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# Nature-Based Solutions to Hydro-Climatic Risks: Barriers and Triggers for Their Implementation in Seville (Spain)

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**Abstract:** Nature-based solutions (NbS) are currently a priority of international institutions (UN and EU) to improve urban resilience to hydro-climatic risks. However, responsible institutions, such as river basin authorities and local governments, while still prioritizing gray infrastructure, often present resistance to these strategies. This paper analyzes this issue in the case of Seville (Spain). We identify historical and recent institutional practices related to the development of gray infrastructure and the experience of citizens' movements that demand the implementation of green infrastructure and the naturalization of urban space. Based on the theoretical framework of the sustainability transition, the article contributes to the identification of the factors that hinder or trigger the processes of change, drawing from the results of a case with a long tradition in hydro-climatic disaster management. The research has included an in-depth review of risk planning in the city of Seville, semi-structured interviews with 24 social and institutional actors, and participant observation of both urban planning processes and the practices of citizen movements. Our results show that the generation of shared visions clashes, first with conflicting perceptions of the city's strengths and weaknesses regarding risks; second, with contradictions between institutional discourses and practices, and finally, with the operational limitations of public participation processes.

**Keywords:** nature-based solutions; barriers and triggers; urban green infrastructure; climate change adaptation



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## 1. Introduction

The conceptualization of risk has evolved over recent decades from the *risk-hazard paradigm*, which equated risk to hazard to the *resilience paradigm*, which estimates the current probability of a certain magnitude event of a particular hazard (e.g., floods, earthquakes, or volcanic eruptions), evaluates the existing exposure and susceptibility (vulnerability), and calculates the coping capacity (resilience) to contend with such a hazardous event, including a predictive component based on the change that certain hazards might experience due to climate change and the adaptation process of more increasingly aware communities [1]. According to the IPCC [2] (p. 4), "risk is defined as the potential for adverse consequences for human or ecological systems, recognizing the diversity of values and objectives associated with such systems". In the context of climate change, hydro-climatic risks (HCR) can arise from the dynamic interactions between climate-related hazards (e.g., floods, droughts, and heatwaves), exposure, and the vulnerability of the affected human and ecological systems [2].

Nature-based solutions (NbS) are currently international institutions' preferred option to improve cities' resilience to HCR [3–8]. NbS have been defined as actions based in nature that address societal challenges [9], meaning that they are living solutions underpinned by natural processes and structures designed to address various environmental challenges, while simultaneously providing economic, social, and environmental benefits [10]. This concept was specifically introduced to promote nature as a means to provide solutions to climate mitigation and adaptation challenges [3,11]. It includes the provision of urban

greenery, which can alleviate high temperatures in cities or regulate air and water flows, or the allocation of natural habitat space in floodplains that can buffer the impacts of flood events [12]. In addition to their direct benefits, NbS have a transformative social impact, since they mediate new social relations and new social configurations that contribute to social innovation in cities and change the perception of nature and human–nature relations in urban contexts. In this sense, NbS promote community- and policy-based initiatives to improve sustainability and livability and the aspiration to foster inclusivity and social justice, thus contributing to accelerating ecological transitions in the cities [8,13,14].

In the current quest for the benefits that nature brings, the idea of urban greening has evolved from gardens to brighten up public space to infrastructure capable of providing cities with ecosystem services [15]. In this sense, there is a close link between the NbS concept, green infrastructure (GI), and the ecosystem service concept [9]. GI is defined by the European Commission as a "strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services" [4]. GI connects and gives consistency to the resources of the natural heritage from the trees that line streets and avenues, neighborhood gardens, and city-scale metropolitan parks, to sub-regional agricultural, forestry, and natural spaces. The renaturing of urban spaces, the creation of hydro-ecological belts, and floodable parks are clear examples of GI that respond to the NbS conception thanks to their capacity to provide ecosystem services that improve urban resilience to HCR (heatwaves, flooding, and droughts) [8,16–22], and, thus, enhance the importance of "using and living with" natural and semi-natural ecosystems in cities to improve human well-being [23].

Although the advantages of NbS are generally accepted, their implementation is beset by obstacles framed in the difficulties that confront the wider ecological transition process. For historical and cultural reasons, gray infrastructure continues to dominate the delivery and management of services, even though NbS perform as well or even better than gray infrastructure. Indeed, in many cases, NbS may present more efficient and cost-effective solutions than more traditional technical approaches [10,24,25].

In the case study of Seville, there is a deep history of community resilience construction through the implementation of NbS led by social actors demanding fair ecological transition processes. Notwithstanding, the action plans being drawn up by the city's institutions to tackle climate change (CC) continue to prioritize gray infrastructure-based measures. In the context of the overall uncertain ecological transition process, this paper intends to identify the factors that block or trigger change processes to include NbS as a priority strategy to improve urban resilience to HCR. This is achieved through a case study that considers the local characteristics of a city with a long tradition of hydro-climatic hazard management.

One of the theories that we can call on regarding the difficulties faced by the ecological transition process is the multilevel perspective [26–28], which describes socio-technical transitions through the interrelationships of the following three analytical levels: *regime*, *niche*, and *landscape*. *Regime* refers to the complex structure of scientific knowledge, engineering practices, production processes, procedures, norms, and institutions. It gives stability to social and technical relations and offers resistance to changes that, should they occur, would be more oriented toward optimizing the existing regime than changing it. *Landscape* is composed of socio-political and macroeconomic factors, cultural patterns, the global and environmental setting, etc. Changes to the *landscape* occur very slowly (over decades) and have to be perceived and interpreted by stakeholders to have any influence. *Niches* are the spaces in which individual actors, alternative technologies, and local practices operate and are expressed as new ideas, initiatives, or innovative techniques [29].

According to this perspective, the ecological transition occurs when the *landscape* evolves (the global and environmental setting; political, international, and cultural conditions, etc.) and puts pressure on the *regime*, where internal tensions are intensified. This situation can give rise to an opportunity for solutions that emerge from the *niches* to replace the regime's technologies and structures [30]. In contrast, resistance to transition resides in the socio-technical *regime*; institutional logic could influence actors' perceptions and

the dissemination of new practices [29,31]. Applying this perspective has led to other elements being included in the analysis, including interactions between social actors, social movements, power relationships, etc. [32,33]. As they are intensified by CC, risks are factors that research usually positions in the landscape and could, therefore, pave the way for the transition to new management models [29,31].

Against this conceptual backdrop, we have identified the following concrete barrier typology for the transition process in the city of Seville:

1. The *paradigm of growth*. Increases in the built-up area, including spaces for commerce, infrastructure, etc. seem to be the main focus for development, even under conditions of population decline [34]. The focus remains on economic growth-oriented issues (creating jobs, attracting investments). City budgets for green development and the maintenance of green spaces often face severe financial constraints, while staff and related expertise are decreasing [14,35–37].
2. *Path dependence* is an extremely important factor in our case and describes the situation in which active memory determined by past decisions has a controlling influence on decision-making [14,25,38,39]. This leads to lock-ins and errors being made and repeated again and again, despite voluntary decision-making and enlightened self-interest. Path dependence proposes to formally connect the past and the present, at the (macro) level of institutions, at the (meso) level of technology and governance modes, and at the (micro) level of organizational resources and capabilities [39,40]. Unless path dependence is broken through a combination of reforms, the shift toward the full adoption of nature-based solutions will not occur [25]. The *path dependence* factor can be related to other frequently identified factors, such as *lack of information, knowledge, and understanding in applying integrated, adaptive forms of management*; *insufficient resources (capital and human)* [40], and *fear of the unknown (operational performance)* [12,41–43].
3. *Sectoral silos* is a concept that refers to traditional structures of city departments that commonly have their own *sectoral language*. Knowledge is, thus, trapped in *sectoral silos* [12,14,44–46]. Similarly, local public administrations tend to have separate departments, each following distinct administrative specializations associated with different objectives, legal frameworks, and responsibilities [13]. All this is interrelated with the lack of a coordinated institutional framework, unclear and fragmented roles and responsibilities, and poor inter-organizational collaboration and communication [40]. In contrast to these problems, the transition path for the wider uptake of NbS requires active cooperation and minimal compartmentalization as a precondition [25]. The *sectoral silos* problem can be understood as one of the outcomes of another factor that generally emerges, *the limits of the regulatory framework* [40,47].
4. Lastly, in our case, we detect a factor that we call the *lack of political and public will*, combined with *limited community engagement, empowerment, and participation*. Some authors suggest that community members are often not considered valid decision-makers and, therefore, not informed (made aware) or empowered (engaged to act) to participate meaningfully in decision-making processes [40]. This factor is very prominent in the discourses of both institutional and social agents in our case.

In addition, we have identified the following factors as the enablers or triggers that favor the transition [12]:

1. Establishment and utilization of *collaborative governance approaches*. Policy officers collaborate with civil society, including, but not limited to NGOs, to connect demands for action with responsible actors or partnerships for action and jointly ensure good governance practices that adhere to transparency, legitimacy, and openness.
2. *Valorizing and exploiting the existing tacit and expert knowledge* on NbS of policymakers, policy advisors, urban citizens, researchers, and urban planners is another closely-related opportunity [48,49].

The implementation of NbS to enable the urban sustainability transition requires the collective stimulus of transition initiatives and the participation of urban change agents to mediate and catalyze transformation processes [14]. As practices of transition initiatives in cities, under certain conditions, NbS contribute to accelerating sustainability transition. Thus, civil society can advocate for more radical and progressive ideas. These characteristics of rapid experimentation adapted to the local context enable civil society to function as a driver of sustainability transitions [13,33,50–52].

Based on this framework, this study aims to respond to the following questions: what barriers and opportunities exist in Seville for the implementation of NbS as a CC adaptation strategy? Of these, which are the most significant in this study case? What can we do to move the ecological transition process forward in Seville? We propose the following three operating objectives to contribute to answering these questions: (1) to recognize the various actors' assessments of the risks that the city is facing and the levels of information, clarity, confusion, and conceptual and methodological rigor expressed in their discourses and practices; (2) to analyze the current climate action plans and the levels, operability, and effect of stakeholder participation in the planning processes, and (3) to identify the alternatives that the various actors propose to improve urban resilience to HCR, the factors that operate in the selection of these proposals, and the role that NbS have in them.

We hypothesize that the study case of Seville combines a set of strong resistance factors derived from institutional dynamics with an interesting proliferation of community-based and policy-based initiatives that promote the transition toward NbS.

The study is located in the field of *actionable science*, understood as a type of research designed with the stakeholder in mind that aims to inform decisions, improve the design or implementation of public policies, and (or) influence the strategies, planning, and behavior that affect the environment [53]. Improving the knowledge of ecological transition processes against the backdrop of climate change continues to be a fundamental scientific challenge. There are abundant theoretical and methodological contributions on the topic that are continually being discussed and enriched. Nonetheless, it is imperative to dig deeper into specific highly-significant processes to confirm and refine the results in a contextualized way. As Sarabi et al. [14] conclude, "in-depth analysis of barriers and enablers in each documented case of NbS uptake is required to build a reference based to identify and predict barriers to and enablers of NbS uptake and implementation" [14] (p. 16).

## 2. Study Area

### *2.1. Seville's Historical Trajectory to Address HCR*

Seville is located in the fertile valley of the Guadalquivir River and enjoys good fluvial and land communications (Figure 1). With around 1,250,000 inhabitants in the metropolitan area, it is the most important city in the southwest of Spain and the capital of the region of Andalusia. Its importance has always been especially linked to its position at the start of the navigable stretch of the Guadalquivir estuary, 100 km inland. For centuries, it was the main port for Spain's trade with its American colonies. The geographic situation that explains its advantages is also the root cause of the great HCRs that affect it, i.e., floods, droughts, and heatwaves.

In Seville, a combination of opportunities and extremely severe socio-natural risks converge. The climate is characterized by mild, frostless winters and scorching hot summers. Interannual rain is highly irregular and gives rise to recurrent long droughts, even though the average rainfall is relatively abundant at 542 mm/year. Most of the city is under 7 m above sea level and river floods above this height used to follow a 10-year recurrence period. Seville has been partially protected by walls since antiquity, a defense system that did not prevent the periodic flooding of the city. Historically, rainfall floods (*internal flooding*) have also occurred, in addition to river floods.


**Figure 1.** Seville location, in the southwest of Spain. Source: author elaboration laid over OpenStreetMap.

A chain of actions since the beginning of the 20th century has gradually and radically transformed the river network on which the current city stands and has helped to expand the city's urban surface (Figure 2). This network includes not only the main river, the Guadalquivir, but also several torrential tributary streams on the left bank (the Tagarete, Tamarguillo, Guadaira). In parallel, a belt of levees 12 m above sea level was constructed that increased the size of the historical city's defended area from 260 ha at the beginning of the 20th century to today's 5280 ha. The flood defense works were carried out in conjunction with some large-scale works to regulate the water in the Guadalquivir basin (45 large reservoirs) and to correct the course of the estuary downstream from Seville to help evacuate floodwaters. Today, there are some further projects to extend the defense system and expand the city northwards and southwards. Nonetheless, the truth is that the city has not suffered any severe floods since 1963, apart from some areas on the fringes of the system outside the protected area [54].

*Internal flooding* has a smaller territorial, social, and economic dimension. The modernization of the urban sewer system has gradually reduced this issue in central areas of the city, although sporadic waterlogging problems continue to occur in some specific zones. This, together with more rigorous criteria regarding the quality of wastewater, has recently led to the development of new infrastructure, including rainwater retention tanks (*stormwater tanks*), which are at odds with citizen debate and discourses in favor of NbS strategies, such as sustainable urban drainage systems (SUDS) [55].

As is the case for flood hazards, droughts that affect the water supply are an intrinsic part of Seville's history, although emerging at a different time and following a different timeline. The most recent critical situation developed between 1992 and 1995, when the Civil Protection Authority considered the possibility of partially evacuating the city to contend with a scenario in which the remaining emergency resources were likely to be exhausted. However, the city has not been on alert since then, neither has there been the need to use the resources of the new Melonares reservoir, which was regarded as indispensable by the administrations that constructed it [56]. Amongst other factors, one reason that explains this is the fall in urban water demand, which plummeted by over 40% between 1991 and 2020 due to changes in usage (citizens) and management practices (operators). Currently, the inordinate amount of water regulation infrastructure and the abovementioned evolution in demand have put an end to drought scenarios in Seville.


**Figure 2.** The Guadalquivir River and its tributaries as they pass through Seville and the modifications to their courses. Source: author's elaboration.

The third great HCR in Seville is the excessive heat, more specifically the heatwaves that have intensified in the framework of global warming [57,58]. Historically, heatwaves have been assessed and endured as a significant nuisance but never considered a catastrophe on the same level as floods and droughts. There is a well-known and socially highly valued cultural tradition of adapting to the heat, with modifications to urban and building typologies, the adaptation of schedules, and seasonal changes of residence, all with a highly unequal social distribution. Infrastructural and technological responses have expanded since the end of the 20th century; air conditioning has become more widespread and is today regarded as indispensable in public spaces and a high percentage of homes [54].

As in the case of rainwater management, a significant and, perhaps, more intense social debate is currently being waged around the perspectives, diagnostics, and alternatives to dealing with the risk of heatwaves. A kind of collective imaginary exists around the topic of bringing back the adaptive traditions and the culture of "living with the heat" —shade, vegetation, building orientation, incorporating water into housing—with debates on new resilient community response strategies underpinned by traditional responses. The 1992 World Expo was a landmark in the generation of bioclimatic proposals that enabled the reduction in the outside air temperature at the Expo site by some 5–10 °C. Notwithstanding, thirty years on, these solutions have not been extended to other areas of the city. However, new pilot projects do currently exist to identify innovative techniques to bring down the temperature in public spaces, such as the Cartuja Qanat and Life Water Cool projects, both sponsored by EMASESA.

In sum, the city of Seville has a long and often tragic historical relationship with HCR that is currently characterized by a high level of infrastructural control of floods and droughts and a social feeling of safety. This is the context in which new risks (heatwaves)

and new collective demands for the territory (GI) are emerging when the effects of CC are already noticeable.

### *2.2. The Green Infrastructure System as an Expression of Community Resilience*

Mediterranean cities have traditionally included landscaped areas that serve an unmistakable social and climate function and are a core part of their cultural identity. Recognition of these values has turned green spaces into a historical demand of social and neighborhood movements in Seville. Ignored by the institutions, self-organized civil society has, thus, promoted GI creation and management processes from the 1980s to the present day. As a result, these green spaces are now a structural part of the city (Figure 3). Furthermore, today they also represent an example of responses that generate resilience to HCR [52].

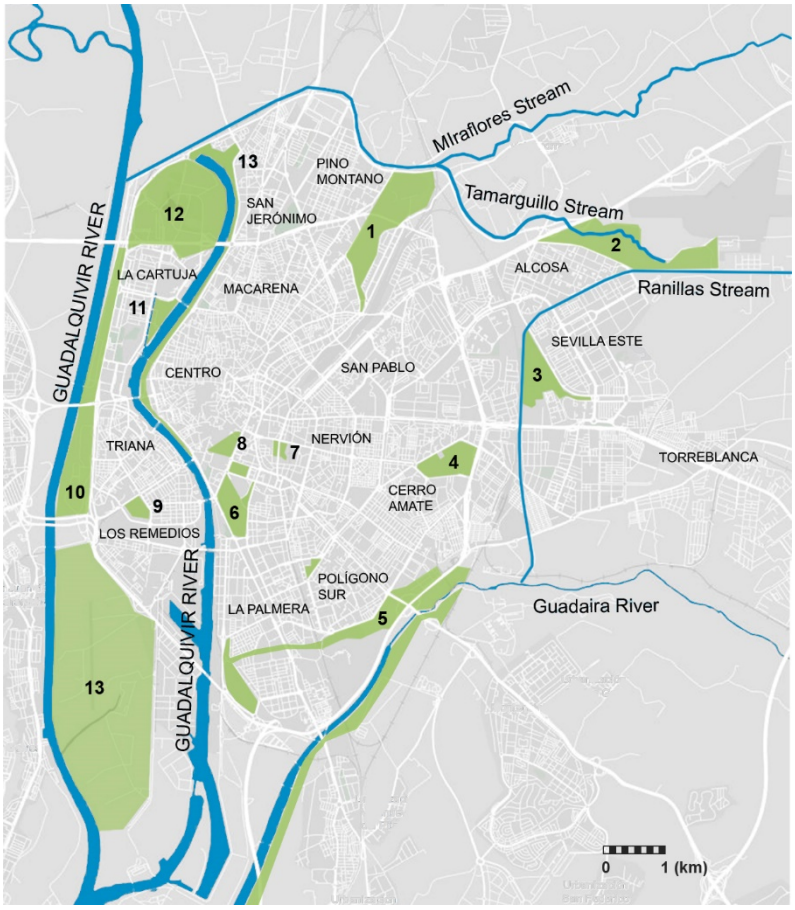


**Figure 3.** Seville city green system. 1. Miraflores Park; 2. Tamarguillo Park; 3. Infanta Elena Park; 4. Amate Park; 5. Guadaira Park; 6. Maria Luisa Park; 7. Buhaira Gardens; 8. Alcázares Garden; 9. Los Príncipes Park; 10. Vega de Triana Park; 11. American Garden; 12. Alamillo Park; 13. San Jerónimo Park. Source: author's elaboration.

As is usual in big cities, there are some large working-class areas on the outskirts of Seville. In these areas, social vulnerability factors (poverty, unemployment, ethnic minorities) have historically superimposed environmental vulnerability factors, especially related to low-quality housing, infrastructure and public space, making them more HCR-sensitive spaces. Prior to the 1980s, institutional initiatives had only constructed green spaces in upper-middle-class districts. Meanwhile, the sprawling residential estates that sprang up on the working-class periphery lacked the basic infrastructure and services that became the target of neighborhood association demands [59]. People view green spaces as a buffer mechanism to cushion these socio-environmental vulnerability factors in their

neighborhoods. Parks improve living conditions and are an instrument of empowerment and appropriation of the territory in which they dwell.

The role of social urban gardens ("huertos urbanos") needs to be highlighted as a mechanism for the construction of many of the city's large parks. In some cases, they gave rise to important public-community collaboration experiments for the management of these spaces. This was the case of the Miraflores Park, Tamarguillo Park, San Jerónimo Park, and Rey Moro Garden. These experiences formed part of the city's neighborhoods strategy to demand public parks in brownfield areas that the local people had previously laid claim to as "squatters". A brief experience with Municipal Participatory Budgets in Seville from 2004 to 2010 gave these initiatives a chance. During this period, social gardens were regarded as an instrument to dynamize and collectively construct green spaces and, through these, generate social cohesion and empowerment [60].

Other citizens' initiatives, such as Green Torreblanca, have sprung up in the city's most impoverished neighborhoods in recent times. These embody the ever more widespread discourse around the necessary adoption of NbS in urban spaces. In the same line, in 2021, a dozen or so social organizations of different types (environmental, trades union, neighborhood, and consumer) grouped under the banner of the Movement of Entities for the Climate and submitted a proposal to Seville City Council for a metropolitan-scale hydro-ecological green belt. This project is understood as a strategic opportunity to adopt a social focus to restore and regenerate the river network within the city and to create territorial-scale GI capable of contributing to hydro-climatic urban resilience. Meanwhile, the Living Guadaira Park Association has been making headway in its proposal for the naturing of the course of the Guadaira River in the south of the town; the Save the Trees platform has denounced the unjustified felling of major tree specimens, and the Platform for a Public Green Tablada District is continuing its fight in the courts for public use of a large flood-prone area on the banks of the Guadalquivir and so on and so forth, with major and minor, and larger and smaller citizen initiatives working on the construction of community resilience by applying NbS to address HCR [52,61].

## 3. Materials and Methods

This work applies case study methodology not only as a procedure to confirm (validate and illustrate) a theory but also as a way of "expressing" and "contextualizing" this theory in relation to the particular conditions of the specific case [62,63]. Data from observations are compared with prior arguments and theories and their validity and weaknesses are analyzed.

We have developed various lines of work to help answer the previously formulated research questions. First, an up-to-date review is conducted of the HCR gray strategies applied in Seville throughout history and the more recent experience of civic demands and initiatives for large-scale green spaces in the city. Both of these aspects contributed structurally to the city's construction process during the 20th century [52,56,59,64–68]. For this, the historical processes of gray infrastructure expansion and of the citizen action that have promoted the conservation or creation of GI in the city are reviewed. The existing bibliography on the contemporary history of the city, as well as our transdisciplinary experience in the subject under study, have allowed us to delve into these experiences. This work identifies the deep roots of the actions, the debates and conflicts that they have involved, and the outcomes achieved. This provides a backdrop that is essential for understanding and assessing the current transition processes.

On this basis, we have studied the proposals of a broad spectrum of institutional and social agents through 24 semi-structured interviews and the observation of some of their practices. The interviews were conducted between April and November 2020 (see Table 1). The interviewees were selected through a preliminary analysis of actors carried out through snowball sampling [69]. On the one hand, this analysis considered policy-makers and technicians from the most important institutions with local influence on climate governance on various scales, and on the other, civil society representatives of different actor

typologies working in climate governance and action, including neighborhood associations, NGOs, professional entities, and academics. A heterogeneous sample was selected until the information was saturated. The interviews were structured into the following two sections: 1. climate emergency and risks in Seville (what do you consider to be the most significant climate risk in Seville? What strengths and weaknesses does the city have to cope with it? What are the places most exposed to it? Who are the most vulnerable groups?); 2. governance and climate action (what resilience plans are you aware of? Are these plans being implemented? Do these plans focus on vulnerable groups?). All the interviews were recorded and later transcribed and analyzed.

**Table 1.** Agents interviewed. Elaborated by authors.

| Social Entities | Interview Ref. Code |
|---|---|
| Seville Movement of Entities for the Climate (Movimiento de Entidades por el Clima de Sevilla–MECS) | #1 |
| 2020 Climate Rebellion (2020 Rebelión por el Clima) | #2 |
| Platform for a Public and Green Tablada District (Plataforma por una Tablada Pública y Verde) | #3 |
| Rey Moro Community Garden (Huerto del Rey Moro) | #4 |
| Living Guadaira Park Association (Asociación Parque Vivo Guadaira) | #5 |
| Ecotono (Environmental Education Cooperative) | #6 |
| Nomad Garden (SL) | #7 |
| Parents' Association Pro Bioclimatic Adaptation in Schools (Plataforma Escuelas de Calor) | #8 |
| Wastewater Treatment Research Group, Grupo TAR (University of Seville) | #9 |
| University and Social Commitment (University of Seville) | #10 |
| Network Action, Andalusia (Acción en Red Andalucía) | #11 |
| International Solidarity, Andalusia (Solidaridad Internacional Andalucía) | #12 |
| Andalusian Social Water Table-Seville Consumers and Users Association (Mesa Social del Agua de Andalucía-FACUA Sevilla) | #13 |
| CCOO Trade Union-Environment Secretary (Medio Ambiente, Comisiones Obreras de Sevilla-CCOO) | #14 |
| Ecologists in Action (Ecologistas en Acción) | #15 |
| **Institutions** | |
| EMASESA (Seville Metropolitan Water Supply and Sanitation Company) | #16 |
| Seville City Planning Office (Gerencia Municipal de Urbanismo) | #17 |
| Guadalquivir River Basin Authority | #18 |
| AEOPAS (Spanish Water Supply and Sanitation Operators Association) | #19 |
| Seville City Council, Dep. of the Environment, Parks, and Gardens (DG Medio Ambiente, Parques y Jardines del Ayto. de Sevilla) | #20 |
| Seville City Council, Sustainable Development Department (Desarrollo Sostenible del Ayto. de Sevilla) | #21 |
| Andalusian Regional Government, Department of Housing (Secretaria Gral. de Vivienda de la Junta de Andalucía) | #22 |
| Andalusian Regional Government, Environment and Water Andalusian Agency (Agencia de Medio Ambiente y Agua) | #23 |
| Former head of the Seville City Council, Dep. of the Environment, Parks, and Gardens | #24 |

The research has been complemented by a review of the local planning that deals with resilience to HCR in the case study. Two municipal-scale planning actions that contain the measures envisaged for adapting the city to CC were selected out of twenty-one identified plans for in-depth analysis, including the Seville City Council Climate Change Adaptation Plan (CCAP) [70] and the Seville Metropolitan Water Supply and Sanitation Company's (EMASESA) Climate Emergency Plan (CEP) [71]. Their diagnostics of the HCR that the city faces have been analyzed, along with the proposed measures to address them, and the participation and decision-making procedures throughout the drafting processes.

As a methodological reference, we have considered the guidelines adopted by these plans, including the Intergovernmental Panel on CC [72] and the Urban Adaptation Support Tool [73], instrumentalized through the Spanish CC Office's Guide for Drawing Up Local CC Adaptation Plans of the Ministry for Ecological Transition and the Demographic Challenge [74].

First, we have analyzed the plans' HCR assessment process, focusing on the study of potential hazards and the evaluation of existing exposure and vulnerability conditions. Second, we have examined the adaptation measures envisaged in the plans and classified them into the following three broad categories in line with the classification proposed in the reference methodology [74]: *gray actions*, related to engineering or technology; *green actions*, including NbS, and *soft actions*, with management, legal, and political community-based focuses. The estimated budgets for these measures are considered when they are included in the plans, although in many cases budgets are given as "undefined". Finally, we have compared the interviewed social and institutional actors' perceptions of the city's HCR situation with the contents of the plans.

The review of historical documents, public planning documents, and the interviews are complemented by the analysis of social initiatives to address CC with a compilation of 26 civil society initiatives [61]. Lastly, this work also draws on the results of participant observation at a variety of public participation spaces on climate policies (EMASESA- CEP) and climate change demands for climate action (actions undertaken by Seville Movement of Entities for the Climate-MEC).

## 4. Results

### *4.1. CC Action Plans: Diagnostics and Proposals*

In the framework of the post-Paris Agreement international and EU climate action policies, in December 2015, Seville joined the European Commission's Covenant of Mayors Initiative on Adaptation to Climate Change. Local authorities that subscribe to the Pact must present a Climate and Sustainable Energy Action Plan that includes a climate vulnerability risk assessment and actions to achieve their CC adaptation objectives. The City of Seville 2017 Climate Change Adaptation Plan (CCAP) was developed in this framework.

In July 2019, Seville City Council announced the Declaration of the Climate State of Emergency in the city. This declaration committed all the public institutions and organizations to setting in motion precise and detailed actions to combat CC. As a consequence, EMASESA prepared its own Climate Emergency Plan (CEP) that sets "clear objectives and commitments regarding CC mitigation and adaptation" [71] (p. 7).

These are the two municipal-scale planning actions that were selected for in-depth analysis as they contain the measures foreseen for the city's adaptation to CC.

#### 4.1.1. Risk Diagnostics in the Plans

CC adaptation action plans require the prior identification of the main risks that the city faces. The analyzed plans adopt a semi-qualitative risk assessment methodology that combines quantitative analyses of hazards and their projections with the study of the consequences (related to exposure and vulnerability) using qualitative tools. According to the reference methodology [74], an analysis should be applied using participatory techniques and expert panels with different member profiles for this qualitative evaluation. In this

sense, both the CCAP and the CEP carry out participation processes with stakeholders with different profiles, many of whom are experts in the subject.

With respect to the quantitative study of the evolution of hazards caused by CC, the forecasts for temperature rises and the frequency and length of the heatwaves are clear. Nonetheless, the diagnostics of the evolution that would be produced in rainfall patterns are not so clear. Both plans state that spells of heatwaves are "very likely" and droughts are "quite likely". Periods of extreme rainfall are considered to be "likely" in one plan (CCAP) and "quite likely" in the other (CEP).

Regarding the analysis of the current condition of the city in relation to risk exposure, strangely, neither of the studied plans offers any diagnostics of the current city's HCR infrastructure system. In addition, neither of the plans considers the effects that GI and natural spaces might have in this respect, especially in relation to heatwaves and floods.

What stands out in both plans' vulnerability studies is the confusion around the definition of vulnerability and the lack of clarity in the criteria adopted for its assessment. The diversity, complexity, and contradictory nature of the definition and the application of the concept of vulnerability in the context of HCR are questions that have been widely addressed in the scientific literature [75–77]. The reference methodology recognizes this complexity and proposes to tackle it through a multidimensional approach underpinned by local knowledge [74]. Nevertheless, the vulnerability assessments of the case study in the plans obviate these requirements. On the one hand, social vulnerability factors (slum neighborhoods, populations with no resources) and environmental vulnerability factors (presence of vegetation and green areas) are well identified in the plans' participation processes but not included in the analyses of the final official document. For example, in the case of the CCAP, the population's vulnerability is only studied based on the age factor, and building construction only considers the density of residents. On the other hand, the vulnerability and exposure analysis are carried out through a qualitative evaluation that, according to the reference methodology [74], should be based on participation processes; however, there is a clear difference between the vulnerability assessment made by stakeholders in the participation processes and what was eventually considered in the final version of the plans.

The outcome of these processes—risk assessment—is, therefore, not very rigorous and contradictory. On the one hand, the CCAP concludes that in the participation processes, "greater priority [was given] to risks related to a greater occurrence and severity of heatwaves and a possible increase in the intensity of droughts" and "flood-related risks were assessed as having less priority in the work undertaken" [70] (p. 85). Despite this, the plan finally only considers that "severe" or "very severe" consequences exist in relation to the risk of rainfall and river floods. Therefore, these are the risks that are assessed as most serious. It is significant, for example, that the consequences of drought for the population are assessed as "moderate" and those of heatwaves for the education sector, as "minimal". In the case of the latter, only the "possible economic impact due to an increased need for cooling" is stated [70] (p. 92), ignoring the fact that primary and secondary schools do not possess any air conditioning equipment and that in recent years, spells of heatwaves have occurred that have forced the end of the school year to be brought forward [78,79].

The situation for the CEP is similar. In the participation process, "the main risks identified for EMASESA come from the heatwave hazard, given its greater likelihood of occurring" [71] (p.10). In these processes, heatwaves are associated with risks mainly assessed as "very high" and "high", and the lack of rainfall is also prioritized as "high" risk, as is occasional extreme rainfall. However, the plan's final assessment mostly attributes the most serious consequences to the risks of extreme rainfall, which are, therefore, risks rated as "very high" and "high". Only in some cases, the risk associated with the lack of rainfall is considered "very high" or "high". Heatwaves are associated with "moderate" consequences, which means that they are not considered high risk at all.

#### 4.1.2. Selection of HCR Adaptation Measures

The actions envisaged in the plans have been synthesized in Table 2 to facilitate their analysis. They have been organized into the following three broad categories proposed in the reference methodology [74]: *gray actions*, *green actions*, and *soft actions*. When the estimated budgets for these measures are included in the plans, they are given in the table. The table identifies the actions in the CCAP, in the CEP, or in both, and the risks that the plans associate with them.

According to the analysis of the set of measures, 89% of the budget specified by the plans is allocated to *gray actions*, 10% to *green actions*, and 1% to *soft actions*. An analysis of the budget allocated according to the measures' impacts on each of the risks shows that the lowest amount is assigned to the risk of heatwaves (€21 MM), compared to drought (€120.7 MM), and lastly, floods (€189.8 MM), to which most resources would be allocated.

In relation to the measure selection process, the CCAP Plan identifies the following three strategic goals: the participation of the stakeholders involved, the resilience of the most vulnerable sectors, and anticipation through innovation [70] (p. 112). However, there does not appear to be any clear relationship between these strategic goals and the measure selection process. A multicriteria analysis method is adopted based on the following criteria and weighting factors: potential risk reduction (40%), technical viability (20%), economic viability (20%), other benefits (10%), citizen prioritization (10%). These criteria are mainly applied by technicians with no information given about cost-benefit or cost-effectiveness qualitative analyses to complete the study. The citizen prioritization process is only given a 10% weight, despite the reference methodology stating that a requisite for the multicriteria analysis is the participation of multiple stakeholders to reach agreements [74].

In the case of the CEP, the document itself recognizes that the measures included in the plan had been identified before the diagnostics, stating that "a preliminary exercise had already been carried out in EMASESA to select a compendium of measures to be implemented and these were set out in the document entitled EMASESA and the Climate Emergency. #50measures" [71] (p. 44). Even some of the main actions envisaged came from prior planning processes. The EMASESA Infrastructure Renewal Strategy (2015) already envisaged an Investment Plan (2015–2019), with actions to improve the rainwater runoff system (retention tanks and sewer system) to a sum of EUR 51 MM and investments to improve and replace networks to a total of EUR 105 MM.

With respect to the contributions made by the CEP participation workshops, some of the main aspects stated referred to the need to identify the most vulnerable sectors of society; a commitment to water reuse; the need to review the cost-effectiveness of the investments in gray infrastructure included in the plan draft, and, more specifically, the evaluation of the projected retention tanks compared to the sustainable urban drainage systems (SUDS) alternative. However, these contributions did not lead to any relevant modifications being made between the CEP draft that was debated and the final version of the document.

### *4.2. Stakeholder Perceptions of the City's HCR Situation*

In the following section, we analyze the responses given to the 24 semi-structured interviews with social and institutional actors in the city. Specifically, in the first part, we focus on the questions related to identifying the HCR with the most serious consequences, the city's strengths and weaknesses to deal with them, the areas and equipment that are considered to be the most exposed, and the most vulnerable social sectors. In the second part, we analyze the interviewees' assessments of the plans' degree of compliance with urban resistance to HCR and the greater or lesser attention paid to the most vulnerable collectives.

**Table 2.** Adaptation measures envisaged in the plans.

| Measures | Budget (€) | CCAP | CEP | Heatwaves | Drought | Flood |
|---|---|---|---|---|---|---|
| ***Gray actions*** | | | | | | |
| Shade plan | 500,000 | X | | o | o | |
| More urban drinking fountains | - | X | | o | | |
| Improvement and replacement of water supply and sewer networks | - | X | X | | o | o |
| Control of unauthorized water consumption | - | | X | | o | |
| Individual water meters | - | | X | | o | |
| Groundwater uses | 171,000 | | X | | o | |
| Regenerated water uses | 15,000 | X | X | | o | |
| Better management of drinking water | - | | X | o | o | o |
| Better knowledge of reservoirs | 134,000 | | X | o | o | o |
| Advanced water quality control techniques | 715,000 | | X | o | o | o |
| Advanced water treatment systems | 118,000,000 | | X | | o | o |
| Retention tanks and rainwater sewer systems | 50,000,000 | X | X | | | o |
| *Gray actions: total budget* | 169,535,000 | | | | | |
| ***Green actions*** | | | | | | |
| Green roofs and facades in municipal buildings and primary schools | 125,000 | X | | o | | o |
| Public space renaturing: balconies, terraces, courtyards, and streets | 64,000 | X | | o | | o |
| Consolidation of green avenues | 7,200,000 | X | | o | | o |
| Environmental improvement to river spaces | 1,500,000 | X | | o | | o |
| Expansion of social and urban garden network | 2,600,000 | X | | o | | o |
| Unique green spaces | - | X | | o | | o |
| Connectivity of green spaces (green belt) | 85,000 | X | | o | | o |
| Green roofs and facades on businesses | 500,000 | X | | o | | o |
| Urban renaturing | 7,900,000 | | X | o | | o |
| *Green actions: total budget* | 19,974,000 | | | | | |
| ***Soft actions*** | | | | | | |
| Improving inter-institutional coordination for climate action | - | X | | o | o | o |
| Making Seville a European benchmark for CC | 40,000 | X | | o | o | o |
| Management of municipal buildings' water footprint | 50,000 | X | | | o | |
| Public awareness campaigns | 800,000 | X | | o | o | o |
| Education about resource use | 173,000 | | X | | o | |
| Creation of a CC web | 25,000 | X | | o | o | o |
| Seville business cluster to address the climate | 120,000 | X | | o | o | o |
| Tax incentives, rebates, and grants | - | X | | o | o | o |
| Encouragement of changes to working hours | - | X | | o | | o |
| *Soft actions: total budget* | 1,208,000 | | | | | |
| ***Sum total of budget*** | **190,617,000** | | | | | |

#### 4.2.1. Appreciation of Risks and Coping Capacity to Address Them

Social appreciation of the risks takes us into a very complex area, including the "degree of danger", "intensity", "frequency", "severity" and so on. From the very beginning, the social actors in Seville have identified risks in the framework of CC; the majority identify heatwaves as the most significant risk in this framework (14 out of 24) on the understanding that they affect people's daily lives and have greater consequences for health, for example, "there are lots of environmental risks … but heatwaves are clearly the main one" (interview #3); "heatwaves and flood, no doubt about it, no doubt at all" (interview #8). When the interviewees are asked to classify risks by how serious they are, sometimes they hesitate and opt for drought or, to a lesser extent, floods (Table 3). We should point out that the latter perspective (drought and floods) is more widely shared among the spokespeople for institutions, who are generally professionals with technical backgrounds and specialized in their various management sectors, than among the social entities. However, the professionals' greater experience does not exclude significant misinformation on some key data in some cases (interviews #18; #23); for example, the reduction in water demand for urban supply.

**Table 3.** Synthesis of interview results.

| | **Social Actors** | **No.** | **Institutional Actors** | **No.** | **Total** |
|---|---|---|---|---|---|
| **Most serious risk** | | | | | |
| Heatwaves | #1; #3; #4; #5; #6; #9; #10; #11; #13; #14 | 10 | #17; #21; #23; #24 | 4 | 14 |
| Droughts | #2; #7; #8; #12; #15 | 5 | #16; #18; #20 | 3 | 8 |
| Floods | | 0 | #19; #22 | 2 | 2 |
| **Strengths** | | | | | |
| Habit, tradition, and risk culture; traditional architecture | #1; #2; #6; #7; #8; #12; #14; #15 | 6 | #16; #19; #21; #22; #23 | 5 | 11 |
| Research | #1; #13 | 2 | #17 | 1 | 3 |
| Social awareness | #4; #13; | 2 | #17 | 1 | 3 |
| CC public policies | | | #17 | 1 | 1 |
| Urban parks | #3; #10; #11 | 3 | #17; #24 | 2 | 5 |
| Hydrology: River (not used) and groundwater | #4; #5; #7; #9; #10; #11 | 6 | | | 6 |
| EMASESA | #9 | 1 | #24 | 1 | 2 |
| Infrastructure | | | #16; #18; #19; #20 | 4 | 4 |
| **Weaknesses** | | | | | |
| Poverty | #3; #6 | 2 | | | 2 |
| Poor quality of building construction (poor neighborhoods) | #3; #11; #14 | 3 | | | 3 |
| Lack of green areas and trees in the urban space | #6; #10; #11; #14 | 4 | | | 4 |
| Lack of institutional commitment | #2; #4; #5; #8; #10; | 5 | #24 | 1 | 6 |
| Lack of social pressure | #10 | 1 | #24 | 1 | 2 |
| Lack of technical culture (except for EMASESA) | | | #24 | 1 | 1 |
| Infrastructure solutions: environmental and economic costs; false sense of security | #6; #8; #12 | 3 | #19; #20 | 2 | 5 |
| Consequences of CC | #15 | | #16; #22 | 2 | 2 |
| Economic dependency on tourism and agriculture | #1 | 1 | | | 1 |

**Table 3.** *Cont.*

| | Social Actors | No. | Institutional Actors | No. | Total |
|---|---|---|---|---|---|
| **Most exposed areas** | | | | | |
| Low-income neighborhoods and social exclusion | #2; #3; #5; #6; #8; #10; #11; #13; #14; | 9 | #20; #21 | 2 | 11 |
| Areas with no trees | #1; #3; #4; #5; #8; #9; #14; | 7 | #17; #21; #23; #24 | 4 | 11 |
| Areas far from the river | #10; #11 | 2 | | | 2 |
| Nervion, North Macarena, Historical Center | | | #17; #20 | 2 | 2 |
| **Most exposed equipment and infrastructure** | | | | | |
| Primary schools | #3; #4; #8 | 3 | #17 | 1 | 4 |
| Bus stops | #4; #6 | 2 | #24 | 1 | 3 |
| Tourism, hospitality sector | #1 | 1 | | | 1 |
| Agricultural sector | #1; #12 | 2 | #20 | 1 | 3 |
| Reservoirs | | | #16 | 1 | 1 |
| Areas outside the flood protection zone | | | #19; #22 | 2 | 2 |
| **Vulnerable collectives** | | | | | |
| Low income groups (overcrowding, quality of housing and urban space, homeless) | #2; #3; #4; #6; #7; #9; #12; #15 | 7 | #16; #19; #20; #21; #22; #23; #24 | 7 | 14 |
| The children | #3; #4; #8; #10; #6 | 5 | #17; #21; #24 | 3 | 8 |
| The elderly | #4; #5; #6; #10; #13 | 5 | #17; #21; #23; #24 | 4 | 9 |
| The sick | #13 | 1 | #17; #21; #24 | 3 | 4 |
| The disabled (mobility) | #4 | 1 | | | 1 |
| Migrants, women | #1 | 1 | | | 1 |
| Homeless people | #15 | 1 | | | 1 |
| Outdoor workers | #3; #14; #15 | 2 | | | 2 |

When the social actors in Seville are asked about the city's strengths and weaknesses to address CC, the community agents, more clearly, and, to a lesser extent, the institutions, emphasize the latter. As a strength, there is a general recognition of habit, experience, tradition, and the culture of adaptation to heat management (10 out of 24). The virtues of the traditional urban planning and architecture are appreciated, while modern developments are criticised. Low construction quality is singled out, especially in the poorest neighborhoods (interviews #3; #11; #14), with the urban developments of the 1950s to the 1980s identified as the most substandard. The interviewees continually mention the failure to benefit from the potentialities of the river and the abundant groundwater (interviews #9; #11; #10). The institutional actors give a great deal of importance to defense infrastructure to tackle floods and droughts (interviews #16; #18; #19; #20). These conventional measures are generally not questioned, although the impacts on the areas from which water is extracted and the dangerous false sense of security and "memory loss" are occasionally mentioned (interviews #8; #6; #12; #19; #20). Infrastructure adaptation is not suggested to contend with heatwaves; on the contrary, the traditional ability to adapt is accepted and the generalized spread of air conditioning is criticized, while recognizing the contradiction it involves (energy consumption and $CO_2$ emission) and that it epitomizes "maladaptation" [80,81].

The interviewees, especially the social actors, consider that the lack of institutional commitment is the city's main weakness (interviews #2; #4; #5; #8; #10; #24). They condemn a lack of experience and technical culture in this regard, except for EMASESA, which is generally positively valued.

There are discrepancies over the number of trees and green areas, although an objective framework for debating the topic was missing. While some institutional actors consider that the city has enough trees (interviews #17; #24), the social actors, despite recognizing the existence of large parks (interviews #3; #10; #11), generally consider that the public spaces lack sufficient tree cover (interviews #14; #11; #10; #6). This deficiency affects streets and pedestrian precincts especially. In fact, this is one of the main aspects of risk exposure mentioned by both social and institutional actors (11 out of 24). The poorest neighborhoods and the most austere urban developments are the most exposed, as they lack sufficient green spaces, amongst other problems.

However, in relation to the identification of the most exposed areas, what is highlighted above all is poverty, the existence of "different Sevilles", the downtown Seville and the Seville of the outskirts, with badly designed street layouts, and mediocre quality and poorly insulated housing construction. Institutions and social agents coincide in referring to the peripheral neighborhoods when they state that "five of the fifteen poorest neighborhoods in Spain" are in Seville (interviews #3; #14; #17). They are the most vulnerable neighborhoods and those with the greatest difficulties to address the risks of social exclusion, energy poverty, and water poverty. A city that is "designed as if the weather was never hot, where areas that were covered in sandy clay in the past are now concreted over" (interview #9); a city that "once again focuses on technological solutions: air conditioning, storm tanks" (interview #3).

The assessment of the most exposed facilities identifies a critical sector, which is that primary schools are not equipped for heatwaves and this has given rise to some interesting reflection and organization experiences, and proposals to deal with this risk. There are also the public bus stops, which predominantly harm social sectors affected by other vulnerability factors (gender, age, economic level).

Social entities also provide information on particular situations thanks to their greater social awareness, including the vulnerable people affected by power outages (e.g., sick people on ventilators), very small and overcrowded dwellings, the lack of drinking fountains in public spaces to ensure access to water, etc. The social collectives most exposed to risks are also identified, such as the people who work or live outdoors, (construction workers, street vendors, municipal police, homeless people), children, the elderly, the disabled, the infirm, and people on low incomes. As mentioned in an interview, "save the vulnerable and you save everyone" (interview #9).

#### 4.2.2. Valuation of Action Plans

There is a major consensus among the social agents that the HCR resilience plans have not been implemented and also that there are no funds or execution dates set for them (13 out of 15). Generally, the social actors positively rate the drafting of these plans but the majority believe that they will not get past the proposal draft stage and will never really be implemented due to a lack of political will. For example, "there is no team of people in the Council devoted to this" (interview #1). So, they become no more than a "declaration of intentions" with a more esthetic purpose than the aim that they should be executed. The absence of budgetary resources and the disregard of deadlines for their implementation are criticized. In some cases, some advances by EMASESA are recognized but are mentioned as an exception in the municipal field. Generally, it is understood that the plans are not expressly focused on the most vulnerable population, a fundamental detail of the social reality in a city that "is looking in a different direction" (interview #5).

The institutional actors give a wide range of valuations. A lack of self-criticism can be noted in the institutions with direct responsibilities. The inability to meet deadlines is justified, as demonstrated by the following interviewee: "we're making headway, but the due dates just eat us alive" (interview #17) or they even defend a high degree of execution (interviews #18; #21). More questions can be perceived from the institutional agents with less responsibility for the direct execution of the measures, which recognize the lack of a budget allocation, tracking, and execution. Regarding the absence of a specific focus on the

most vulnerable population, the argument made is that the plans have a global mission to address the entire city without distinction, which would also include the vulnerable population (interviews #16; #18; #20; #21).

## 5. Discussion

The case of Seville exemplifies two focuses of the adaptation and improvement strategies of urban resilience to HCR. First, there is the top-down focus that has dominated institutional urban planning to date. Carried out with little or no citizen involvement, in this focus, urban resilience is a goal to be achieved with a robust infrastructure system to address HCR. This focus is firmly entrenched in what the multilevel theory analyses of the ecological transition [26] would understand as the *regime*, which gives support to the logic in which it is ensconced. Second, in Seville, we find the resilience construction focus as a process. This focus reflects the ability of bottom-up civil society initiatives to drive NbS that enable the building of a city better adapted to HCR. Furthermore, NbS are themselves generators of community resilience through social benefits in the form of a sense of place, empowering communities, and establishing ties between social groups [13]. These experiences are understood as transition initiatives, *niche* spaces that generate transformation opportunities for *landscape* evolution that will put pressure on the regime to move forward in the ecological transition process [29].

The interviewees reflect a society characterized by a "generalized amnesia" with respect to the severe past and contemporary impacts of droughts and floods. Seville has one of the longest (nine hundred years) and fullest histories of flooding, but the last floods occurred in 1961 and 1963 and have not been repeated since then. As for droughts, since the end of the 1992–1995 crisis, there have not even been any situations of alarm, demonstrated by the following interviewee: "no one remembers that in the nineties the water was being cut off at 2 in the afternoon. That would be unthinkable today" (interview #16). From the point of view of reducing impacts, we can talk about the success of the infrastructure strategy, the increase in resistance based on the creation of man-made watercourses, the constant expansion of the belt of dikes, and the establishment of an over-equipped infrastructure system to guarantee the water supply. However, several voices warn about this false sense of security, lack of social awareness, and the potential impact of climate-change aggravated floods and droughts (interviews #19; #20).

This great investment effort to transform the territory during the last century corresponds to the so-called *paradigm of growth* [14,34,37] (Figure 4). The city set out a roadmap to subjugate and prevail over the complex river and stream system on which it stands [82,83]. In contrast to this background, the strategy to integrate these courses (or their vestiges) into the city's great parks through an extensive green belt is a social demand for a city model in which the concept of integration replaces that of domination [83,84].

In relation to flooding, there is no confusion among the interviewees regarding the magnitude of the current defense system that the city has inherited as a product of history. However, there is certainly some confusion around drought risks; in some cases (Guadalquivir River Basin Authority, City Council) the key factor in the adjustment to resilience—a drastic fall in water consumption—is unknown. This explains and generates governance issues, including a frequent lack of technical information, confusion, inaccuracies, mistakes even among institutional actors; a lack of shared basic data in a common language. This phenomenon can be understood as an expression of the type of barrier that, in line with *path dependence*, has been identified as a *lack of information, knowledge and understanding in applying integrated, adaptive forms of management* [40].

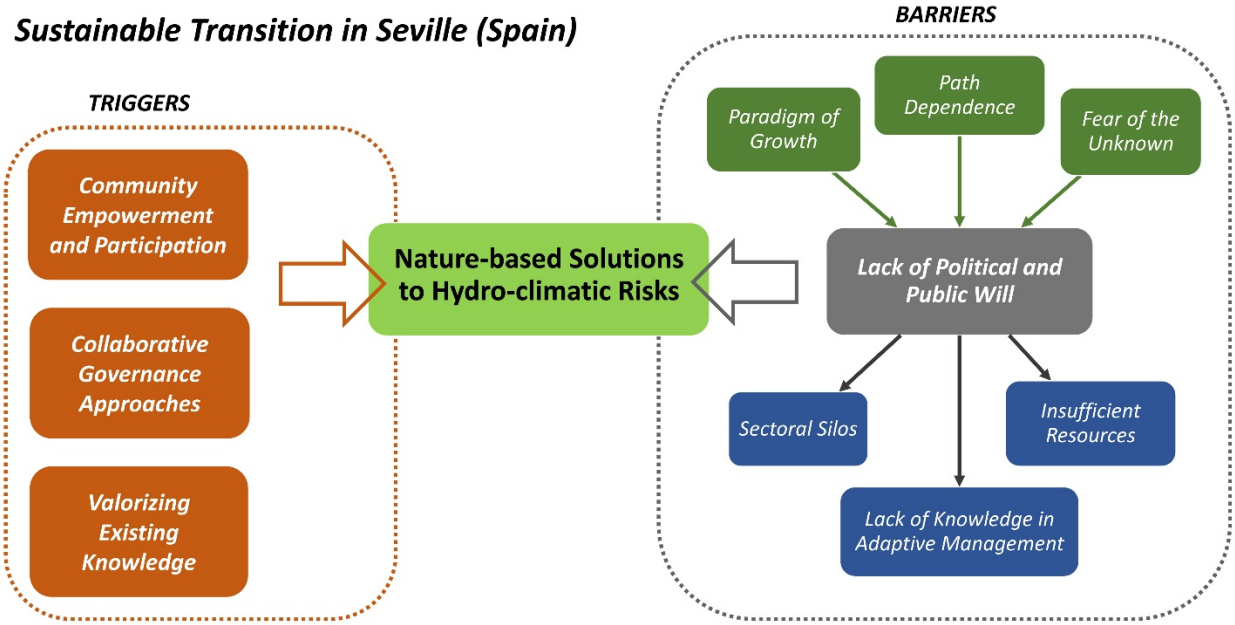


**Figure 4.** NbS to HCR. Synthesis of triggers and barriers to community and institutional responses in Seville. Source: author's elaboration.

In addition, in relation to this barrier, a certain lack of accuracy and some confusion has been detected in the use of risk-management terminology in the plans analyzed in this paper (CCAP, CEP). This is especially true regarding the definition and assessment of vulnerability and its relationship with the impacts and consequences of the risks. This lack of conceptual clarity can subsequently be observed in the methodological rigor and the contradictory results of risk assessment.

On the one hand, the plans are lacking a rigorous analysis of the factors that shape the unequal distribution of vulnerability and risk exposure and missing the fundamental aspects of the geographic context from the socio-environmental point of view. Although some elements of exposure are unrelated to socio-economic factors, the identification of vulnerability with poverty is clear. It is very significant that although a very broad consensus exists around this issue among both institutional and social actors, social vulnerability factors are not taken into account in the main plan's evaluations of the spatial distribution of risks. So, the absence of a suitable territorialized analysis of the current situation makes it difficult to identify the system's weaknesses and, consequently, the most appropriate actions to turn them around.

One of the most evident expressions of this *lack of information, knowledge, and understanding* was revealed by a comparative analysis of risk assessment in the various processes (Table 4), including the assessment made by interviewed stakeholders (A); that apprehended in the action plan participation processes (B); and lastly, that considered in the plans' diagnostics (C), bearing in mind that it is the last of these that is used to justify how the proposed actions and investments are prioritized. In the framework of the local-scale plan participation processes (B), the actors, with their broad range of technical and social profiles, provide a homogeneous and similar assessment to what was captured in the interviews (A). In these processes, a greater risk level is attributed to heatwaves (increased recurrence and severity), a possible increase in the intensity of droughts is recognized, and floods are relegated to third place. The plans (CCAP, CEP) also initially recognize the greater risk of heatwaves and drought and even identify the risks associated with floods as less severe. However, paradoxically, the final risk assessments made by the plans (C) consider that river and rainwater floods pose the greatest risks.

**Table 4.** Comparative analysis of risk appreciation.

| | **Interviews (A)** | | **CC Adaptation Plan** | | **Climate Emergency Plan** | |
|---|---|---|---|---|---|---|
| Risk assessment | Social actors | Institutional actors | Participation process (B) | Plan diagnostics (C) | Participation Process (B) | Plan diagnostics (C) |
| Indicator | Most severe risk | Most severe risk | (No. prioritized recipients) | (No. high-risk recipients) | (No. risks identified as high or very high) | (No. risks identified as high or very high) |
| Heatwaves | 10 | 4 | 17 | 7 | 6 | 3 |
| Drought | 4 | 3 | 9 | 3 | 4 | 6 |
| Flooding | 0 | 2 | 0 | 11 | 2 | 9 |

These contradictions are the result of the methodology being inadequately applied. As has already been mentioned, the complexity of quantitatively assessing the consequences of risk is, precisely, what led to the use of the participation-based qualitative methods laid down in the following reference methodology:

> "To minimize the level of uncertainty around qualitative assessment, it is necessary to resort to the highest number of experts with different profiles and knowledge of the subject and the application of analytical techniques such as expert panels, focus groups, Delphi questionnaires, etc. This is especially important if it is borne in mind that uncertainty can originate from a variety of sources in a climate change context" [74] (p. 56).

Instead of contrasting the visions of the technical personnel and the stakeholders in the spaces created for debate, the "technocratic" bias has been applied *ex-post* to the diagnostics and the proposals, and with such great authority that the final results contradict those of the participation process.

The described process clearly corresponds to so-called *technocratic path dependence* [14,25,38–40]. This is one of the main barriers found in this case and has had direct consequences for the decision-making processes in the framework of the climate action plans. We understand that, inter alia, this difference in risk assessment comes from a pre-existing plan that already envisaged heavy investments, the EMASESA Investment Plan (2015–2019). So, investment efforts in the analyzed plans are mainly directed at *gray actions* (89%) rather than *green actions* (10%) and *soft actions* (1%). Moreover, these measures will mainly be aimed at improving the ability to tackle risks related to internal flooding, despite there being a consensus on its assessment as less severe. The *path dependence* concept, therefore, leads to self-reinforcement that is detrimental to the creation of climate-sensitive infrastructure and, consequently, makes NbS implementation difficult [25].

Another of the identified barriers can be added to this, which is the mistrust of NbS due to the lack of experience and *fear of the unknown (operational performance)* [37,41–43]. This aspect would be related to the political model that promotes pilot experiences and isolated technological *niches* (Expo 1992, Cartuja Qanat, and Life WaterCool projects), focused on the prestige of the sponsoring institutions—including sectors of the academic community—but that does not lead to adaptation mechanisms being rolled out to all parts of the city, least of all the areas identified as the most exposed and vulnerable. Rather than these sophisticated experiments, the interviewees value traditional solutions linked to urban greenery and the lack of green spaces is identified as an exposure factor that exacerbates the problems in the most vulnerable neighborhoods.

The city not only possesses infrastructure, but it also possesses knowledge, experience, and local, technical, and community culture, which, despite being tempered by confidence and a false sense of security, nonetheless, continue to be a component of the local identity. This characteristic of the local culture appears to be a possible trigger for *valorizing and exploiting the existing tacit and expert knowledge* [48,49] but it requires *community engagement, empowerment, and participation* through *collaborative governance approaches* [40]. For this, the

transition initiatives require sufficient resources to be made available to them, such as time, budget, space, or a political mandate to enable changes toward sustainability [13]. In our case, the extant will and knowledge of the implementation of NbS promotion policies are not being sufficiently exploited. No stable frameworks exist for collaboration with citizens or the local scientific community. The failure to convene the participatory organs is systematically denounced and, when it is achieved, the contributions made are not properly translated into political action.

The factor that the greatest number of interviewees recognize as the city's main weakness at the current time is the *lack of political and public will* [40]. This is related to the interviewees' little confidence in the plans being fulfilled and there is a general sensation that they are neither effective nor will be realized. Despite Seville being the first large city in Spain to endorse the Climate Emergency Declaration (2019), this position has not been turned into specific strategies. The Council did set up some workgroups that involved social organizations but they were devoid of any meaning, since the heads of the relevant municipal areas did not attend as they did not recognize these spaces for dialogue. This is clearly related to the barrier regarding the existence of *sectoral silos* [12,14,44–46] that result in a lack of coordination and involvement of the municipal departments directly responsible for implementing NbS, except for the case of EMASESA, which is generally rated positively. A failure of leadership has been denounced, as has the lack of "a human team in the Council devoted to these issues" (interview #1).

HCR adaptation planning or strategies, such as NbS, which work on the boundaries between different scientific disciplines and between science and policy [9], often may not fit into the traditional structures of city departments, which have defined as fields of duty and restricted responsibilities. From the point of view of case study research, this lack of inter-organizational coordination, which is one of the most commonly identified barriers to transition [40], generates a major limitation due to the information sources being fragmented.

In the case of Seville, the problem is twofold. On the one hand, although the two deeply analyzed municipal-scale plans are supposed to contain all the measures envisaged for adapting the city to CC, we have identified some actions undertaken by municipal departments that are not included, i.e., extraordinary social resources in periods of extreme temperatures. On the other hand, there is no department responsible for monitoring the degree of implementation of the plans and all the measures envisaged, which makes it difficult to assess the real progress made. In these senses, our case study confirms that learning and institutional adaptation should be an important focus of policies. This will require public policymakers to assume a new role, that of an enabling actor and catalyst rather than a regulator or sponsor of technology [26]. Another limitation, or a greater difficulty for drawing firm conclusions, that we can point to is that the chronological scale of the case combines two very different perspectives, which are as follows: first, Seville's long history of measures to address HCR, of which we have some confirmed facts and data that allow us to assess the actions undertaken and the obtained results, and second, some recent experiences located in very dynamic socio-ecological processes, framed in the context of the uncertainty surrounding climate change. Under these conditions, the conclusions must be presented with great caution.

The socio-technical transition toward a paradigm of greater sustainability and resilience in which NbS play a relevant role is a process driven by global physical and discursive mechanisms, influenced by local social constellations and cultures. There are abundant theoretical and methodological contributions on the topic that are continually being discussed and enriched. Nonetheless, it is imperative to dig deeper into specific highly-significant processes to confirm and refine the results in a contextualized way. This is the goal of this paper, which is the result of a three-year empirical study, based on profound previous knowledge of the selected case study (Seville). The paper's results demonstrate the usefulness of theoretical debates, which do not replace but rather guide the understanding of spatially contextualized historical processes.

## 6. Conclusions

Improving the knowledge of ecological transition processes against the backdrop of climate change continues to be a fundamental scientific challenge. This is the context in which this paper aims to make some contributions to the field of research.

To contribute to these discussions on ecological transition theory, Seville first brings the specific experience of a city with a long history of major disasters that are deep in the memory and collective imaginary of the population, a factor that has to be taken into account. Second, the long-standing policy of solutions based on large-scale infrastructure with major social inequalities and high economic costs has resulted in a robust drought and flood defense system, even though it is currently questioned in today's scenarios of climate change and social dissatisfaction. An analysis of the planned investments in the city over the coming years shows that, even though NbS proposals obtain the highest social rating, infrastructure strategies continue to be the preferred solution and, meanwhile, their trade-offs are ignored. Finally, the city encompasses social sectors that have been generating ideas and promoting NbS to HCR for decades, on the margins of and even in confrontation with the institutions that neglect their needs.

One of the most noticeable characteristics of the HCR planning processes that institutions are currently developing is that the plans lack a rigorous analysis of the factors that shape vulnerability and risk exposure. Among other things, they are missing the fundamental aspects of the geographic context from a socio-environmental point of view. Although a broad consensus exists around the identification of vulnerability with poverty, social vulnerability factors are not taken into account in the main plan's evaluations of the spatial distribution of risks. Therefore, the absence of a suitable territorialized analysis of the starting point makes it difficult to identify the system's weaknesses and, consequently, the most appropriate actions to turn them around.

However, the ability of some administrations that are directly responsible for managing CC to negotiate forms of resilience, such as EMASESA, cannot be ignored. In fact, new debates have emerged in the participation processes around the public water company's CEP. The existence of these spaces may imply that these administrations have a certain ability to generate negotiated resilience, although the impact of social actors on the content of the plans is also limited, even in this case.

To sum up, the results of this research show that the generation of shared visions needed for this paradigm change clash, first with the still conflicting and confusing perceptions of the city's strengths and weaknesses in dealing with risks; second, with the weaknesses and contrasts between institutional discourses open to change and practices conditioned by inertia and networks of interests, and lastly, with the operational limitations of public participation processes.

Nevertheless, even in a city with such an entrenched history of infrastructure and technocracy as Seville, the growing evidence of HCR compels us to advance in more adaptive and resilient strategies focused on NbS. The case study shows the ability of bottom-up civil society initiatives to drive NbS that enable the building of a city better tailored to HCR and that also generate community resilience through social benefits in the form of a sense of place, empowering communities, and establishing ties between social groups. The vitality and ability of community actors to influence this process will determine just how consistent and fairly distributed these advances are in the near future.

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