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Learning in, with, and through the Territory: Territory-Based Learning as a Catalyst for Urban Sustainability

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Abstract: Territorial problems such as the socio-ecological degradation of urban rivers represent a great challenge to achieving sustainability in cities. This issue demands collaborative efforts and the crossing of boundaries determined by actors that act from diverse spheres of knowledge and systems of practice. Based on an integrative territory notion and the boundary approach, the goal of this paper is to comprehend the boundary crossings that take place in multi-actor initiatives towards the resolution of this problem and what type of territorial transformation is produced as an outcome. Our analysis is built on participatory research on the Taquara Stream case, a degraded watercourse in a socio-ecologically vulnerable area, in southern Brazil. Our data analysis applied a visual chronological narrative and an interdisciplinary theoretical framework of analysis that combined concepts related to the territory (geography) and the boundary approach (education). We verified that local territorial issues functioned as boundary objects, fostering and facilitating dialogical interaction among involved actors, knowledge co-production, and collaborative practical actions that led to changes in the territory in terms of practices, comprehensions, and physical concrete transformations. We framed this study as one of territory-based learning meant to advance the understanding of territorial intervention processes towards urban sustainability.

Keywords: urban sustainability; vulnerable communities; territory; boundary crossing; boundary objects; brokers; social learning; knowledge co-production

1. Introduction

Environmental degradation, social inequalities, and socio-spatial segregation feature amongst the biggest challenges to achieving more sustainable urban environments [1–3]. In the Global South, one of the recurring manifestations of these challenges is the informal, unplanned occupation of the riverbanks by marginalized social groups, characterizing areas of social, ecological, and economic vulnerability [2–5]. The frequency, severity, and complexity of the ecological and social aspects of urban river degradation-related issues point to the need for advancements in the development of technical and socially inclusive processes towards the balance between ecological and social systems, improved social justice and quality of life for local communities, and sanitation infrastructure and housing provision [3,5,6]. Responses to this multifaceted problem call for integrative approaches and concerted actions carried out by diverse social actors (e.g., local communities, public and private sectors, educational institutions, civil organizations, etc.) acting upon and in a given territory from

different interests, forms of knowledge, systems of practice, capacities for articulation, and influence in decision-making [7–11].

Territory is understood here as an entity emerging from the interconnected dynamics between society and nature [12,13] and regarded as an important concept for critically reflecting on the socio-environmental processes enacted by initiatives towards urban river regeneration. The territory is formed by the interplay of diverse systems of practice, ideologies, and forces engendered by the social actors interacting and co-producing these evolving socionatural spaces [14]. It implies diverse modes of collaboration, forms of appropriation, and power relations [15,16]. From this standpoint, we argue that initiatives aiming at the transformation of the harsh reality engendered by the degradation of urban rivers must be comprehended not just in terms of the desired concrete biophysical changes they should achieve but as actions embedded in territories that deal with territorial issues and all the complexity conveyed by this notion.

The search for solutions to such territorial problems implies collaborative efforts and the crossing of boundaries established by actors that act relatively independently from diverse spheres of knowledge and practice [9,11,17–19]. Such boundary crossing can take place when a group composed of representatives of different social actors act in concert, interact and conduct dialogue, critically reflect together, and collectively learn [20,21] so as to co-create sustainability-oriented solutions to tackle urban river-related issues. In cases of socio-ecologically vulnerable territories situated along riverbanks, particularly in the Global South, there seems to be greater complexity of articulation between a diversity of social actors in solving such issues. In these contexts, wide social, economic, technical, and epistemological disparities between them make interactive practices and dialogue more difficult [22]—at least marginalized groups inhabiting streambanks have limited opportunities for their participation in decision-making processes [5,6].

Against this background, the goal of this paper is to comprehend what boundary crossings are generated by different social actors engaged in the socio-ecological regeneration of degraded urban rivers in vulnerable areas as well as what elements contribute to such crossings and what type of territorial transformation is produced by them. With this aim, we propose to analyze the case of the Taquara Stream, located in the city of Porto Alegre, in southern Brazil. This case has received attention as it comprises a group composed of representatives from the local community, the public sector, and academia that are acting coordinately and collaboratively to find sustainability-oriented solutions to overcome the territorial challenge posed by the degradation of the Taquara Stream. This paper proposes, thereby, to interconnect concepts from the fields of education and geography, by linking the learning generated by the interaction and crossing of boundaries between involved social actors in this case, with the territorial dimension. We observe that the proposed correlation is still scarcely explored; thus, we intend to leverage existing conceptual tools in order to obtain new insights and comprehend, from a transdisciplinary perspective, processes involved in territorial interventions aiming at the socio-environmental transformation of local realities towards sustainability.

2. Territory and Learning at the Boundary

Territory is defined here from an integrating perspective. It is conceived as a complex interaction, in space and time, between society and nature; between politics, economics, and culture; and between materiality and "ideality"—a common notion amongst geographers, e.g., [12,14,15,23]. From this standpoint, the territory emerges from the relations between the biophysical environments and the individual, collective, and social actor(s) involved in its production and re-production. Social groups develop a specific way of relating to a given environment, according to their ideologies, knowledge, systems of practices, and socio-economic and political power [14], resulting in different forms of control, dominance, and/or appropriation of the territory [13]. Territories are produced by internal and external forces that are in constant tension. Internally, there are forces emanating from individuals and groups acting within specific geographical limits (e.g., the watershed), based on local rationalities. Externally, there are forces arising from wider or broader contexts, based on external rationalities,

which are projected onto the territory, also determining it (e.g., government rules, decision-making authority, or macroeconomic systems) [12].

With regard to territories that encompass degraded urban rivers, particularly in the Global South, there seems to be a complex interaction of internal and external forces leading to such a problematic situation. Broadly, this condition is engendered by intricate factors such as striking socio-spatial inequalities, great imbalances in income distribution, and uncontrolled urban growth [3,24]. Economically disadvantaged segments of the population unable to acquire "legal" land eventually occupy illegally lower market value or inappropriate areas [25], such as permanent preservation areas along rivers. Informal settlements in these areas normally present precarious housing conditions, huge deficits in sanitation infrastructure provision, direct disposal of sewage and solid waste in water bodies, increased risk of flooding and landslides, as well as exposure of populations to waterborne diseases [3,26]. Such spatial inequality related to land access also implies an unequally distributed geographical location of risks since segments of populations inhabiting areas of environmental degradation are most susceptible to being affected by the intensity of climate change effects and extreme weather events [27]. The production of these irregular occupations also stems from omissions by the public sector both in terms of failure in the application of land use regulations and in effective inspection actions over riverine areas [28,29]. Inefficient housing policies and/or the inability or unwillingness of local and national governments to provide social housing for the poor, inadequate water and waste management, lack of financial resources to invest in needed social and physical infrastructures, as well as inefficiencies in environmental governance systems are also observed [2,4,5,30].

Based on the presented notion of territory, we argue that responses to overcome the degradation of urban rivers in contexts of social, economic, and environmental vulnerability require not only the comprehension of the forces that produce such situations but also a complex articulation among involved actors and their practices to transform these territorial realities. Within this rationale, we identify formal and informal practices to tackle this territorial issue. The formal ones are associated with planning and management mechanisms employed by the public sector, which are normally top-down oriented [31,32]. On the other hand, there are practices that we refer to as informal or bottom-up oriented. They do not constitute a unified movement or technique but, in general, are characterized by a citizen participatory base that has an experimental character, entailing a "do-it-yourself" approach, and applying immediate and even "acupuncture" modes of intervention in circumscribed spatial scales and short time horizons [33–36].

In contexts of economic constraints and socio-ecological vulnerability, responses to river issues are unlikely to be achieved through solely community-based efforts or bottom-up oriented initiatives [19]. At the same time, formal or technical interventions are generally top-down oriented and arguably lack in promoting participative democracy, territorialized agendas, social conflict resolution, social cohesion, and emancipation and autonomy of local communities [32,35]. The literature on urban and development studies has shown consistently that participation of disadvantaged groups is a highly unequal process [37]. Disadvantaged communities illegally occupying urban riverbanks are, to a great extent, social groups that do not have significant political representativeness, being usually excluded from effective political participation in decision-making processes and rarely involved in problem analysis as to identifying locally suitable solutions to develop their biophysical environments in a socio-ecologically balanced way [5,6]. Therefore, it is particularly important for the success of actions in these riverine territories to not only offer feasible and effective short-term solutions to people who live in extreme precarious situations but also engage them in a broader debate that goes beyond purely technical approaches [5,38].

In this sense, joint efforts based on the interplay of formal and informal practices to regenerate urban river territories as well as forms of organization that facilitate cooperation between specialists and laypeople and between local governments and disadvantaged communities appear to be key in addressing this problem [8,12]. Collective initiatives with this aim demand, however, the integration of actors that act from widely different spheres and employ diverse systems of practice. For this reason,

we consider the interdisciplinary notion of boundary—largely used in educational theory [20,21,39,40]—useful to understand practical initiatives that integrate multi-actors and the crossing of their boundaries so as to generate learning and desired territorial transformations. Boundary is understood here as a "sociocultural difference leading to discontinuity in action or interaction" [20]. Discontinuity is commonly used to refer to actions or interactions that require considerable effort to occur or to situations where people or groups face a problem caused by a difference in practices [21].

Due to the recurrence of such challenges in real contexts (e.g., in health care contexts, school–work relations, higher education domain, field of technology and design, etc.) several studies have sought to understand ways of promoting continuity in action and interaction [41–44]. To this end, the concepts of boundary crossing and boundary objects are considered fundamental. Boundary crossing refers to the "efforts to establish or restore continuity in action or interaction across different practices" [45] (p. 225). The concept of boundary objects, in turn, refers to artifacts "that articulate meaning and address multiple perspectives" [20] (p. 140) or that have a "bridging function between various practices" thus facilitating the crossing of boundaries [46] (p. 393). People also play a key role in crossing boundaries. In this process, individuals who participate in different practices and bring elements of one into the other represent the basic level of interaction [21] and have been referred to as brokers, boundary crossers, or boundary workers [47–49]. People in those positions face the challenge of integrating elements from diverse boundaries to achieve learning and hybrid situations [39].

Akkerman and Bakker [20], drawing from a systematic literature review of theoretical and practical research on boundary crossing and boundary objects, have systematized four main learning mechanisms that capture the different ways through which crossings of boundaries trigger processes of learning. The authors described the mechanisms of (1) identification (generated by the mirroring of different or complementary practices and/or agents roles identities likely leading to renewed insights); (2) coordination (stimulated by procedures for the maintenance of effective cooperation between practices in distributed work but usually requires minimal face-to-face interaction); (3) reflection (promoted by mutual reflection of people or groups likely leading to perspective making and taking); and (4) transformation (triggered by a shared motif, which can potentially promote a profound change in practices or even the emergence of new ones). It should be noted that we adopt in this paper an understanding of learning in line with Akkerman and Bakker [20], which is related to the production of "new understandings, identity development, change of practices, and institutional development" (p. 142).

Drawing from the literature on boundaries as well as on the idea of territory—from the viewpoint of a biophysical base that is tensioned by multiple forces, apprehended in different ways and transformed from different systems of practice—we have developed a framework of analysis that is presented in the methods section, after the case of the Taquara Stream.
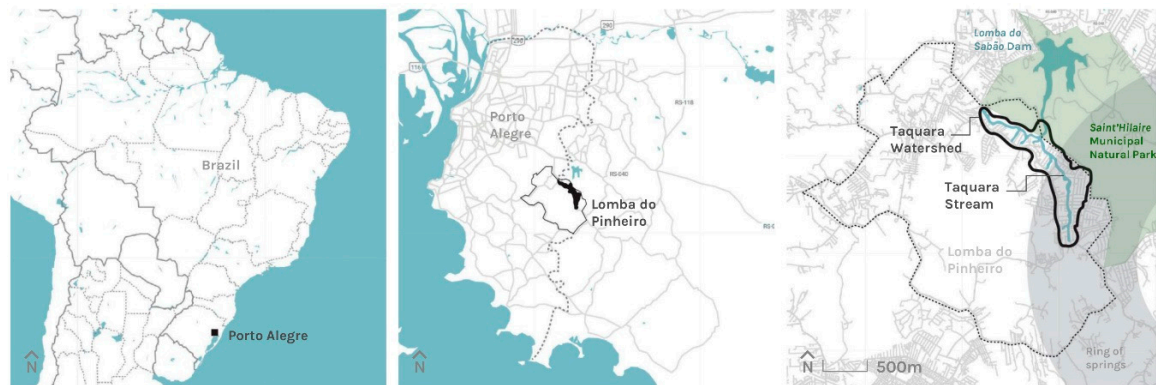
3. The Taquara Stream Case

This analysis is built on the case study of the Taquara Stream, located in the city of Porto Alegre, in southern Brazil (Figure 1). It was selected as representing the reality to be investigated: A collective process, wherein a group composed of diverse social actors is acting coordinately and collaboratively to find sustainability-oriented solutions to recover a degraded stream in a socio-ecologically vulnerable area.

The Taquara Stream (approximately 2.8 km in length) presents its spring and a major part of its course in the most urbanized area of Lomba do Pinheiro neighborhood, which is adjacent to an ecological protected reserve (Saint'Hilaire Municipal Natural Park), containing part of the "Ring of Springs" of the city and the Lomba do Sabão Dam [50]. The Taquara Stream is a constituent part of this ring and of the dam's formation. It is estimated that a population of 20,000 inhabitants live in its watershed. Over recent decades several interrelated problems have made the Taquara streambanks socially and environmentally vulnerable: (a) Informal occupation and consequent suppression of the stream's riparian vegetation; (b) wastewater directly discharged into the stream by a great number

of dwellings located in the streambanks; and (c) solid waste disposal on the watercourse. As a result, part of the population living in the watershed is at risk of flooding and being exposed to pollution-related diseases.

Due to this situation, as an outcome of local articulations with representatives of the public sector and university, the Taquara Stream Watershed Working Group (WG)—composed of members from the local community, the public sector, and educational institutions—was set up in 2015 with the goal of developing actions for the socio-ecological recovery of this watercourse and the area comprising its watershed, through participatory and collaborative processes.

Figure 1. The city of Porto Alegre, Lomba do Pinheiro neighborhood, and the Taquara Stream Watershed.

4. Methods

The overall research strategy adopted for the investigation of the Taquara Stream initiative was the case study. It was an empirical investigation, and the case was chosen due to its unique socio-environmental characteristics [51]. The case was the subject of a participatory research project conducted by the lead author of this paper between 2015 and 2019. Data gathering focused on three dimensions of interest of this initiative: The individual (focused on engaged individuals and their roles in the process), the collective (focused on the leading group of the initiative and their collective learning practices), and the territorial (focused on local socio-environmental practices; institutional regimes, norms, and routines; and social, economic, political, and cultural factors connected to the local problem). While this multi-dimensional framework was considered, the focus of the analytical work and the discussion was on the collective dimension. Particularly, the transformative and social learning processes that took place in the Taquara Stream case within the leading group of the initiative were investigated, see [18,19].

The territorial dimension, nevertheless, was found to have a potential for further exploitation. For this reason, and for its identified relevance, in this paper we revisit the produced database, using additional theoretical lenses. Hence, we further explored concepts related to the notion of territory, and, in particular, how internal and external forces acted in and upon this dimension as well as how actors with distinct systems of practice interacted, engaged, and learned with and from each other to solve the territorial problem. When discontinuities between these systems were detected, we considered the concepts related to boundaries [20]—understood as dialogical phenomena—as an appropriate tool for analysis of the local process within the territorial dimension.

In the following section, we detail original data gathering procedures and subsequently explain how existing information is currently analyzed in this paper.

4.1. Data Gathering

The participatory research carried out by the lead author applied a range of methods, such as participant observation, in-depth and semi-structured interviews, focus group conversations, and secondary data gathering (e.g., public sector records, cartographic materials).

The participant observation was carried out during a period of approximately 18 months (between May 2016 and December 2017); the lead author engaged the initiative as both a participant and researcher. A field diary and observational protocol were adopted to register field observations. The presence of the author was fundamental to understanding the process through direct experience and establishing trusting relationships with the participants to obtain valid responses. The community also benefited from the researcher's support in the development of local solutions and actions as well as from the expansion of the initiative's network.

Individual and focus group interviews were conducted with a limited number of participants from the group leading the initiative. Eleven participants were selected accordingly with the following criteria: (1) High attendance at the leading group's meetings; (2) key roles in events carried out in the community; (3) ability to foster connections with other collaborators. It should be noted that the group of respondents includes at least one representative from each social actor involved (see Souza et al. [19] for further participants' details).

Two rounds of semi-structured interviews were held. The first round was carried out between December 2016 and April 2017 (after six months of the researcher's engagement in the initiative) and the second one between December 2018 and February 2019 (one year after field research conclusion). In-depth interviews were conducted in December 2018 with two participants from the local community who engaged in all actions since the initiative was established in 2015. The first focus group was held in September 2017, after larger events carried out by the WG in the community. The second group conversation was conducted in December 2018 and focused on a retrospective assessment of the main activities carried out by the WG since the initiative's set up. It applied a "timeline" methodological procedure, which consisted of a joint recapitulation of the outstanding moments of the project, simultaneously analyzing its challenges, achievements, and experiences learned throughout the process [52].

All individual and collective interviews, as well as field diaries, were transcribed in their entirety, and data were tabulated according to the previously mentioned dimensions.

4.2. Analyzing Data from the Territory and Boundary Lenses

We applied two principal procedures for data analysis in this paper: (1) Elaborating a Visual Chronological Narrative (VCN) and (2) reading of the original raw data using new analytical tools. The VCN aimed at producing a structure for explaining the case as a process [53], establishing connections between themes for action, activities, and processes in the local context over time. This narrative was based both on the researcher's field diaries and on the referred "timeline" elaborated with the participants. The VCN starts with the first action that led to the WG's creation and extends to December 2017, when the participant observation was completed. We also visually represented the local problems in order to make a clear connection with the material dimension of the territory.

Original raw data were revisited based on the elements presented in the first column of Table 1, which also includes the VCN. In regards to the territory, we searched for (1) concrete physical changes, (2) changes in practices (e.g., in formal practices such as changes in public sector routines to tackle the issue and/or in informal practices, such as stream conservation practices carried out by the inhabitants), and (3) changes and/or increased understanding of the territorial issues. We then correlated these changes to the learning processes that have taken place in the case using the boundary theoretical framework [20,21,39,49]. Therefore, we searched for elements that indicated the presence of (1) boundaries, (2) boundary objects, (3) brokers, and (4) boundary crossings. Table 1 presents the verified elements (indicated in columns) within data obtained by the different methodological procedures (indicated in the upper row).

Table 1. Framework for data analysis.

		Participant Observation	Collective and Individual Interviews	Visual Chronological Narrative (VCN)
Boundary concepts	Boundary	Statements in meetings indicating differences and/or discontinuity between systems of practices and/or views. Observation of different systems of practices.	Statements indicating differences and/or discontinuity between systems of practices and/or views.	-
	Boundary objects	Statements in meetings and/or events of specific situations that required coordinated action for their solutions.	Statements of specific situations that required coordinated action for their solutions.	Representation of "problems" that mobilized joint action (displayed in different colors in the VCN).
	Brokers	Observation of people who fostered connections with diverse stakeholders and facilitated integrations of different systems of practices.	Statements of one's experience in fostering connections with diverse stakeholders and facilitating integrations of different systems of practices.	Representation of articulation among representatives from different social actors.
	Boundary crossing	Statements in meetings indicating efforts to establish integration between actions and practices.	Statements indicating the efforts to establish continuity in action or interaction across practices.	Indication of joint actions listed in the activity's legend.
Territory	Concrete physical change	Visual observation/ Photographic record	-	Photographic record
	Change in practices	Statements in meetings indicating changes in practices. Observation of changes in systems of practices.	Statements indicating changes in practices.	Indication of a new system of practice in the activity's legend.
	Change in comprehension of local issues	Statements in meetings indicating changes in understanding of local territorial issues.	Statements indicating changes in understanding of local territorial issues.	-

5. Results

Figure 2 presents the Visual Chronological Narrative (VCN) of the Taquara Stream initiative. The image is organized around a timeline, represented by the central thick line, along which a series of local events (represented by the larger circles) are sequentially positioned. The dark grey rectangle indicates the biophysical limits of the Taquara Stream Watershed and makes a distinction between activities that occurred within the watershed's spatial limits from those related to the local problem but that occurred elsewhere in the city.

The VCN starts with the "Diagnostic Walking" along the Taquara Stream, which resulted in the creation of the Taquara Stream Watershed Working Group (WG). This activity was promoted by the Lomba do Pinheiro Community Garden in partnership with the public university. The outcomes of the activity were presented at a meeting in the garden in which members of the community and public university and technicians from the public sector participated (e.g., health and water and sewage departments). At that time, the WG was created.

Figure 2. Visual Chronological Narrative (VCN) of the Taquara Stream initiative.
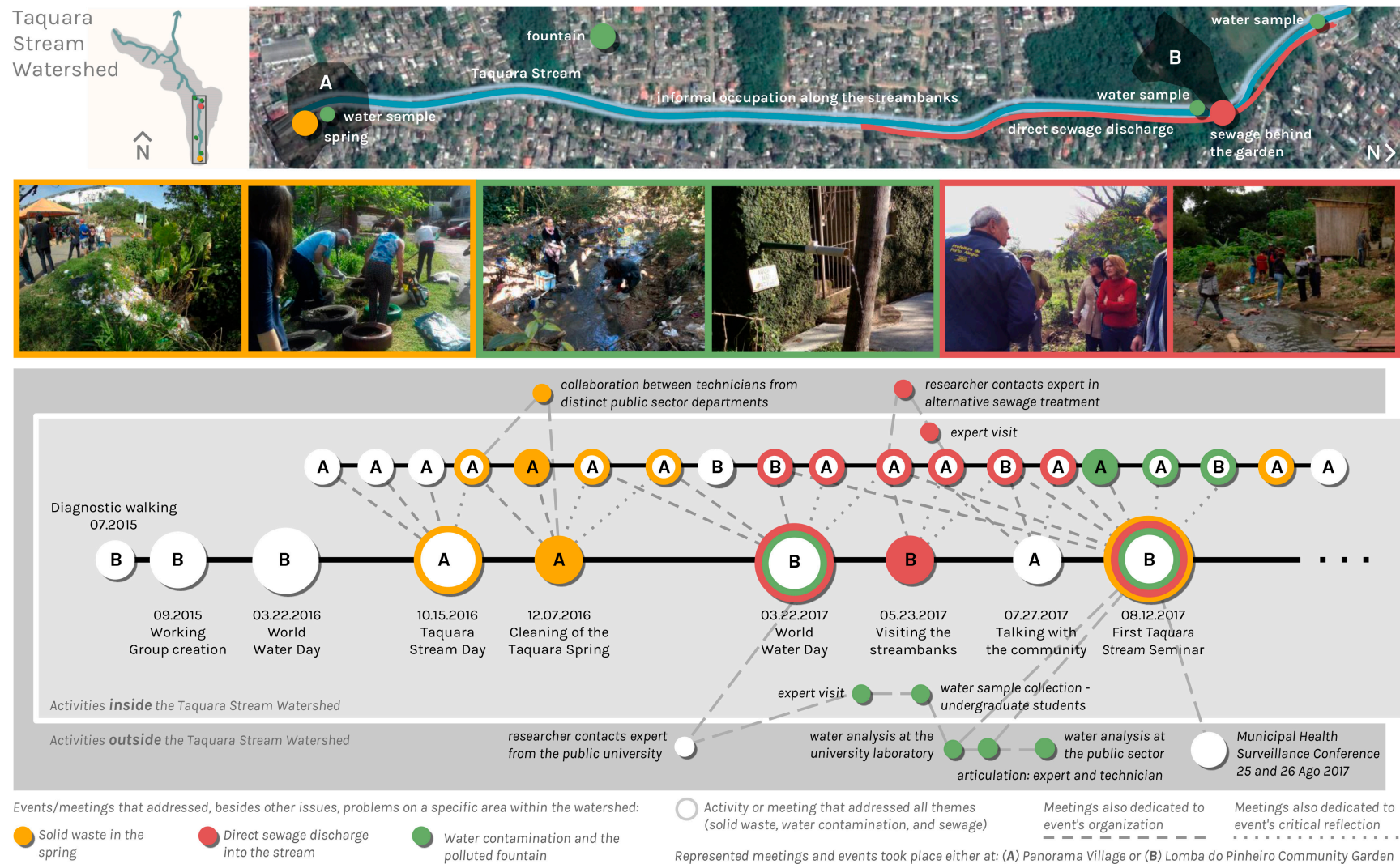
Since its creation, as well as carrying out the events displayed in the central line, the WG has been conducting regular meetings in the community. The meetings (represented by small circles in the line above the events) were focused on the organization of actions, discussions on local issues, and moments of joint critical evaluation of the events. The events aimed at sensitizing and creating dialogue with the local population and stakeholders on the Taquara Stream issues as well as promoting joint actions to improve the social and environmental conditions of specific areas along the watercourse. It is worth mentioning that first group meetings were largely focused on developing and discussing participant's points of view and values so as to define common goals and guidelines for the initiative's work. However, the continuous expansion of the initiative's network and inclusion of new participants throughout the process led to a review of first established aims and the addition of new ones.

Both the events and meetings are circumscribed within the biophysical limits of the Taquara Stream Watershed as well as parallel activities (in smaller circles), promoted by representatives of the public sector and the public university. Outside the watershed limits, we have represented activities that involved a reduced number of participants, carried out either in public sector departments, expanded discussion forums in the municipality, or the public university. The circles' colors when depicted in white indicate that wide-ranging issues have been addressed and, when colored, represent that a specific localized issue in the territory has been addressed.

5.1. Articulating Conceptual Analytical Tools within the Case

This section articulates the conceptual analytical tools related to the boundary theoretical framework, as outlined in the methods, to the Taquara Stream case so as to interrelate the learning processes triggered by the local initiative to the territorial dimension.

This case articulates the joint action of three social actors: The community, the public sector, and academia. For the community, we refer to the inhabitants of the Taquara Stream Watershed and their practices within its biophysical limits; for the public sector, we refer to its different departments and their practices on site; and for academia, we refer to two public universities and their practices promoted through the participatory research conducted by the first author (linked to a university in São Paulo) and academic activities conducted by the School of Ecology of the local public university.

We have identified from the content analysis of individual and collective interviews and participant observation notes that discontinuities defining boundaries between these actors were mainly associated with differences in (1) language used between the groups; (2) practical ways of dealing with the territorial problem (systems of practices); and (3) ways of knowing and understanding the territorial problem.

Our data analysis also suggested the existence of other internal boundaries within the major ones between the involved social actors. We have observed internal boundaries within the community sphere related to (1) differences in practices between mobilized and non-mobilized residents (e.g., the ones who dispose waste in the stream and the ones who do not); (2) social differences (e.g., cultural, income-related, etc.); and (3) spatial distances between the residents themselves (e.g., the ones who occupy the streambanks and the ones who do not). Within the public sector, disarticulation between the different departments' routines were observed (e.g., non-integrated actions between the water and sewage and urban sanitation departments). Within the university, internal boundaries were related to the different fields of knowledge (e.g., fragmentation generated by the disciplinary compartmentalization of knowledge). Such discontinuities were perceived by participants as constraints towards a cohesive work aimed at promoting regenerative practices to overcome the local problem in this specific case.

In the following sections, we analyze and discuss the case from the main boundary object, which corresponds to the very territorial problem of the Taquara Stream Watershed, and specific ones, which are featured as specific territorial issues that compose the larger problem, driving particular articulations and processes in the case, as elements that enabled boundary crossings [20].

5.2. The Main Boundary Object: The Degradation of the Taquara Stream Watershed

The "Diagnostic Walking", the first event represented in the VCN, led the participants to confront the degraded conditions of the Taquara Stream. The confrontation with a real problem is described in the literature as the first compulsory step to trigger the learning mechanism of transformation, which imposes the need for intersecting practices to rethink their systems of operation and forms of relationship [20].

The conditions of the stream were discussed in the second event, in which representatives of the community, public sector, and academia recognized the existing territorial problem as a "shared problem space" [54] whose resolution depended on their integrated action; consequently, the WG was created. Such recognition usually follows the confrontation and provides the needed direction for the transformation that must emerge out of the practice systems integration [20]. Since the territorial problem of the Taquara Stream was the main reason for a joint activity that brought together different actors and systems of practices, we have classified it as the "main boundary object" of this case. The speech of a university professor that joined the group reinforces our argument:

"From the identification of the local problem, it is possible to articulate, within the WG, a network by activating the participant who can act from this integrated view shared by the group. The WG coordinates a series of actions carried out by people based on their fields of knowledge, which would otherwise be disconnected if the WG did not exist."

Particularly, in this specific case, as well as found in other cases reported in the literature [41,42,55,56] we also noticed that language-related boundaries as well as the different views on the problem were very pronounced between involved social actors, since it is (1) a typically multifaceted territorial problem involving many different actors and (2) takes place in a vulnerable context in which there are accentuated cultural differences.

The WG functioned as an integrative platform that enabled coordinated actions and dialogical interaction between the diverse representatives of the social actors. It should be emphasized that direct interaction and dialogue between stakeholders operating across distinct boundaries are deemed to be essential in the transformation mechanism as described in the literature [39]. The WG promoted social learning-oriented practices through which dialogical interactions took place. In this case, dialogue was facilitated by factors such as (1) informal interactions in a friendly atmosphere; (2) climate of mutual trust among participants; (3) balanced participation of members; and (4) a perceived egalitarian atmosphere between participants [19]. In the individual interviews the participants reported that the quality of the group interaction was not hampered by the existence of asymmetrical power relations. They attributed this to a personal predisposition of WG participants to conduct a highly horizontal process guided by listening and dialogue [19]. They also acknowledged that the WG enabled the equalization of diverse existing languages in the group (e.g., popular, technical, and academic), thereby facilitating the integration of different forms of knowledge in order to co-create solutions to the local problems.

As such, dialogue among participants created a means for boundary crossing to the extent in which it promoted perspective making and taking among them, characterizing the learning mechanism of reflection [20]. Such a mechanism implies boundary crossing when individuals or groups become aware of variances between their practices and own perspectives by mirroring them in relation to others' perspectives and practices [21]. In the Taquara's case, all group members reported in individual interviews having both changed their perspective on the local problem by being confronted with other participants views and/or expanded their knowledge on the problem. Our comparative analysis of the interviews as well as observations of how participants manifested their views on local issues over time, demonstrated this progressive growth in problem comprehension. The following statement by a dweller that joined the group demonstrates this point:

"There is a difference in how I thought about the problem before and after the WG. If, in the past, I approached a person, for example, a neighbor, and tried to explain to this person that we are dealing

with the stream in a wrong way, I would not even know how to explain it, and this person would not even understand me. Today, I can give alternatives and I can explain the problem."

Furthermore, our data analysis suggests that the WG enabled the emergence of a specific type of broker. A broker here refers to a participant who is able to make connections between different systems of practice and/or to make further connections with other supporters for specific contributions to facilitate local solutions.

In the following sections we critically analyze three practical actions carried out by the WG and different ways through which boundary crossings occurred, consequently resulting in different types of territorial changes. These actions sought to generate tangible results such as cleaning up stream sectors and developing and implementing strategies for local sanitation, as well as for establishing dialogue with groups living on the streambanks and producing knowledge about local territorial issues. These specific experiences took place at different locations in the Taquara Watershed (see VCN), within the timeframe of the conducted participatory research.

5.3. Solid Waste in the Spring as a Boundary Object

The issue of solid waste in the spring was identified through the action "Taquara Stream Day" (see VCN). The spring where a large amount of solid waste was dumped is located alongside the street where the event took place. During the event, there was a confrontation with this concrete problem as it was visible to the various participants.

On this particular activity, it became apparent that when held in open spaces, the events brought, simultaneously, different actors into contact with local problems, provoking questions and spontaneous debates in the local territory. In this occasion, the reflection on the causes and possible solutions for the waste in the stream's spring led the actors who act from different vantage points to observe their practices in interrelation aiming at finding a prompt and practical response. For this reason, we argue that this particular problem in the territory was itself a boundary object. In this respect, we emphasize the potential of open events with a broad theme in the local territory, involving multiple actors, for the identification of issues and the emergence of articulated actions for their resolution.

In a WG meeting following the event, the group organized a collective cleaning action of the spring area. It was observed that this articulation produced both boundary crossings between the involved actors and within their spheres of practice. In the public sector sphere, internal boundaries were crossed through the articulation between technicians from different departments to obtain the necessary material resources to carry out the action. At the community level, internal boundaries were crossed to the extent that residents engaged in the initiative, and non-engaged residents interacted in this action. Here we note the crossing of boundaries simultaneously occurring at an institutional level (by the articulation between different departments) and interpersonal level (by the collaboration between technicians and residents) yet not what is referred to in the literature as a crossing at an intrapersonal level, since neither participant is simultaneously engaged in two systems of practice (this would be the case, for instance, if one of the technicians were also a resident) [57].

The joint cleaning action was considered, as reported in individual and collective interviews, as an effective way to integrate people with different languages and forms of knowledge into a concrete and hands-on activity that facilitated exchanges between participants, which might otherwise be hindered by exclusively dialogic interactions as observed in the WG meetings. Notably, this approach was pointed out by the interviewees as being generative in stimulating a broader engagement of the most marginalized segments of the population, who often seem to have difficulty in engaging in more theoretical debates. Agramont et al. [22] call attention to the great epistemological disparities between diverse social groups brought together to collectively solve water-related issues in vulnerable areas and the importance of utilizing diversified ways to engage them so as to overcome such differences.

As a concrete result of this action, a public garden was built in a place formerly perceived as an abandoned waste disposal area. Following this action, a considerable reduction of solid waste discharged into the area was observed, which denoted a change in practices of residents that inhabit

the immediacies of the spring. When the improvement was implemented in the territory and a transformation was perceived, residents undertook some form of participation, as exemplified by the dweller next to the spring, who took over the maintenance of the area over time. This is in line with findings of Tidball and Krasny [58], who suggest that the recovery of green areas in shanty towns contributes to promoting social health and well-being of local populations, as they help reverse vicious cycles associated with poverty, crime, and unhealthy lifestyles. This action has also resulted in a more in-depth understanding of the tensions between internal boundaries that exist in the territory and constitute barriers to the problem resolution. This was noticed in the complaints of the resident (at a meeting approximately one year after the action took place) who looked after the area and reported the hostility of those who are still degrading it, albeit to a lesser extent.

In regard to changing in the practices of external agents, it was noticed, as reported in the second focus group and in statements in the meetings, that technicians acknowledged the effectiveness of an integrated and acupunctural action [34], which can potentially establish pathways for co-creating solutions with the community, inspire more pro-environmental community behavior, and foster ownership of the public space. This type of action was henceforth seen as likely to be implemented by the public sector more regularly in situ, as evidenced in the scheduling of new clean-up actions in later meetings.

5.4. Direct Sewage Discharge into the Stream as a Boundary Object

The issue of the direct sewage discharge into the Taquara Stream, albeit a constant topic of discussion since the WG was created, has been directly confronted in the "World Water Day" event (see VCN), when participants walked along its streambanks bordering the community garden. It is worth noting that the community garden itself can be seen as an acupunctural intervention that emphasized the perception of this problem, since this place comprises environmental regeneration practices that contrast with the degradation of the Taquara Stream.

In the WG's subsequent meetings, the impossibility of solving the problem in a conventional way, due to the technical infeasibility of connecting the houses emitting effluents into the stream to the public sewage system located at a level above them, was recognized. The issue provoked an intense debate among WG members on alternatives to tackle it, thus revealing internal knowledge constraints that led the participants to look for additional expertise. In this case, we argue that the sewage problem behind the community garden configured itself as a boundary object insofar as it exposed the need to cross new boundaries by including new knowledge and system of practice, which were not initially visualized.

Therefore, in view of the group's prioritization of sustainable solutions, an expert in local alternative sewage treatment (e.g., small-scale nature-based systems such as bio-remediators) was contacted by the researcher (the lead author). Here we emphasize the influence of the researcher on the local process by inviting an expert who was part of her network (see articulation at VCN). This indicates the significative role of the participatory research in strengthening and promoting advances in this local movement [59] as the researcher became an agent capable of leveraging the crossing of new boundaries. The researcher's role can be associated here with that of a broker, as it facilitated the integration of different systems of practices [49].

Representatives of the WG and the invited expert then visited the site so as to assess the feasibility of implementing an experimental project alternative to conventional city solutions—following the same approach of an acupuncture solution adopted in the previous reported case. This action exposed, however, another set of shortcomings to the resolution of this particular issue: (1) The lack of regulation for small-scale alternative sewage treatments and (2) the population's refractory behavior to this type of solution. The first point led the WG's technicians to question the current practices adopted by the responsible public departments to solve such problems. Regarding the second aspect, the technicians attributed this population behavior to the lack of confidence of these vulnerable communities in actions involving the public sector, given the low level of response from the government to their demands.

The residents who participate in the WG also mentioned that such resistance might be connected to the coercion imposed by the presence of drug trafficking in the region.

In short, although this experience has not led to concrete physical changes in the territory, it has nevertheless generated a change in practices of the WG itself, as far as the group acknowledged the need to broaden its network as to tackle the local issues' complexity. Moreover, it has promoted a deeper comprehension about the hardship involved in dealing with the local issues due to existing barriers imposed by external and internal forces that affect territory. The legal issue involves, for instance, articulations in other territorial management scales (e.g., municipal scale) and implies changing regimes and transgression of practices that hinder concrete advances towards sustainability [60,61]. From the perspective of the internal territorial forces, it involves addressing the deep social and structural disparities that compose this local challenge [24].

5.5. Water Contamination and the Polluted Fountain as Boundary Objects

The lack of updated quantitative data on the Taquara Stream's water quality was frequently reported by technicians and residents at WG meetings as a shortcoming in their comprehension of the extent of the stream's pollution. We have considered this issue as another boundary object that mobilized the WG to seek further expert assistance to tackle the problem—the same procedure adopted in the previous experience. The researcher (the lead author) contacted, therefore, an expert professor in water analysis (see VCN) from the School of Ecology of the public university who works with action-oriented research in vulnerable community contexts. The expert proposed to carry out her course on "Water Contamination" based on this case, which then enabled the linking of the initiative with the public university.

Thereafter, an action involving the expert and members of the WG—the researcher, a community leader, and a technician from the water and sewage department who develops sanitation works in the neighborhood—was set up as to identify points for water sample collection. This action revealed the significant input of participants familiar with the area (particularly the technician and the resident) in identifying the most relevant sites for collecting samples, which otherwise would not have been easily identifiable; this indicated a boundary crossing between local and technical knowledge in this particular situation. Furthermore, an articulation between the expert and the technician enabled the sample analyses both in the university laboratories and in the water and sewage department (see VCN) in order to generate comparable and validated results. This activity in partnership between the university and the public sector, spheres that traditionally do not act in cooperation, denoted another boundary crossing promoted by this experience. The results of the water analysis showed that there was a high level of pollution in all samples. These included a water fountain (located in the area marked by a green circle in the aerial image of the VCN), which was used by the population of the surroundings as a source of water supply.

This particular case, as well as the previous one, did not result in concrete physical changes in the territory. However, due to the results obtained in the analyses, there have been changes in the practices of the health surveillance department, which, besides interdicting the fountain, has implemented a routine of monitoring its water quality. Additionally, the community leader, along with members of the community, astonished by the fountain's non-potability, have tried to identify its contamination's origins. Consequently, a change in comprehension on local issues was noticed, since the fountain water quality, hitherto perceived as a one-off element in the territory, has become observed as being the result of more comprehensive territorial dynamics.

As apparent in this last case, and from a retrospective view of the three described experiences, it is possible to notice a form of learning that feeds back from the practical interventions on site and dialogical interactions between participants. In other words, each new action on a particular problem that has interfaces with the general territorial issue provided in-depth understandings and uncovered facets of the issues addressed, thus outlining and/or refining approaches to deal with them. We also emphasize that, according to statements and observations gathered during the fieldwork, participants

found the initiative to be successful in terms of its continuity over time. This continuity apparently was not hampered by the adversities imposed by a context of socio-environmental vulnerability, but rather benefited from the recognition and increased interest manifested by other groups that joined the process (e.g., academic groups), and the greater understanding of participants of how to deal with local issues.

6. Discussion

The case of the Taquara Stream has been framed as one of territory-based learning. The analysis shows that learning in this case is rooted in place and, although less clear from this study, in identity and in the ability to transgress the boundaries of both the stream and the watershed and of the communities living on its banks as well as between involved outside actors (the public sector and academia). The expansive learning that can be observed highlights the importance of social learning and establishing relations with outside actors. Expansive territory-based learning is facilitated by creating high quality relationships between multiple social actors. By recognizing that all actors have certain capacities and forms of knowledge and knowing that hold part of the puzzle to regenerating socio-ecological systems, such relationships can be established more easily. The case of the Taquara Stream is reminiscent of what Davidson-Hunt and O'Flaherty [62] refer to as Place-based learning communities (PbLCs), which they define as dialogic networks formed to generate cross-cultural understanding on local problems with the goal of supporting "people in responding to their own needs, developing a capacity to generate their own research projects, creating supportive relationships with other actors through the building of dynamic processes for the coproduction of locally relevant knowledge" [62] (p. 295).

Our research shows that boundary objects, those elements capable of promoting boundary crossing [20], can act as levers for dynamic processes for coproduction of locally relevant knowledge. In the Taquara Stream case, the occurrence of a particular type of boundary object (i.e., "sewage discharge") requires integration of different groups to work towards a solution, which in turn invites the crossing of boundaries. It is worth mentioning that such understanding of a boundary object as a lever for problem solving [54] differs from what is conventionally found in the literature, which generally refers to specific artefacts that can bridge intersecting practices [46,63].

Since the focus of this paper is on a territorial transformation, it is important to pay attention to the learning mechanisms referred to in the boundary literature as "reflection" and "transformation", as those are usually related to investigations of practical intervention effects [20,21]. The reflection mechanism involves perspective making and taking, as originally described by Boland and Tenkasi [64], stimulated by the mutual critical appreciation of a particular thematic, such as the territorial issue central in this study. As for the transformation mechanism, it may lead to the emergence of a new "in-between practice", which may be called a "boundary practice" [20]. Our analysis of the Taquara Stream case shows if not evidence then at least signs of both learning mechanisms of reflection and transformation.

Furthermore, the WG meetings' regularity provided for continuous joint work at the boundary. According to Akkerman and Bakker [20], this is conditional for preserving the productivity of boundary crossings and promoting lasting transformations. As such, the interactive platform created by the WG seems to play a similar role as in so-called boundary-crossing laboratories, wherein people from different systems of activity are invited to work on shared problems at the boundary [20]. The WG was not only responsible for orchestrating various practical actions carried out within the Taquara Stream Watershed, but also for putting specific topics into a broad territorial integrative perspective. The integrated perspective was facilitated by critically mutual reflection among participants and soliciting and brokering support from external experts to assist in specific themes. As can be seen in the visual chronological narrative as well (Figure 2), the complexity of collaborative links increased when over time several parallel activities were carried out by partners outside the limits of the watershed. Nearly two years after the initiative was set up, a growing interest from external agents in the Taquara

case could be observed. Their involvement became an additional source of learning about the theme of degraded urban rivers.

A particularly crucial outside link in this case is the connection with the university, through the researcher, a professor, and students, who all collaborate to produce knowledge on the local problem and, from this case, on the urban rivers' issues in areas of socio-environmental vulnerability. What seems critical here is that the relationship is of a symbiotic nature in that all involved stand to gain from the relationship. The stream community is not used as mine from which data can be extracted but rather provides a context for co-learning, in-depth analysis, agency, and joint action. The university can also elevate the status of both the community and the issues by paying attention and listening to both the social and the ecological and utilizing its own capacities and connections to help improve the socio-ecological quality of the stream and its community. Such a symbiotic approach is in line with emerging strands of community engaged research and the Responsible Research and Innovation (RRI) agenda that announces a higher education system that advocates ethical and critical engagement and boundary crossing between academia and society so as to address the complex sustainability challenges [65].

Lastly, coming back to another parallel with the research carried out by Davidson-Hunt and O'Flaherty [62], referred to earlier, we have identified similarities between communities in contexts of economic, social, and ecological vulnerability, as focused on in the present article, and indigenous ones addressed by their study. As their research indicates, ours too shows that multi-actor processes involving marginalized communities working on their local issues do not just expose the differences in forms of knowledge but actually demand their blending in dialogue as a prerequisite for processes of knowledge co-production. However, when we propose to observe multi-actor processes towards urban river regeneration in vulnerable areas from a territorial perspective, new complexities arise. Having the territory as a frame implies understanding such issues from the various forces acting in and upon territorial realities (e.g., internal and external forces) and acknowledging the utilization of different forms of intervention (e.g., formal and informal practices) in collaborative actions towards local transformation. Diverse actors mobilized to solve territorial issues face what we may call an opaque problem that can best be addressed through continuous dialogical and practical collaborative work at boundaries, boundaries that need to be crossed, integrated, and even transgressed.

7. Conclusions

This study identified how boundary crossings have occurred between distinct social actors (residents from the local community, technicians from the public sector, and members from educational institutions) engaged in an initiative for the socio-ecological regeneration of the Taquara Stream, located in the city of Porto Alegre, southern Brazil. Our findings suggest that practical responses to tackling local issues stimulate the crossing of boundaries as they require concerted actions promoted by the diverse engaged actors, bringing together different forms of knowledge, and articulations at different institutional levels. In the Taquara Stream case, these responses are enabled by ongoing dialogue that is nurtured by regular meetings carried out by the Taquara Stream Watershed Working Group. The analysis of three specific interventions of the group in the local community demonstrates that they were triggered by confronting a practical problem at an event or meeting. Subsequently, the group held meetings in order to further investigate the problem and plan a practical action to be implemented. The outcomes were either concrete physical changes in the territory and/or changes in practices and problem comprehension.

The case of the Taquara Stream has been framed as one of territory-based learning in which urban river issues are observed as problems of multi-level complexity. Learning is promoted by collaborative processes aimed at the socio-ecological regeneration of degraded rivers. Such learning goes beyond the individual and collective levels and challenges institutionalized mechanisms and anachronistic routines that hamper advancements towards more sustainable practices. From this early investigation, we have observed that a territory-based learning approach might enrich the debate on

urban sustainability as it exposes and includes the need to deal with antagonisms and contradictions of multi-actor processes. The investigation of a territory-based learning approach to regeneration in other contexts will enable its further development and help identify new opportunities for its application.

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