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The Territorial Approach to the Integration of RES in Mountain Areas. Participatory Planning with the Support of 3D Representations: Examples of Application in the Eastern Mediterranean

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The Territorial Approach to the Integration of RES in Mountain Areas. Participatory Planning with the Support of 3D Representations: Examples of Application in the Eastern Mediterranean

Dimitrios Goussios, Ioannis Faraslis and Prodromos Mardakis

Introduction

- 1 Driven by the dynamics of globalization and concern over climate change, the evolution of public policies, consumer expectations and technologies has contributed in recent decades to the recognition of the multi-functionality and value of mountain resources (Gumuchian et Pecqueur, 2007). A development framework for mountain areas is emerging that expands their options in overcoming marginalisation (Goussios, 2019; Rieutort, 2020). By adopting the territorial development model, mountains enter a learning process with regards to the integration and management of the new relationship between resources and heritage, including the (Landel et Senil, 2009; Fortin, 2008; Peyrache-Gadeau, 2009; Peyrache-Gadeau et Perron, 2010). In this new context, the promotion of renewable energy sources (RES), favoured by public policies and new technologies, is approached as an intervention in the emerging dynamics of territorialisation in mountain areas (Brenner *et al.*, 2003). By focusing on fragile land uses, land structures and relationships (Howard *et al.*, 2009) and particularly on mountain landscapes, this intervention affects resource ownership (Nadaï et Van der Horst, 2010; Pavlis, 2020). It seems, therefore, that the main challenge for local

mountain communities is the harmonisation of energy transition with their own ongoing territorial development process (Gross, 2007).

- 2 However, mountain areas face significant barriers to participation in the planning of RES integration within their areas:
 - a. the verticalisation of energy policies despite the promotion of decentralisation,
 - b. the organisation of institutional RES siting regulations exclusively at the national level and approach to the relationship with the landscape through a geometric perception of space and
 - c. territorial capacity and territorial engineering without the experience and methods required to support the integration of RES in a territorialisation process (Rieutort, 2020).
- 3 Such a process is based on the territorial capacity of mountain areas to produce and co-produce territorial information in support of local planning by combining the issues of:
 - a) the materiality of each energy form with the geography (relief, habitation and land relations) of each area and
 - b) harmonization of RES integration in the space and landscape with the management of territorial resource elements (Gauche, 2015).
- 4 A decisive factor between materiality and territorialisation is the restrictive approach to RES integration using “geometric” criteria that are promoted by the national institutional framework. This does not incorporate the prospects created by the activation of territorial resources and, consequently, the new needs for local regulation. The constraints placed on the relationship between RES installation and point of interest does not consider the position of the latter in a surrounding space which the local community defines as a “place of territorial interest.” Therefore, the relationships and links developed between existing and/or potential functions, and material and intangible resource components are disregarded at the scale of such places.
- 5 This means that the effort to harmonize RES integration with the process of territorial development must incorporate the places included in the process of territorialisation by the local communities. By integrating territorial resources, this transition modifies the nature and dimensions of interfaces between the impacts of RES (installation, landscape integration) and places of interest and may determine the fields of a new regulatory framework for planning (location-resource-function relationship) (Dérizoz, 2004; Grasset *et al.*, 2006). It can also contribute to the expansion of the definition of RES carrying capacity, which is constrained by the institutional framework.
- 6 This whole process of harmonizing RES integration reveals the necessity of local community participation in planning: as managers and activators of territorial resources but also as sources for a “territorial” information system (territorial capital) through geo-visualization (Labussiere et Nadaï, 2014; Yingjie *et al.*, 2015).
- 7 The production, management and processing of territorial information for this system can be guaranteed through an interactive methodological chain (Lopez-Uroz, 2012). Participatory methods, with the use of public participation GIS—PPGIS & 3D representations in the fields of geo-informatics, can create an interactive environment for this purpose by activating the actors. In the context of these processes, the implementation of 3D-PPGIS methods functions as a common “language” of communication between researchers, residents and organisations, enhances dialogue and consensus between partners thus contributing to the co-production of territorial information, the spatialisation of resource functions and components of the resources

and to a more objective assessment of the impacts of RES (Appleton et Lovett, 2005; Judge et Harrie, 2020; Onitsuka *et al.*, 2018).

- 8 The whole methodological process incorporates territorial information in the planning of complex spatial issues such as RES integration in territorial mountain areas (Goussios *et al.*, 2012). This process ultimately renews interactive participatory planning in a field where centrally designed RES policy meets the bottom-up dynamics of territorialisation. (Yu *et al.*, 2020; Lovett *et al.* 2015)

Materials and Methods

- 9 The dual objective of the approach to the relationship between RES, landscape and territorial resources in mountain regions with the active participation of local actors, determined the organization of the methodological chain. This includes the 3D Public Participation GIS (3D-PPGIS) application as a support instrument to the dialogue between experts and residents of the mountain areas regarding RES siting issues. The proposed methodology combines landscape visualisation, interactive virtual tours and the use, processing and analysis of information systems.
- 10 For the effective implementation of 3D representations by residents, particular attention was paid to two components.
 - The combination of tools, GIS, remote sensing and 3D animation graphics for the interactive representation of new landscapes created by RES installation. This makes use of the basic functions of the 3D-PPGIS such as the realistic visualisation of space, overflights from different viewing angles, the immediate addition-subtraction of information, as well as the ability to record in real time.
 - The ability to alternate between information on multiple scales. The 3D model's ability to present information related and linked to the different research scales is exploited. Essentially, achieving a transition from the parcel of land to overarching scales.
- 11 More specifically, the three scales used are:
 - The large scale where exploitation of the energy potential, the institutional framework constraints (settlements, landscapes, etc.) and the distribution of infrastructure meet.
 - The medium scale where limits in range and impact zones of RES infrastructure on the landscape of multifunctional sites and their resources are investigated.
 - The small scale where adjustments to the RES-territorial resources relationships are sought, due to the diversity of situations presented by mountain places.
- 12 The spatial identification of the impact of RES installation was attempted through, on the one hand, interface zones between RES installations as a set of infrastructures and energy production systems that impact the landscape and claim space, and on the other hand, the multifunctional places where ownership and territorialisation dynamics emerge.
- 13 A place is defined as a distinct geographical unit which is the recipient of material and intangible elements of existing, potential or hidden resources. A place of territorial interest is characterised by the existence of functions that can be integrated into economic activities. To evaluate the impact on places, the term of convergent impact is introduced, defined as the concurrent visibility of multiple wind towers and farms. The consultations included people from the region of the territorial system (elected representatives, entrepreneurs, the social field). Local community representatives,

farmers, cultural and environmental organisations, elected officials and development companies participated. This methodological chain was implemented in two case studies in two mountain areas presented below.

Energy Transition in Mountain Areas: The Cases of Greece and Cyprus

- 14 The two mountain case study areas (fig.1) concern two different cases of RES installation. The first was based on research conducted on Mount Othrys (Municipality of Almyros, Greece) in 2013¹ and then updated in 2020. The goal was to design and implement scenarios regarding social acceptance of RES installation. The second, in 2019, aimed at investigating the optimal choice for RES siting in the mountain region of Troodos (Cyprus). These Mediterranean mountain regions possess different geographies and different RES potential. Troodos is densely populated and neighbours two large urban centres (Nicosia, Limassol) and has a developed second home presence. Interest in RES primarily concerns solar power. On the other hand, Othrys is sparsely populated, despite being rich in natural resources. It has one large, declining, village in its centre, surrounded by five smaller settlements towards the plains, all showing signs of decreased human activity. Producers are engaged in aromatic herb and livestock farming and recreational rather than tourism activities are developed (paths, caves, monasteries, botanical gardens, etc.). In both cases, RES siting is evaluated based on materiality, the conditions set by the national institutional framework and the importance given by the local community to places and landscapes that bestow value to territorial resources.

Fig. 1. Case Study Areas

Othrys–Almyros

- 15 The exploitation of the wind energy potential started in 2006 (19 wind turbines [WT] with a capacity of 17 MW) as the result of the subsidy policy.
- 16 The following map shows zones (fig. 2) with a wind capacity over 5 m/s. Currently, 13 wind farms (WF) (89 WT, 320.25 MW) are in the process of approval. This development shows a serious expansion and upward trend: in size (tower height from 55 to 166 m), WT capacity (from 0.85 MW in 2006 to 6 MW today) and number of installations.

Fig. 2. Wind Potential in the Othrys Area

- 17 The region has a limited paved road network but due to livestock grazing, has a dense network of rural and forest roads. Access to the installation sites is relatively easy due to the mild relief. The lack of suitable networks and substations does not favour the installation of small RES units and partly explains the expansion trend. As responsibility for the construction of new interconnection networks lies with the investor, it reasons that only large WFs can do so.

Consultation and Results

- 18 The strong RES investment interest, coupled with the upward trend in size, explain the growing fear of additional impact on the landscape. (fig. 3)

Fig. 3. Aggregate visual impact of WTs in the Othrys region (2006–2021)

- 19 In the case of Othrys, consultation focused on the interdependencies between the zone of wind energy potential and the places of territorial interest, where the local community is seeking ownership of resources. The visual impact on the landscape resulting from the expansion trend in WFs of the region was investigated, based on the national institutional framework for RES siting (rules regarding installation density and landscape protection).
- 20 First, the boundaries of the areas of interest to the local community were determined, followed by places of high territorial value (sunny places, aromatic plant terroirs, etc.) within these boundaries. Based on the distribution of potential resources in the area, two such cases emerged:
 - a. Places-terroirs for the agricultural production of renowned products: meat, herbs, tea, etc. Pastoral, organic livestock farming in the communities of Anavra, Vrimena, etc.
 - b. Recreational/tourism places: Alternative tourism (nature, mountaineering, education, etc.), botanical gardens, monasteries, etc. in Prosilia, Tsatali, Tsairaki, etc.).
- 21 In reality, these places are of particular local importance and of multiple functions and uses, as well as a specific resource base. Next, the interface zone between the park sites and the places of territorial interest was established. This is determined by the visual impact, distances and the relief. The following were taken into account: visibility range and distribution of WFs, a distance of 5 km and a visual impact not exceeding 20% of the field of view. (fig. 4 και fig. 5).

Fig. 4. Zone of WT visibility (in blue) from a distance of 5 km

Fig. 5. Viewpoint assessment from tourist places of interest in Othrys

- 22 The future large-scale impact on landscapes resulting from a tripling of the height of WTs was assessed (fig. 6). In order to evaluate this impact, two impact indicators were visualized:
- 23 a) visibility and visual impact: This relates to the range of visibility and its gradual decrease, depending on the height of each tower. Although the area occupied by the terroirs is only slightly affected, 75% of the recreational and tourist activities zone is within the 3 km zone (fig 7.).

Fig. 6. Virtual Integration of WTs in the Othrys Landscape

Fig. 7. Range of visibility of towers, from a distance of 3, 4.5 and 6 km

24 b) viewpoint assessment from the tourism activities zone in Othrys (fig 5.): Three important locations-points of interest were assessed². This method assesses the overall limitation in the field of view of the three aforementioned points of interest, into three impact zones. These points of interest correspond to three tourist sites.

- 25 This example demonstrates that a localised approach to the assessment of the visual impact (points of interest for the local community) of WFs, does not create barriers to the installation of RES (<20% visual impact).
- 26 The combination of the two main indicators (visibility-impact and viewpoint assessment) enables the local community to try to adopt a more objective and comprehensive approach to the impact of RES. Having already created the visibility impact zones as a result of the upward trend in size and (prospective) expansion of WTs in the area (fig. 7), it presents the impact threshold of the RES installation in zones of gradually decreasing range. Next, the second criterion assesses these impacts on the places of tourist interest, as specified by the local consultation. However, knowing that in this process these points are incorporated into a broader set of places of interest, the local community approaches and evaluates them as elements of territorial resource functions and components. In this context, the meeting of the local community and experts in a 3D environment, enabled the co-production of the necessary information and the search for solutions on a small scale. The example of the installation at the “Prosilia” site, a place of territorial interest demonstrates the possibility of looking for ways to avoid visual impacts on a very small scale. The simulation of an area in a 3D environment (fig. 8) (combination of horizontal and vertical aspects of the field of view from the site towards the WF) enables the identification of suitable installation sites or natural screening. Furthermore, the consultation participants determined that the material elements of resources are related more to nature activities than to functions embedded in the landscape. This finding highlighted the different dependencies of these elements on the surrounding landscapes, with the accommodation facility being the most dependent.

Fig. 8. Search for installation site outside the visibility field of the WF

Troodos

- 27 The acceptance of the necessity of energy transition in the mountains of Cyprus by the local community is mainly the result of the high cost of electricity and the problematic supply of electricity to households and businesses. The evolution of the past decade has revealed the dominance of small-scale PV installations and is an expression of the resultant environmental and technical (inadequate interconnection network) constraints and the freedom of establishment of PV installations facilitated by scattered small-scale ownership (impossibility of expansion).

Fig. 9. Geographical distribution of RES installations with a capacity >20kWp up to 2017.

Consultation and results

- 28 The area functions as a basis for PV installations and is approached through the following main spatial configurations: the mountain as a geographical unit, valleys as a spatial unit with dense habitation, intense activity and an attractive landscape and finally, the overarching scales of intervention (settlements, zones, terroirs, etc.). The issue of individual (family property, fragmentation and multiple ownership of the land) and collective choice for PV siting is raised at this scale.

Region of Troodos

- 29 The region is the scale at which the institutional framework governing RES, inherited spatial structures of the mountain and the goals of the NSDMCC³ intersect. The final map configuration of PV installation sites was determined by institutional constraints. It was used as a basis to attempt to incorporate various criteria for PV siting in Troodos with the focus on integration in the landscape (visibility).

- 30 The inclusion of the visibility criterion into the multi-criteria model takes into account the importance, as recognized by the NSDMCC, of the close link between local resources and the landscape, and responds to the need for PV siting to be accompanied by measures to avoid the degradation of the traditional character of the landscape.
- 31 A 3 km radius from the main road network was adopted as the exclusion zone. This entails identifying viewpoints visible from the main road network and then excluding them from PV siting. The adoption of this limit considered: a) the literature (Katsaprakakis, 2012) which states that a distance of 2 to 5 km is the limit beyond which the visibility of an object belonging to the landscape decreases, b) the area's geomorphology and the organisation of life in small, densely populated valleys, and c) the residents' choice. The adjacent map shows the possible PV siting zones for Troodos (fig. 10), which largely coincide with the boundaries of the valleys.

Fig. 10. Potential PV sites in Troodos

Valleys

- 32 Their importance regarding PV siting is related to two factors:
- Their boundaries are the meeting point of a strong local sense of identity and belonging, and resources which are linked to agro-food, processing and important natural and cultural heritage elements.
 - The geomorphology and spatial organisation of the valleys create distinctive viewing conditions. The entrance to these valleys gives the impression of a high density of objects situated continuously and successively on its slopes (visual saturation).

Fig. 11. Implementation of the 3 km visibility criterion at potential PV installation sites in the valley of Solea.

- 33 The reduction of the visual impact with the removal of visible surfaces is in fact perceptible at the scale of the valley (fig. 11). The non-visible surfaces ultimately represent the potential PV installation sites. The geomorphology of the valleys and their inclinations determine the final distribution and concentration of these sites in distinct zones. These zones appear to form at the highest points of the western slope of the valleys (fig. 12). In the case of the valley of Solia, this potential PV siting zone is harmoniously integrated into its spatial organisation, is situated above (to the west of) the settlement of Kalias and is adjacent to the wider agricultural zone. It extends across the bottom of the valley where the settlements are located and the river and the main road network pass. This zone includes paths, traditional settlements, monuments, terraces, etc. The adjacent map (fig. 13) illustrates, in more detail, the proximity and overlapping of the PV zone and the Solia olive terroir.

Fig. 12. Potential PV installation zones

Fig. 13. PV zone and other activities around the settlement of Kaliana (Cyprus)

Interventions on Smaller Scales

- 34 The use of representations and the ability to switch (3D environment) from the scale of the valley to that of a PV zone, allowed the consultation to focus on issues that arise at smaller scales (land structures, local plans, seeking deviations from the 3 km radius). In

this case, the simulations contributed to the investigation of possibilities to a) reduce the impact on the landscape when the terrain allows small-scale natural screening interventions (fig. 14), ensure no PV installation visibility from the settlement, search for the optimal density of PV installations inside an olive terroir or a high-value landscape such as terraces and b) find collective solutions to high interconnection costs, etc.

Fig. 14. PV visibility identification and response (natural screening) scenario

- 35 It emerged that the activation of participants in a 3D environment favours the search for solutions to various borderline situations which occur at the lower scales, where institutional constraints, proposed actions by the NSDMCC and new territorial perspectives (terroir exploitation)⁴ are simultaneously involved.
- 36 The contribution of the implemented methodological chain is apparent in facilitating the transition to places of varying scales, in other words, from the small scale of individual ownership and decision-making, to the overarching scales of the valley and Troodos, where the energy infrastructure is connected or opposed to collective decision-making, the use of common goods and the exploitation of the multi-functionality of places.

Discussion

- 37 The institutional framework, policies, energy potential and new technologies narrowly define the siting, distribution, size and density of RES installations. In this context of energy transition, the role of materiality (interconnection network, energy storage) still seems to be a determining factor in the evolution of this issue in mountain spaces in general. In contrast, both the inherited structures of the mountain (habitation, land relations, network of expatriates, etc.) as well as the new prospects created by a territorial approach to development, are taken into very little account in the design of

this transition. It appears that both distributive and procedural justice neglect the fact that local participatory planning can also contribute to sustainable and consensual RES integration in host areas.

- 38 The methodology attempted to introduce the territorial component into the dialogue regarding the siting and visual impacts of RES units in mountain spaces, through interactive visualization tools in both areas. The territorial dimension offers new prospects by highlighting functions, for the local economy, embedded in the landscape-resource relationship. This approach illuminates the difference between the formal restrictive perception of space (institutional framework) as a landscape adorned with points-locations of interest, and the places of territorial interest proposed by local communities. In the mountain, these places are linked to valleys, small plateaus of interest to tourists, terroirs, etc., which the local communities incorporate into their territorialities. Within this framework, the geo-visualization methodology assumes the role of “mediator” between RES and territorial building when it contributes to the production and/or co-production of territorial information.
- 39 Highlighting the material and intangible resource elements within the space-landscape is at the source of the production of territorial information. It is small-scale, often implicit information, but necessary for territorial planning. The whole process of visualization and navigation in a virtual environment enables actors to determine, through their experiences and territorial plans, the relationship between material and intangible elements as components of one or more resources.
- 40 This relationship is important as it creates value and ensures inherited or new functions are anchored to specific locations. The location is incorporated into a place as part of a set of functions with strong anchors and idiosyncrasies which can be integrated into activities and services based on local planning.
- 41 As this methodological path discovers-reveals the links between the elements and the place, it forms the basis for the local community to assess the potential risks to the region posed by energy transition, through the impact on the landscape (towers) and/or land competition (terroirs, terraces). In fact, it involves the integration of this territorial information into the spatial relationship between RES, landscapes and resources. This integration leads to the broadening of the object of protection, from the point-location adopted by the institutional framework for RES, to that of location-place defined by the territorial approach. In other words, the transition from the impact on the landscape to the impact on the place and its existing or potential functions. This means that the methodology contributes to the assessment of the impact caused by concurrent visibility and actual, or seeming due to the relief, density of installations, while focusing on the place, functions (e.g., terraces, nature activities), land uses as well as land structures and relationships.
- 42 This process of a two-way approach to the relationship between RES and places in the space created the need for continuous transitions between spatial environments defined by the different scales, observer viewing angles, the object viewed, etc. They provide information of a territorial nature such as the dependence of the resource on a landscape where material (paths, forest, herds, etc.) and intangible (heritage, practices, etc.) elements intersect. Geo-visualization facilitated virtual movements between these spatial contexts.

- 43 The identification of interfaces between resources and RES with the contribution of the interactive methodology constitutes the decisive step for the meeting-negotiation of the local community's territorial plans with the visual and spatial impacts of RES installations. The research shows that these interfaces are determined by two factors: view (visual impact) and the distribution of installations (land use competition). On the other hand, in terms of territorial resources, highlighting the relationship between point-location and the material and intangible links between functions and resources, at the broader "place scale" through 3D PPGIS, allows us to the redefine the dimensions of the object of protection in space (from the point of interest to the place of interest). This approach, via interfaces combining 3DPPGIS with territorial information, supports interactive participatory planning (Yu *et al.*, 2020) and the specialization of local plans in terms of regulating the spatial relationship between RES-landscapes-resources (land uses, zones, etc.). It also enables the expansion of the current spatial-geometric approach and therefore the definition of RES carrying capacity.

Conclusion

- 44 The attempt at an objective approach to RES in mountain spaces was actively supported by the multidimensional role of the methodological chain that was implemented. This role was not limited to technical issues (two-way movement and transposition of information at different scales, adaptation of digital representation to the real-time needs of consultation). It also functioned as a bottom-up territorial information system that activates territorial identity and enriches territorial intelligence and engineering. In addition, it appeared that the technical capabilities mentioned above, act synergistically with the diversity of situations offered by mountains due to geomorphology, habitation, land uses and territorial dynamics. Finally, the consensual embedding of heritage elements and functions in virtual space, enabled the recognition and inclusion in the dialogue of implicit territorial information. The result represents a supporting element to the process of resource ownership and territorialisation, and contributes to the formulation of local regulations regarding the relationship between resource, landscape and RES.
- 45 The whole process of visualization and navigation in a virtual environment strengthens the position of mountain communities in the process of co-constructing the territorialisation of energy transition. It improves the abilities of local actors in specialising local plans, thus contributing to the renewal of planning in terms of the spatial relationship between RES, Landscape and territorial resources. Finally, the methodology contributes to the more effective connection of knowledge and action in mountain spaces and strengthens territorial competence.
- 46 This ability contributes to the objectivity of the approach to new issues such as those that connect the past with the future in the space (heritage and RES). It also contributes to a field where the perceptions and demands of the regulatory interventions of two forces meet: one stemming from underlying dynamics of territorialisation and the other imposed by the centrally designed RES policy.

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NOTES

1. European ENERSCAPE programme (2013)
2. National institutional framework for RES siting (2008)
3. National Strategy for the Development of Mountain Communities of Cyprus
4. The NSMCC views the contribution of RES positively, on the condition of their harmonious integration into the landscape and their contribution to the improvement of living and production conditions for the local population.

ABSTRACTS

Harmonising energy transition with the process of territorial development represents a substantial challenge for local mountain communities. This effort to harmonize RES (renewable energy sources) integration must escape the restrictive geometric and “point” approach to regulating the relationship between RES and landscape, and incorporate places included in the process of territorialisation by local communities. By incorporating functions and territorial resources, this transition modifies the nature and dimensions of the interfaces between the impacts of RES (landscape, land) and places of interest. As a result, it can determine the fields of a new regulatory framework for planning (location-resource-function-relationship). It can also contribute to the expansion of the definition of RES carrying capacity, which is constrained by the institutional framework.

This whole process of harmonising RES integration reveals the need for local community participation in planning: as managers of territorial resources and as a source for a “territorial” information system through geo-visualisation. The whole methodological process incorporates territorial information in the planning of complex spatial issues, such as the integration of RES in territorial mountain areas. This process ultimately renews interactive participatory planning in a field where centrally—designed RES policy meets the bottom-up dynamics of territorialisation.

Harmoniser la transition énergétique à travers le processus de développement territorial représente un défi important pour les communautés locales en zones montagneuses. Ce souci d'harmonisation de l'intégration des SER (Sources d'énergie renouvelable) doit échapper à l'approche restrictive, géométrique et « ponctuelle » de la réglementation de la relation entre les SER et paysage, et appréhender les lieux compris dans un processus de territorialisation des communautés locales. En intégrant les fonctions et les ressources territoriales, cette transition modifie la nature et la dimension des interfaces entre les impacts des SER (paysage, territoire) et les lieux d'intérêt. En conséquence, elle peut déterminer les champs d'un nouveau cadre réglementaire pour la planification (relation lieu-ressource-fonction). Elle peut également contribuer à l'élargissement de la définition de la capacité énergétique des SER, limitée par le cadre institutionnel.

Tout ce processus d'harmonisation de l'intégration des SER révèle la nécessité de la participation des communautés locales à la planification : en tant que gestionnaires des ressources territoriales d'une part et en tant que productrices d'un système d'information « territoriale » d'autre part, à l'aide de la géovisualisation. L'ensemble du processus méthodologique incorpore des informations territoriales dans la planification de questions spatiales complexes, telle que l'intégration des SER dans les zones montagneuses. Ainsi, un tel processus renouvelle les questionnements quant à la planification participative interactive dans un domaine où la politique des SER, conçue de manière centralisée, rencontre la dynamique ascendante (dite *bottom-up*) de la territorialisation.

INDEX

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