

GREENWAY NETWORK: A PARTICIPATORY PLANNING APPROACH FOR MUNICIPALITIES OF THE SOUTH REGION OF BRAZIL

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ABSTRACT

Development of greenways represent a planning strategy that seeks to reconcile both nature conservation and human uses. It is crucial for maintaining landscape connectivity in an increasingly anthropized world. Such strategy encompasses complex socio-ecological variables and its success greatly depends on the integration of different types of knowledge and active support from the local communities and stakeholders. This demands participatory planning processes within multidisciplinary platforms that promote a close collaboration between experts and lay people. The goal of this paper is to describe and analyse a participatory planning approach for the early-stage design of a greenway network for municipalities in South Brazil. The majority of southern Brazilian municipalities contain a very high rate of small farms which are under intensive agricultural production, and consequently, harming the natural landscapes. Actions to effectively tackle this problem are scarcely observed. The procedures encompassed by the approach were determined by the context constraints and potentials that make it applicable in the reality at stake. The approach is focusing on the early-stage design of a greenway network plan and comprises two phases with each a multi-stakeholder workshop for the local landscape analysis and the plan co-design by experts and local actors. The application of the approach in a municipality in southern Brazil has enabled local actors to use key concepts of connectivity planning and foster a critical reflection on local issues, and allowed the incorporation of local knowledge into the solution developed by participants. This resulted in a plan tailored to the local reality.

Keywords: greenways, landscape fragmentation, greenway network planning, participatory planning, Brazil

INTRODUCTION

Accelerating changes in the composition of the natural landscape are largely caused by human actions such as the development of agricultural land, cities, and transport infrastructure (Ellis *et al.*, 2010). Such actions lead to increased landscape fragmentation and disruption of natural flows of matter and energy, so hindering a balanced functioning of natural ecosystems (Bryant, 2006; Pardini *et al.*, 2010; Hilty *et al.*, 2020).

Mitigation of the effects generated by landscape fragmentation depends, among others, on land use planning approaches and policies that preserve landscape connectivity (Forman & Collinge, 1997; Jongman & Pungetti, 2004; Wiens, 2009; UNEP, 2019). Landscape connectivity can be defined as the ability of a landscape to facilitate biological flows, which depend on the proximity of habitat patches, the density of ecological corridors and stepping stones, and the matrix permeability (Bennet, 2003; Rubio & Saura, 2012). The maintenance and/or re-establishment of connections between patches, across different scales, is recognized as a fundamental principle for the planning of progressively anthropized landscapes in which multiple objectives are simultaneously pursued (Benedict & McMahon, 2001; Keeley *et al.*, 2019; Hilty *et al.*, 2020). Such connections can be made by greenways, which are defined here as a type of corridor of vegetation that allows connectivity between patches of vegetation, not only providing ecological conservation but also making it compatible with human uses (Ahern, 1995; Jongman & Pungetti, 2004; Hellmund & Smith, 2006).

Ahern (1995) highlights key ideas brought by the concept of greenways: (1) their linear configuration is advantageous for the flow of organisms, nutrients, matter, and energy; (2) their spatial efficiency is underpinned by the co-occurrence hypothesis, which suggests that resources of ecological and social value tend to be distributed along corridors; (3) greenway networks articulated at multiple scales in the landscape present synergistic properties; (4) greenways may reconcile multiple uses, including anthropic activities, as long as they are not detrimental to their ecosystem balance. A greenway network constitutes, therefore, a planning strategy that can be used to maintain the integrity of natural processes while reconciling human demands for land use (Ahern, 1995; Jongman & Pungetti, 2004; Vimal *et al.*, 2012).

The application of the concept of greenways into landscape planning tends to promote significant changes in how different plans regulating the occupation of a given landscape may be combined. Such changes are expected to take place since the connectivity features of greenways determine a need for integration between local plans and those in the broader landscape context (e.g. local and regional or national scale) (Jongman & Pungetti, 2004). Furthermore, the need for integrating scientific and place-based knowledge in the planning and implementation of greenway networks requires collaboration between lay people and experts (Benedict & McMahon, 2001; Jongman & Pungetti, 2004).

Procedures and data applied in a greenway network planning vary largely according to the context, landscape characteristics, intended goals, and scale of the plan (e.g. Flink & Searns, 1993; Ahern, 1995; Hilty *et al.*, 2006; Hellmund & Smith, 2006). The landscape analysis and definition of the planning goals, followed by the identification of suitable areas for greenways and design of an initial plan and subsequent detailing of the proposal for implementation, are steps commonly reported in the literature (p.ex. Flink & Searns, 1993; Hellmund & Smith, 2006). Essentially, such planning approaches should include the participation of various actors (e.g., local communities, public and private sectors, educational institutions, civil organizations etc.) throughout the different design and implementation phases of the greenway network (Ahern, 1995; Benedict & McMahon,

2001). As emphasized by Bennett (2003) and confirmed by the project review by Keeley et al. (2019), no greenway network planning can achieve its desired results without active support from local communities and key stakeholders.

The inherent complexity of this type of planning demands, therefore, the use of inter- and transdisciplinary approaches in which different types of knowledge are handled in a complementary manner and the various stakeholders are engaged in ways that enable the co-creation of solutions reconciling diverse interests (Dramstad & Fjellstad, 2011; Nassauer, 2012; Swaffield, 2013; Meli *et al.*, 2017). This demands a transition from the traditional stance of scientific knowledge as normative and participation only as informant of landscape planning to processes that enable a strong interaction between science and practice (Nassauer & Opdam, 2008; Namaalwa, 2013).

However, transdisciplinary, iterative and reflexive approaches wherein experience and knowledge from local stakeholders are integrated into landscape greenway planning are less prevalent than typical top-down and technically-oriented processes (Opdam, 2013; Calderon & Butler, 2020). Despite the increasing appeal for genuine participation in landscape planning, guided by inclusiveness, power balance, and consensus-building (Calderon & Butler, 2020), there is a need for enhanced horizontal communication and social learning processes between experts and the population at large as well as capacity-building of stakeholders so that they can effectively take part in the debate and design of solutions (Valencia-Sandoval, Flanders, & Kozak, 2010; Meli *et al.*, 2016).

Given this background, the objective of this paper is to describe and critically analyse a participatory-based approach devised for the early-stage design of a local greenway network as applied in a municipality in southern Brazil: the municipality of Feliz. Mostly southern municipalities, as represented by Feliz, are characterized by being predominantly rural, with a great proportion of small-size farms compared to the rest of the country. Such land structure has led to intensive use of land for agricultural production and progressive landscape fragmentation and degradation while the deployment of planning strategies and policies for landscape connectivity in these areas are still scarcely observed. These municipalities cover a large area of southern Brazil and the condition of their landscapes make them important targets for conservation and regeneration-led planning strategies.

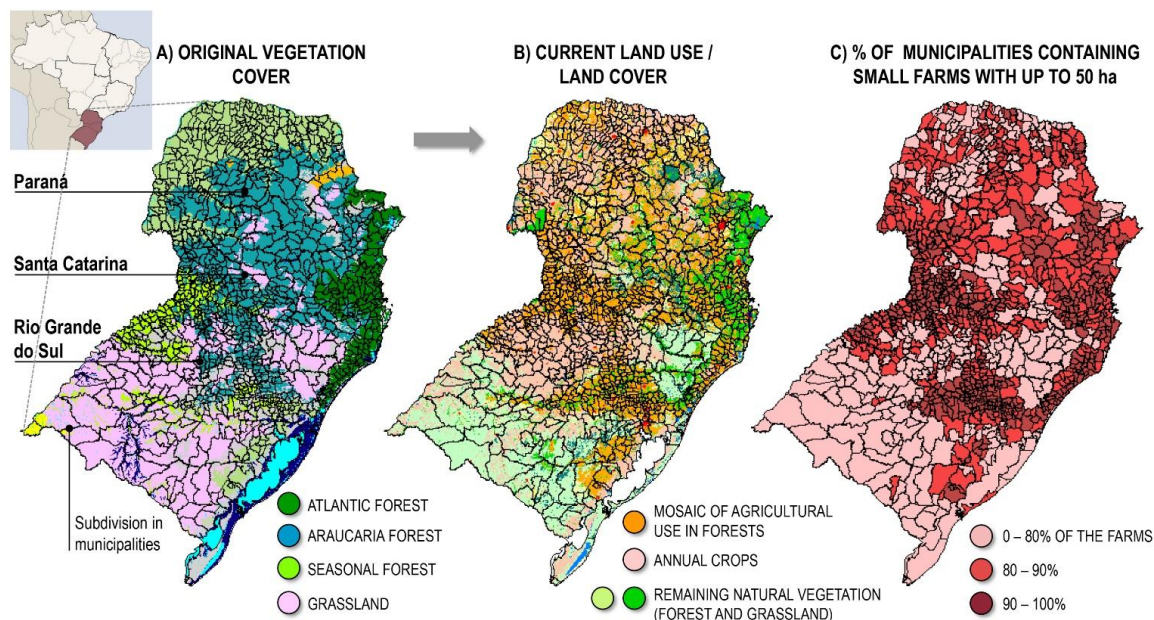
STUDY CONTEXT

The southern Region of Brazil, one of the five regions of the country, is composed by the states of Paraná, Santa Catarina, and Rio Grande Sul. The great majority of the municipalities — which are the lowest hierarchical level of government in Brazil — in these states are predominantly rural, with extremely small urban areas (IBGE, 2011). In approximately 70 % of those municipalities (which corresponds to 52 % of the total area of the country's southern region) more than 80 % of their rural properties are smaller than 50 hectares (500,000m²). From those, at least 50 % are smaller than 20 hectares (200,000m²) (IBGE, 2017). According to the number of tax units measured in hectares and defined by the land conditions for economic exploitation, in the southern region, these properties are classified as small (INCRA, 2020). Also, the vast majority of these municipalities have less than 20,000 inhabitants, a population size that exempts them from the requirement of the Municipal Master Plan, a planning instrument designed to establish specific regulations for land use.

Such land structure has derived from the late colonization of South Brazil in the 19th century, when small farmlands were granted by the government, free of charge, to settlers coming from directed immigration, with the aim of occupying vacant areas (mostly located in

Atlantic rainforest areas) (Herédia, 2001). Map C, in Figure 1, shows the prevalence of small farms in municipalities of the South Region, which are further concentrated in areas originally occupied by Atlantic rain forest (Map A) where today agricultural uses predominate (Map B). The small size of the properties has been leading to an exploitation of the land's maximum potential for economic gain and resulting in progressive degradation of local landscapes; the areas that are still preserved as nature protected areas are mainly those located in steep regions, where cultivation is more difficult.

Fig. 1: Change in land cover of South Brazil over time (A-B) and proportion of small farms in the region (C).



The main federal environmental law that regulates land use in Brazil is the Native Vegetation Protection Law (NVPL – Lei de Proteção da Vegetação Nativa, in Portuguese), which is poorly complied in these areas. The NVPL does not explicitly address landscape connectivity nor include specific strategies to respond to particular landscape features at the municipal level. Nevertheless, the deployment of planning strategies to conserve and/or regenerate landscape connectivity, such as a greenway network, are imperative in the context of southern municipalities in order to prevent further fragmentation and sustain and/or recover a balanced functioning of local ecosystems. However, prevailing profit interests, lack of political will and environmental awareness of stakeholders, scarce financial resources, at local level low technical skills, to name a few obstacles, prevent the development of effective local environmental protection actions and regulations (Neves, 2016; Abessa *et al.*, 2019).

The Municipality of Feliz, in the State of Rio Grande do Sul (Figure 1), with nearly 13,000 inhabitants (IBGE, 2011), is illustrative of the investigated reality and was selected as the subject of this study. Feliz has an area of approximately 95.37 km² (IBGE, 2011), being one of the smallest Brazilian municipalities. According to its official limits, the urban area of the municipality corresponds to 20.4 % (1945 ha) of its total local area and the rural area, to

79.6 % (7592 ha), mainly composed by small farms used for family agriculture (IBGE, 2011; 2017).

Fig. 2: Rio Grande do Sul State and the Municipality of Feliz.



MATERIAL AND METHODS

This section describes the proposed planning approach that is intended to assist small municipalities in South Brazil designing their own greenway network plan. The aim of this approach was to create a collaborative and participatory planning process that stimulates the engagement of both experts and lay people in a debate on ecological concepts and local environmental issues as well as in the design of the greenway network. It is worth mentioning that it was not within the scope of the approach to detail the greenways or precisely define its positioning in the municipality's landscape. In the first place, it was focused on creating a means for multi-stakeholder participation at the early stage of a landscape planning process so that experts and lay people could work together within a multidisciplinary platform, acquiring knowledge on key issues of their local environment and concepts of landscape connectivity, raise environmental awareness, and develop a sense of ownership of the collaboratively designed plan.

Two requirements, based on the area covered by the plan (the municipality), the intended level of detail, and the available resources in the local context, were applied to guide the selection of procedures that compose the approach in order to make it easily applicable in the context at stake. Given the local scarcity of financial and technical resources for purchasing and/or producing specific unavailable mapping datasets (Neves, 2016), the first requirement was the acquisition and use of standard data, publicly available for Brazilian municipalities. The second requirement highlighted the adoption of user-friendly data analysis procedures that would not require a complex training of technicians nor specialized equipment. This made the planning process accessible, cost-effective, and feasible in the face of context constraints.

The proposed approach comprised two phases that included multi-stakeholder workshops enabling participation in the planning process. The first phase and workshop were mainly

directed to understanding the local landscape while the second phase and workshop were aimed at designing the greenway network initial plan.

Phase 1: Understanding the Local Landscape

Phase 1 of the approach included the production of thematic maps to support the design of the greenway network and a workshop with key local stakeholders to identify their interests and include their knowledge in the design. The thematic maps aimed at identifying targets to be interconnected by greenways and the most suitable areas for their location. Based on recommendations obtained in the literature addressing maps used for greenway planning (e.g. Hilty *et al.*, 2006; Hellmund & Smith, 2006), an analysis of public data available for small Brazilian municipalities was carried out. This led to the definition of the set of key thematic maps to be produced, as follows:

- *Levels of Landscape Anthropization Map.* This map was derived from the reclassification of patches contained in the land use map produced from the QuickBird satellite image of the municipality. The landscape anthropization levels (1) non-anthropized or easy-to-renew landscape, (2) managed and cultivated landscape, (3) suburban landscape, and (4) urban landscape were adapted from the landscape classification proposed by Forman and Godron (1986) to the local reality.
- *Areas of Permanent Preservation (APP) and Water Supply Wells Map.* The APP is established by the Brazil's Native Vegetation Protection Law (NVPL) and refers to areas such as hilltops, steep slopes, coastal shrublands, mangroves, water springs, streams, pounds, and reservoirs and their surroundings areas.
- *Slope Map.* This map was defined according to the Federal Law of Urban Land Parcelling which prohibits the parcelling out of land with 30 % slope or over.
- *Relevant Natural Spots and Areas of Urban Expansion Map.* This map was produced based on information gathered by the local stakeholders in the first workshop.

The public domain data employed to produce the maps, were: topographic and hydrographic cartography produced by the Brazilian Geographic Service Army in the 1970s and 1980s and a QuickBird satellite image of the municipality from 2009. The thematic maps were prepared by the first author in the geoprocessing platforms Cartalinx, Idrisi Taiga and ArcGIS View 3.2 — although non-free mapping platforms have been used, all basic operations performed can be easily accomplished using freely available ones.

The workshop of Phase 1 took place in Feliz City Hall during one shift and it was attended by six people. It was opted to conduct the activity with a small group since there is evidence in literature that collaborative learning and co-creative processes are more effectively achieved in such format (Muro & Jeffrey, 2008). Participants were selected on the basis of their expertise, practical experience on local territorial issues and capacity to further disseminate the plan among stakeholders in later stages of the planning process. Four technicians from the public sector responsible for land use planning, environmental licensing and monitoring, agricultural technical assistance and environmental education activities in the municipality as well as two local farmers (one of them is a city councillor) who lead an initiative to clean up the main local river, joined the workshop. The meeting was facilitated by the lead author with the support of another researcher who took notes of the discussions and recorded the activities.

The first step of the workshop was explaining the greenway network concept addressed by the planning approach and presenting the thematic maps (printed on the scale 1:15,000, on boards of 80 x110 cm) to the group. This was followed by a 3-step discussion about: (1) the

participants' perceptions of the presented concepts, (2) the degree of preservation/degradation of the local landscape, and (3) the feasibility of the planning strategy in the local context. To facilitate the activity and enhance communication among participants, a visualization technique for participatory projects was applied for discussing the last two topics. The participants worked in pairs to respond to questions about the municipality's landscape and feasibility of the strategy. The answers were recorded in coloured cards (the colours differentiated strengths and weaknesses of the landscape and planning strategy following the SWOT approach) and displayed in a panel for the discussion with the whole group.

In the final activity, the participants were organized in trios to elaborate the map of Relevant Natural Spots and Urban Expansion Zones. They made markings based on pre-defined labels for the identification of elements in the landscape on a 1:15,000 printed QuickBird satellite image of the municipality. After the conclusion of the workshop a group interview was conducted with participants in order to reflect and assess learning outcomes, and challenges they may have faced over the process.

Phase 2: Designing the Greenway Network

The Phase 2 of the approach comprised the production of a synthesis map and a workshop with the same participants in which the design of the greenway network was conceived. The routes were determined on the basis of criteria applied to the information in the synthesis map. The map was produced by the lead author using the overlay mapping technique, a user-friendly procedure widely applied in the development of greenway plans (e.g., Flink & Searns, 1993; Linehan *et al.*, 1995). All thematic maps were overlapped in order to identify the targets and most suitable areas for the location of the corridors.

The targets derived from information in the maps, were: Areas of Permanent Preservation defined by the NVPL (e.g., hill tops and springs and its surrounding preservation area), spots of natural relevance defined by stakeholders (e.g., areas of natural beauty), and water supply wells. Areas deemed most suitable to constitute the greenways were those with the lowest levels of anthropization (classified in the categories non-anthropized or easy-to-renew landscape) and little potential for urban or agricultural use (those with a slope of more than 30 %); which are essentially the ones that present the highest quality habitat and are the most likely to conversion for conservation.

The second workshop took place in the same venue as the first workshop and was carried out in one shift. The first step was to present the synthesis map derived from the previous meeting and guidelines for the corridors network design. After sharing perceptions about the guidelines, the participants were invited to co-design the greenway network. The lead author and the research assistant, who facilitated the activity, did not interfere in the design process except for clarifying specific doubts.

The proposal was drafted by the group on a transparent plastic placed over the printed 1:15,000 synthesis map. The participants followed a general principle and were asked to establish a minimum of two connections for each target. As a general principal it has been established that the targets should be connected from the shortest distances so as to expand the possibilities of the corridor implementation and increase the degree of targets' interaction (Linehan *et al.*, 1995), going through the areas considered most suitable. Based on graph theory (Cantwell & Forman, 1993) and the attributes of redundancy and robustness, it was set that the targets should be served by at least two connections. Redundancy in a greenway network (understood as the multiplication of connections that reach a target), is always desirable (Bennett, 2003) as it increases the network's capacity to support eventual disruptions without compromising connectivity. Redundancy enhances the robustness of the

system, that is, the maintenance of the characteristics of the network despite the fluctuations in the behaviour of its components or environment (Carlson & Doyle, 2002). After the conclusion of the workshop a group interview was conducted with participants in order to reflect and assess learning outcomes of the process.

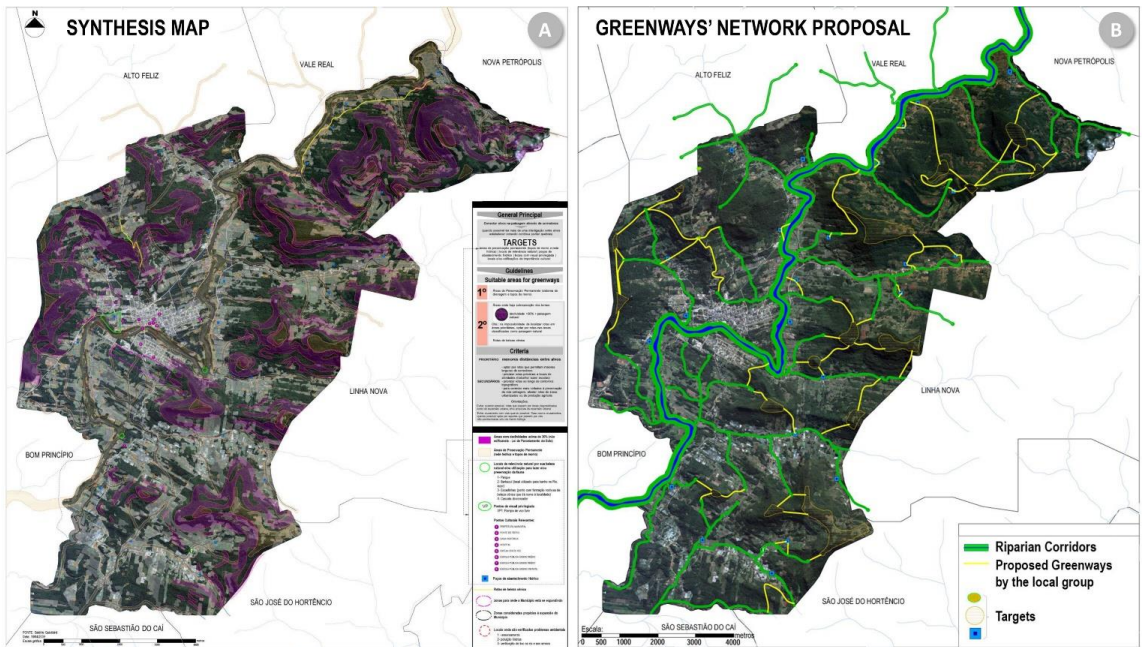
RESULTS

The synthesis map and the greenway network proposal map (Figure 3 – A) represent the tangible outcomes of Phase 1 and 2 of the approach, respectively. The thematic maps also represent valuable results in that they were fundamental to underpin a discussion and in-depth analysis of the local landscape. They illustrate a number of themes that led the participants, as reported in the group interview conducted after the conclusion of the first workshop, to a broader understanding of the local landscape transformation dynamics and areas of environmental conflict. It should be noted that the procedures employed for producing all the maps proved to be easy to perform, with the possibility of being carried out even manually, without the help of specialized software. The data gathered from public sources and workshop inputs presented in the synthesis map also proved to be sufficient to launch the basic plan of the greenway network. However, the printing scale of the maps affects the number of identified targets since there is a greater or lesser degree of detail displayed depending on the scale used.

The greenway network map designed by the group (Figure 3 – B) present 47 connections in the landscape that provided new linkages between the targets. The enforcement of NVPL, although not explicitly aiming at re-establishing and/or promoting landscape connectivity through a coordinated system of nature protected areas (Garcia *et al.*, 2013), already generates a corridor network composed of preserved strips of riparian vegetation along the natural hydric network (Brancalion *et al.*, 2016). However, the analysis of the satellite image of Feliz revealed several areas of environmental conflict within protected riparian zones. As reported by workshop participants, such conflicts basically arise from two causes: (1) economic pressures on small farmers that push them to fully exploit the land to expand profits disregarding the areas that should be compulsorily preserved by law, and (2) lack of financial resources and staffing in local environmental departments that hinder regular landscape monitoring activities.

Regarding the criteria for the design of the greenway routes, the participants emphasized the importance of having flexible, context-adaptable guidelines so that specificities and local knowledge may be incorporated when making decisions about the most appropriate routes. They also suggested that the land structure of the municipality should be included as a criterion for determining the routes. Feliz's rural area is predominantly composed of small farms and due to this peculiarity, they observed that the corridors should be located perpendicular to the smaller size of the property, which would increase its implementation potential as a smaller area of land would be destined to this end while guaranteeing greenways with larger widths. This was a valuable feedback, however, including such information into the planning process would only be possible with the assistance of geoprocessing tools as the data would not be clearly visible in the printed maps used in the workshops since it would require rather large printing scales. Nevertheless, it is suggested that this information should be taken into account when adjusting and detailing the greenways positioning and widths in further stages of the planning process. These aspects indicate the critical importance of the empirical knowledge of local actors as well as a necessary flexibility in the application of the criteria proposed by the approach.

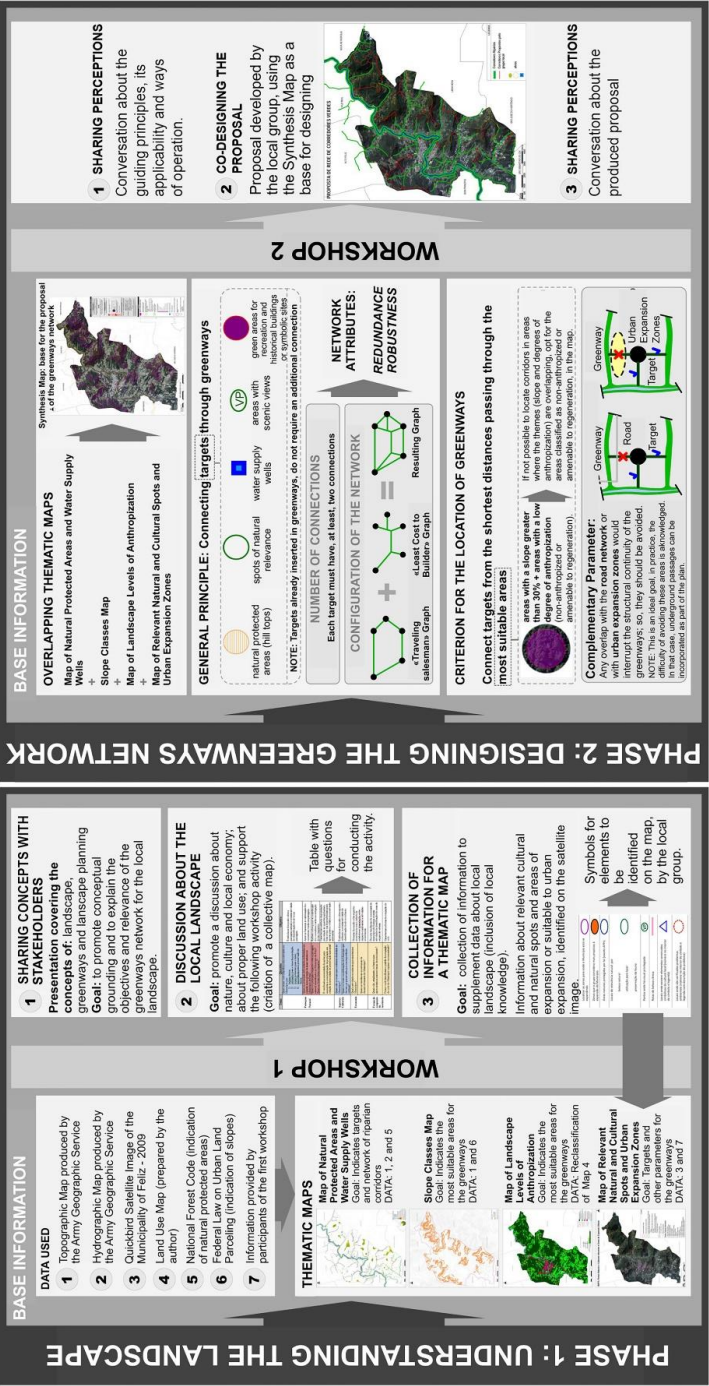
Fig. 3: Synthesis Map (A) and Greenway Network Proposal for the Municipality of Feliz (B).



A summary chart of the approach in which its phases are presented and detailed in a visual and easily comprehensible manner, was produced in order to guide the participatory planning process (Figure 4). The chart was hand out to the workshop participants after the conclusion of this research. It should be stressed that although the Municipality of Feliz provided support for developing and testing the approach, the utilized data analysis rationale and planning process are generic and can be applied in other small municipalities in South Brazil.

The multi-stakeholder workshops in phase 1 and 2 also enabled the critical reflection of participants on the local landscape dynamics as well as on difficulties faced by the municipality in conserving and regenerating its natural areas. In the group interview after the workshop, the participants reported that there was a previous lack of knowledge or unfamiliarity of stakeholders with the concept of landscape connectivity and that they have comprehended, after the workshop activities, the benefits that a greenway network could bring for a balanced ecosystem functioning. They have also considered the plan proposal relevant and necessary to guide local land use. However, the technicians from the public sector reported difficulties in complying with the existing environmental legislation, developing policies and/or integrated plans that are effectively committed to more sustainable landscape planning. To a large extent, these problems have been attributed to the lack of financial resources, insufficient personnel, precariousness of available data, and even to the lack of dialogue between the different departments within the public sector, which makes effective intersectoral articulation difficult around a common goal in landscape planning. Related to this, the participants also reported the lack of awareness of a great majority of the population on environmental issues as an important hurdle towards nature protection and the deployment of sustainable landscape planning strategies.

Fig. 4: Summary chart presenting the stages of the participatory-based planning approach.



DISCUSSION

The success of a greenway network greatly depends on the support from local actors. Local stakeholders provide the plan with complementary perspectives to those of the experts. This results in proposals that are more connected and coherent with the local reality and more likely to be implemented (Luz, 2000). According to research conducted by Keeley *et al.* (2019) on a large number of connectivity conservation plans worldwide, multi-stakeholders' participation in the initial and penultimate draft plan phases was deemed fundamental for including suggestions from the various actors involved in the plan, for project's decisions to be consensual, and for adding final adjustments that facilitate implementation. The approach presented in this paper sought to promote a participatory landscape planning approach that takes into account the context of the lowest hierarchical level of government in Brazil: the municipality. The approach sought to promote a multidisciplinary process for the co-production of the initial phase of a greenway network plan, involving experts and lay people. It also considered existing constraints of the planning context so that they do not become impediments for the deployment of the plan.

The workshops that constituted the approach enabled stakeholders to produce the first draft of the greenway network and also created space for collective critical reflection and learning about local issues, expanding participants' knowledge on landscape transformation dynamics and the importance of connectivity focused strategies. Such collective learning was facilitated by dialogical interactions among participants throughout workshops' activities. Dialogue is the basis of social learning processes, which take place when a group of people work together to find solutions for a local problem (Wildemeersch, 2009), interact in a favourable social climate and communicate in a relatively open conversation wherein diverse and even contrasting views are welcomed and used as drivers for knowledge production (Wals, 2011). Dialogue facilitation in participatory landscape planning processes can help diminish communication barriers associated with hierarchical relations that might occur between experts and local community members, wherein dominant agendas tend to keep being reproduced (Calderon & Butler, 2020). Accordingly, the approach proposed by this study enables a space for inquiry and creation of alternatives to exclusively top-down interventions through dialogue interaction with members of the local community already in the initial stage of the plan, which is expected to be extended and intensified in later phases of the plan's development.

Furthermore, the sense of ownership towards the plan is enhanced by the way through which stakeholders co-produce the proposal. When stakeholders can add their views and narratives in an envisioned landscape scenario, or even modify a technical planning procedure, an increasing sense of shared ownership over the process can be noticed (Brown *et al.*, 2016). In the case of the municipality of Feliz, participants integrated their knowledge into the plan by identifying areas to be connected by greenways, outlining the routes, and critically evaluating design criteria in order to make its application more flexible when necessary. The participatory planning process as proposed by this study helps, therefore, local stakeholders to dialogue and develop an integral view of the municipality's landscape as well as acknowledge key environmental issues, best responding to local needs.

In the case of the predominantly rural municipalities as in South Brazil, where the land structure is composed by small farms in terms of total area, a landscape planning process that effectively includes local farmers since the early stages of the greenway network design, is particularly crucial for the plan's implementation. The lack of awareness among local farmers, as reported by participants in the workshops in Feliz, is suggested to be an important barrier for the plan success. Furthermore, the capacity of local authorities to ensure the integrity of natural preserved areas through surveillance and monitoring measures is always

limited and the active involvement of the population remains the most effective form of protection at this level (Bennett, 2003; Jongman, 2008). In this sense, it is crucial to work on the development of this type of proposal along with environmental education practices involving both farmers and the general public, using appropriate language and activities to the local culture in order to foster a proactive behaviour of local population towards environmental protection (Armesto *et al.*, 2007).

Yet, solely the support from local groups is not enough to guarantee the greenway plan implementation. Potential hurdles to this planning strategy, as raised by participants in Feliz, concerned the cost of implementing the greenway network and whether existing legal tools could be used to enable the network. According to the workshop participants, assessing these issues would be crucial to determine whether or not the plan is feasible in the context of southern Brazilian municipalities. In this sense it is fundamental to promote economic policies that provide tax incentives to encourage the conservation of valuable green areas on rural properties without compromising farmers' income generation. Economic instruments (e.g., technical assistance, subsidies, tax credits, compensation for conservation actions) are widely recognized as an efficient measure to support connectivity conservation (Hilty *et al.*, 2020). However, in general, environmental protection actions taken by Brazilian municipalities greatly depend, in general, on resources obtained from local revenue (which competes with other demanding areas such as sanitation and urban infrastructure) and on political initiatives to allocate funds to that end, which results in a limited capacity for implementing self-financed environmental programs (Neves, 2016).

Also, it is important to point out that the enactment of new legal instruments is time consuming and should not postpone actions for landscape protection and/or regeneration (Hilty *et al.*, 2020). However, it can be confirmed that most countries' legal systems already present various tools, at various levels of planning, that can recognise and protect ecological corridors (Hilty *et al.*, 2020). An analysis of existing legal frameworks and planning tools of Brazilian municipalities reveals that there would be no need to enact new mechanisms to deploy a greenway network at the municipal level but to use the existing ones on the basis of new concepts. The concept of landscape connectivity and the greenway strategy could be included as a guiding principle for the territory's occupation and land use zoning in Municipals' Master Plans.

The Municipal Master Plan in Brazil can determine, for instance, guidelines for the location of legal reserves (LR), established by the NVPL, as well as for the compulsory green areas for public use when within urban allotments, as determined by the Federal Law of Urban Land Parcelling, in such a way that natural preserved areas become part of a connected system. The LR is the proportion of farm area set-aside for the sustainable use of natural resources and the conservation and/or restoration of ecological processes. This is, along with the permanent preservation areas (APPs) defined by the NVPL, one of the main tools for environmental conservation in Brazil, within rural properties. Therefore, in the predominantly rural municipalities of South Brazil, a possible way to create a greenway network is through building connections between LRs, which are compulsory for every farm. However, such coordination between the LR's of different farms in order to create a network implies a complex process of planning and can be made more difficult by new guidelines for LR location established by the NVPL which allows the compensation of LR areas of farms to be made in different biomes of the country, that is far from the landscape where the farm is located (Garcia *et al.*, 2013).

Additionally, the Municipal Master Plan is not obligatory for municipalities with less than 20,000 inhabitants, which in South Brazil represent the majority (around 80 %, which represents 32 % of the total land cover of the southern region) of those that are predominantly

composed of small farms (IBGE, 2017). This does not mean that such planning instrument cannot be adopted by municipalities with less than 20,000 inhabitants, however poor technical structure and lack of financial resources of southern Brazilian municipalities, make its implementation more difficult. And yet when the Municipal Master Plan is adopted it mostly regulates urban areas, which actually represent a minimal proportion of the territory of such municipalities. A master plan that integrates both urban and rural areas, in a macro planning of the local landscape, would contribute to promote an integration between urban and environmental planning since policies with different approaches are developed and applied by different public sectors for urban and rural areas in Brazil (Santoro & Pinheiro, 2004). In this sense, a greenway network and the approach devised in this study aim to facilitate such integrative planning and could provide a framework to promote a needed interconnection between the urban and rural landscape while enabling conservation.

In addition to the issues discussed above, other hurdles are present in the Brazilian context, such as the poor infrastructure of local environmental agencies for the enforcement of legislation and lack of political will to carry out long term landscape planning strategies such as greenway planning. Long term planning strategies are also negatively affected by administrative discontinuities and government staff turnover (Keeley *et al.*, 2019). All this reinforces the need to improve the infrastructure of municipal environmental agencies and their technical capacities as a key issue for the development of environmental plans and maintenance of local biodiversity (Neves, 2016). However, what is observed in Brazil is the intensification of actions by the current government in the opposite direction, with the dismantling of national environmental agencies and policies that protect nature, in order to facilitate predatory economic activities that leads to escalating deforestation and landscape fragmentation (Abessa *et al.*, 2019).

Finally, it must be emphasized that the proposed approach aims at facilitating a participatory greenway network planning to identify corridors that must be conserved and/or regenerated in the face of intensified agrarian land use. It aims at improving dialogue among different stakeholders as well as cooperation between the public sector and the local population. Such a greenway network plan is meant to help sustaining the ecological balanced of landscapes on the long run and not to be an excuse for land use conversion of areas where there is already a great proportion of natural preserved areas.

CONCLUSIONS

Authentic participation and integration of knowledge from various stakeholders involved in greenway network planning is a key aspect to producing a sound and feasible plan to guide land use. This research has specifically focused on developing an approach for the greenway planning geared to the context of mostly rural municipalities, in the South Region of Brazil. These areas are focused on intensive agricultural production and present progressive landscape degradation. The proposed approach sought to provide and foster a participatory landscape planning process in these settings by considering and addressing the following aspects.

First, it considers local resources for the implementation of the planning process, so that economic constraints and/or insufficient training of technicians do not constitute barriers to the development of the project. It uses public data available to these municipalities and employs simple techniques for the preparation of thematic maps. It also provides clear and easily understandable information and uses readily applicable criteria for the development of the corridor network design, therefore facilitating the engagement of lay people. Second, it proposes a participatory planning process through workshops that allows local stakeholders

to learn about concepts underlying the proposal. The activities that comprise the approach promote dialogue and critical reflection among stakeholders who must reach a consensus vision of the plan, enhancing therefore the chances of its implementation. The approach also enables learning about the main local challenges for the execution of effective environmental conservation and/or regeneration plans, regulations, and actions. Third, it incorporates the local knowledge in the developed solution enabling a plan that is tailored to the local reality and legitimized by local actors in its early phase, thereby likely increasing commitment and interest in the following stages of the proposal's development.

In conclusion, this study advances on research regarding ways to enable genuine participation of local stakeholders in landscape planning processes, moving beyond participation as a mere informer of the planning process. The developed approach is not intended to provide conclusive solutions for the context to which it is addressed and is meant to be an initial study to be further explored. Also, broadening participation in further stages of the greenway network plan in the studied context, such as the detailing and implementation phases, is a major challenge in corridor planning and should be investigated in future studies.

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CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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