation	4	4	4	4	4	0.5	1	0.25	0.75	3.000
Risk Prevention and Management	3	3	3	3	3	0.5	0.75	0.25	0.25	0.563
Environment Protection	3	3	3	3	3	0.75	0.75	0.25	0.5	2.081
Resource Efficiency	3	3	3	3	3	0.25	0.75	0.25	0.5	0.656
Mean	4	4	4	4	4	0.25	0.75	0.5	0.75	1.332

Note: Pos/Neg: Positive vs. Negative; End/Exo: Endogenous vs. Exogenous; Sus/Sho: Sustainable vs. Short-Term; Mul/Sub: Multiplier vs. Substitution; Pol/Int: Policy Intensity; Reg/Sen: Regional Sensibility. Source: [6].

In general, these impacts are positive. However, they are between low and moderate, with one dimension (Adaptation to Climate Change) with significant results in LMA. This signifies that, in general terms, POSEUR was not as effective and efficient for fostering environmental sustainability processes in the LMA. However, a positive note is provided by the significant positive impacts found in the climate change adaptation dimension, due to several impactful investments made to protect the seacoast against coastal erosion and rising sea levels. Conversely, the analytical dimensions of the low-emissions economy, risk prevention, and management and resource efficiency did not see more than low positive impacts from implementing POSEUR in the LMA. Below is a summary of the main contributions of the POSEUR for each of the analysed dimensions.

4.1. Low-Emissions Economy

The path the EU has been following concerning a low-emissions economy, with initiatives to decarbonise sectors of activity such as the European Climate Law [38], created a platform for the European capitals to build their economies in a less pollutant environment [39]. One of the entities interviewed explained that several efforts have been made to improve urban environmental sustainability processes in past years through local urban planning and recently due to the intervention of POSEUR. One of the most meaningful impacts in this field was the proliferation of bike lanes in the city centre and the implementation of new green spaces [40]. Some measures included energy-efficient buildings in services, schools, and universities to reduce carbon emissions [41].

The LMA has also benefited from the research and development executed in the various universities and research centres, with the Instituto Superior Técnico as a promoter of a low-emissions campus [42,43]. This investment also contributed to a change in the mobility paradigm of the city and the launching of the Navegante monthly card, which allows LMA inhabitants to use any public transportation at low prices in the region. This initiative stimulates a low-emissions economy as some citizens tend to leave their vehicles

at home and take public transport instead, thus reducing the traffic and CO_2 emissions in the city [44]. The EU agenda has effectively mitigated CO_2 production by companies in the region. This phenomenon is evident in the tight policy implemented in terms of plans for cement companies and more of the most pollutant businesses, following the Paris Agreement [45] and the European Green Deal [5] guidelines. However, the impact score of 0.750 obtained in this analytical dimension shows that there is still a long path to go to achieve the POSEUR targets for a low-emissions economy in Lisbon.

4.2. Adaptation to Climate Change

The solutions to improving climate adaptation in the LMA focused on tackling the floods in the Alcântara (Lisbon) area by building a station to raise the water level in Terreiro de Paço (downtown Lisbon). The Water Group of Tagus Valley pointed out that as a tool to fight climate change, water treatment stations can potentially solve urban phenomena such as microplastic contamination of wastewater [46]. Initiatives for water reuse are also priorities in the EU water policy framework. The LMA has been trying to create the conditions to reuse water in urban areas [47] in green spaces. The water cycle is complex to manage in the LMA due to the heterogeneity of the territory. The hilly morphology of the LMA makes it difficult to provide water and sanitation services to all of NUTS II [48,49].

One of the biggest challenges that POSEUR tried to tackle was to provide water to the most peripheral areas in municipalities such as Palmela or Setubal at a rate equivalent to the water provided in the centre of Lisbon. This dimension registered the highest positive impact score in the analysis. This phenomenon can be explained by the high prior sensitivity of the region in this domain and the target investments in sensitive areas such as coastal protection, which effectively impacted the south bank of the Tagus River by limiting the risks caused by the cliffs' erosion.

4.3. Risk Prevention and Management

The LMA presents several environmental risks requiring an investment higher than the remaining Portuguese NUTS II, as highlighted by the entities interviewed. Sand dredging, allowing ships to access the Sines port, endangers the Sado estuary and the animal species that inhabit the area [50]. Degradation of the estuary is an issue for the population because it leaves the peripheral regions more exposed to climatic phenomena such as floods or coastal erosion [50].

Cliff erosion in Costa da Caparica (Tagus River south bank) is one of the most urgent issues to be solved by the local government [51], as mentioned before. Therefore, a large chunk of the investment made by POSEUR in the dimension of risk prevention went to the coastal stability of littoral areas, one of the European priorities to increase the quality of beaches [52]. This also reflects the quality of the water in the river Tagus, which has been suffering the effects of pollution in recent decades [53,54], and few initiatives were made to tackle the issue during the period of activity of this operational programme. The low positive impact score in this dimension can be explained by the small extent of these initiatives to improve citizens' lives.

4.4. Environmental Protection

POSEUR contributed to providing changes to the water cycle in the main avenues of Lisbon, with positive impacts on creating new tourist spots [55]. Meanwhile, the environment and public health were preserved with several other projects [56,57]. Furthermore, a new waste collection system has been developed in the LMA, similar to the Spanish strategy [58]. Here, the Palmela municipality built a network for biodegradable waste that promotes a circular economy through ad hoc containers strategically placed in industrial areas. In all, the contacted entities recognise that it is essential to improve existing conditions for citizens to recycle and assemble infrastructural requirements to guarantee a rise in recycling levels at a municipal level [59,60]. Hence, regarding environmental protec-

tion, POSEUR was poorly effective in significantly improving this crucial sustainability dimension in the LMA.

4.5. Resource Efficiency

POSEUR was not used to finance the construction of large environmental infrastructures. Nonetheless, in the Palmela region, it was essential to guarantee the introduction of innovative smart equipment that stabilised water losses in the pipelines of the area. This project did not have a notable impact on the population because it did not include a drastic change in the water cycle dynamic. Its impact is not fully visible, since most of the work happened in the pipelines [61]. Nonetheless, mitigating water losses in the long term was fundamental. According to the interviewees, it was economically and environmentally helpful to the Palmela municipality. Also, under the POSEUR framework, the entities were allowed to apply for funding with projects already being executed.

This process explains why Lisbon municipality chose to invest in the water cycle system by financing new tools for water transportation. A critical example is POSEUR's contribution to solving some of the sanitation problems in the Sintra municipality by resuming the modernisation of sanitation pipelines and rehabilitating some water treatment stations. Concerning biowaste collection, POSEUR allowed full coverage of the Sintra municipality with recycling structures that leave no citizen without the option of selective waste collection. The impacts of POSEUR in this domain are relatively low, given the regional needs.

In the following section, this research further discusses the reasons behind the ineffective impacts of POSEUR, identifying bottlenecks and displaying the structural fragilities that a deficit in implementing future EU Cohesion Policy projects can bring to the LMA region.

5. Discussion

The interviewed entities showed their general concern with the region's financial dimension of POSEUR investment. One of the interviewees, responsible for the development of the Lisbon area, pointed out that the large enterprises and the significant population living in the LMA do not correspond to the portion of funding made available to the region. This stakeholder mentioned that, compared with other Portuguese NUTS II, several urgent environmental issues need increased attention from national authorities. Problems such as the Sado estuary flood risk, the Costa da Caparica's coastal erosion, and the river Tagus's water quality were not sufficiently addressed by the POSEUR, compared to environmental issues in other Portuguese regions. This interviewee emphasised that 49% of the public expenditure is aggregated in the Lisbon area, making the investment made by POSEUR and the regional operational programme insufficient compared to the percentage of the population concentrated in the area.

Nonetheless, the European Commission elaborated the bureaucratic and formal processes leading to the concretisation of the POSEUR, and the national/regional government entities and all the interviewees showed their satisfaction with the efficiency of communication in the POSEUR. The various stakeholders reaffirmed that the attention given to the municipalities' needs was significant, even if sometimes it was not enough to result in solid policy implementation of the programme. The readjustments that the operational programme had to go through due to the emergence of new risks and the outbreak of the COVID-19 pandemic played a role in the insufficient implementation of some initial targets. These unexpected events also obliged the beneficiary entities of POSEUR to change their priorities and the original framework of some projects. Hence, one of the stakeholders connected to municipality management pointed out that it would be necessary for future operational programmes to take a closer look into the practical features of the projects in the terrain. The stakeholder felt that some of the changes required by the beneficiary entities (especially in large enterprises) could only be understood when facing the difficulties encountered with public contracting, including rising resource prices and tight deadlines.

These technical issues, complemented by other problems that will be further discussed, prevented POSEUR from achieving more significant results.

In the low-emissions economy, funding was mainly dedicated to long-term solutions such as energy efficiency in public buildings, the development of renewable energy solutions, and a more interconnected urban mobility network. The implementation of environmentally friendly materials in buildings destined for public services was concluded with success. Despite this, given that the urban landscape of Lisbon is composed of primarily old buildings [62], the equipment changes were insufficient to adjust the region's energy spending levels adequately. Due to the urban characteristics of the LMA, the public transport sector tried to tackle its carbon footprint by investing in fewer pollutant buses and a more efficient railroad that could promote easier commutes. The acquisition of buses fuelled by cleaner energy solutions such as natural gas accounts for the most considerable portion of the project concerning this sector of activity. The *Navegante* monthly card can also be regarded as an indirect result of these mobility changes, which promotes commuting inside the city [63] and is part of several initiatives to reduce the use of private vehicles in the Lisbon area. As the impact scores point out, implementing these measures is expected to bring long-term benefits in the low-emissions economy.

In the domain of adaptation to climate change, most of the projects were related to urban management plans, such as the plan for adaptation to climate change in the metropolitan area, sensibilisation to the climate change risk, or the mapping of heat vulnerability. These projects do not require a significant investment as most of the work is carried out in evaluating the environmental risks of the region and reuniting the expertise to design solutions that can be applied in the long term. These plans and mapping of the regional hazards do not require further practical implementation in the terrain, which facilitates the accomplishment of targets defined by the public stakeholders involved in this dimension. On the other hand, the work carried out in waterfront areas in Lisbon and peripheral cities (Barreiro and Setúbal) was successful and visible to the whole population. Therefore, it contributed to citizens' well-being and the region's tourism value. The modifications executed with the help of POSEUR on the different Lisbon shores make those areas attractive, environmentally friendly public places [64].

In the risk prevention and management domain, one can highlight the positive impacts of acquiring vehicles for several small firefighter headquarters, the support given to flood risk prevention, and the stability of the slopes and cliffs. The investment in the abovementioned projects amounted to more than two-thirds of this dimension's total investment. The interventions on the left bank of the river Tagus are essential to protect the urban area that surrounds the coast from environmental-related damage [65] and, at the same time, follow the EU strategy to improve the quality of beaches. These interventions increased the solutions to access the beaches in Costa da Caparica, Ericeira, and Cascais, which became more attractive without the risk of severe coastal erosion. Regarding the stability of slopes, the intervention of POSEUR was decisive in Palmela. It contributed to the short-term and long-term sustainability of the Palmela/Setúbal region because it solved the emergency of the instability of the Palmela castle and São Filipe fortress slopes, whilst implementing a technology system that will regularly monitor the evolution and risks of these natural structures.

As regards the environmental protection dimension, the most positive aspects can be seen in two types of projects: on the one hand, biowaste and the optimisation of its collection and, on the other hand, improvements made in biodiversity-protected areas. The investment in biowaste collection is complementary to the recycling sensibilisation interventions that POSEUR tried to implement. To achieve more systematic waste management, new infrastructures for biowaste collection were created, such as new containers and more well-equipped vehicles. This funding follows the European guidelines to achieve a circular economy. There were also innovative ways to manage waste collection, such as a door-to-door system typically applied in northern European countries. To effectively promote a circular economy, the infrastructures to treat waste are fundamental [66]. With the

growth of biowaste collection, POSEUR also had to fund construction activities to expand the waste treatment capacity of companies like AMARSUL in Palmela or TRATOLIXO in Trajouce. These adaptations inherent to a circular economy represent a considerable financial investment. However, it is a concrete step to reducing dependency on imported resources when looking at it from an urban management perspective [67].

Finally, the resource efficiency dimension supported diverse projects on energy efficiency and the sanitation cycle. The investment made in resource efficiency can be explained by the funds allocated to the Lisbon metro expansion project [68]. Regarding energy efficiency applications, POSEUR again follows the carbon-neutral policy rationale and makes the city 'smarter' in its use of resources. Almost all projects are dedicated to changing older buildings that host public services by replacing conventional lights with LED ones. Other measures to renew this typology of buildings include installing solar panels to produce energy for self-sufficient consumption and replacing the windows with thermal glass to preserve the heat inside buildings.

6. Conclusions

This paper presents the main impacts of POSEUR (2014–2020) on the LMA, in five analytical dimensions: (i) low-emissions economy, (ii) adaptation to climate change, (iii) risk prevention and management, (iv) environmental protection, and (v) resource efficiency. For the first time, it presents the Impact-WEB_GIS platform created to 'spatialise' the impact scores of projects, programmes, or policies. It is supported by a TIA methodology that facilitates public and relevant stakeholders' access to such policy impact analysis.

Regarding the Impact-WEB_GIS platform, being deployed at the moment, an expert review on usability analysis will take place soon, with five experts following the literature guidelines to assess the usability and task satisfaction of this analytical Graphical Information System, in the context of the POSEUR (2014–2020) policy case study. This will lead to another iteration of development and an improved system user experience. Additionally, system development will continue by integrating new features such as the visualisation of aggregated statistics in the mentioned territorial units, improvements of the ETL process via interoperability with APIs from third parties, and improved support via the development of an analytical engine. Under this roadmap, there are also plans to use this system for more policy intervention analysis, such as ex-ante analysis of the Interrreg-A V programme (2021–2027) in Europe, the estimated territorial impacts of the Ukranian War in Portugal (municipal level), and the assessment of the main impacts of the Lisbon Strategic Urban Development Plan (2014–2020) in all the Lisbon city parishes, amongst other cases.

The obtained general impact score (+1.3) represented a low-to-average positive impact of POSEUR on promoting environmental sustainability processes in the LMA. The stakeholders that benefited from POSEUR funding demonstrated that it was insufficient to tackle the region's systemic environmental challenges and needs in the five analytical dimensions. However, under the TARGET_TIA methodology, high positive impact scores were observed in the dimensions of adaptation to climate change (reaching a significant positive impact figure) and environmental protection (with moderate positive impact). These results emphasise that there is no necessary mandatory causality between the amount of expenditure and its effects on the terrain. In these dimensions, POSEUR accomplished its goals of creating sustainable urban management plans to be executed in similar operational programmes and a renovated waste collection system that increases the recycling numbers of the benefiting municipalities. These follow the guidelines of the UN Sustainable Agenda for 2030 and promote the awareness of stakeholders and citizens about the environmental risks associated with a lack of infrastructure and adequate planning.

The low scores obtained in the remaining three of the five analytical dimensions exhibit this EU policy programme's fragilities (i.e., insufficient effectiveness and efficiency). For instance, the focus on small-scale projects prevented POSEUR from supporting solutions

to tackle potential regional natural hazards more effectively, in addition to the problem of hiring external companies to execute projects on the field via public selection. Due to the unusual set of global events, such as the COVID-19 outbreak, the war in Ukraine, and rising inflation, some projects were not executed, which prevented the production of a sounder ex-post impact analysis of POSEUR. This can be seen as one limitation of this research work, the other being the choice of stakeholders to be interviewed. The opinion of our interviewees was crucial to measuring the scores using the TARGET_TIA model; although, the possibility of interviewing other entities could have contributed to changing the overall analysis.

In a nutshell, POSEUR served as a positive public investment vehicle to mitigate national and regional environmental sustainability needs. The selected projects were adapted to the LMA's urban management model and the national public policy priorities of decarbonising the economy, supporting intermodality, and solving sanitation issues. Hence, the region became technologically more innovative. As seen, the impacted scores did not relate to the investments in each analytical dimension. Nevertheless, as one of the most developed regions of Portugal, the LMA did not receive the investment that other, more rural Portuguese NUTS II did. This turned out to be prejudicial to implementing measures that could produce a significant transition towards a more sustainable economy and use of resources in the region.

There is a generalised expectation for the future Portuguese environmental sustainability operational programme (2021–2027) to achieve far better impact scores that were not successfully reached with the financial help of POSEUR 2014–2020. For that, the bulk of the available funds towards improving environmental sustainability in the LMA should focus on making this large metropolitan area as self-sustainable as possible in producing energy via renewable sources of energy (i.e., solar power) and food in vertical farms, as well as supporting an effective circular economy process and a modern, smart, and green network of public transports. If, not, the level of public funding inefficiency would remain unacceptably high.

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