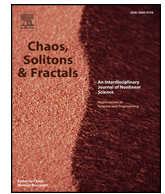




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A nonlinear, data-driven, ANNs-based approach to culture-led development policies in rural areas: The case of Gjakove and Peć districts, Western Kosovo

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ABSTRACT

We develop a computational approach to the analysis of cultural vibrancy and to the role of the cultural and creative sectors in the socio-economic organization of two districts of Western Kosovo, Gjakove and Peć. Our analysis is built on a geolocalized mapping of the cultural activities and facilities, and on the main socio-economic variables for the two districts, and makes use of innovative data analysis techniques: Theory of Impossible Worlds (TIW), the Topological Weighted Centroid (TWC), and the AutoCM ANN. We find that the dynamics of cultural vibrancy of the territory is mainly driven by the competing attraction pulls of the nearby countries of Serbia and Albania, that also form the region's main and often conflicting ethnicities, and that such dynamics are likely to further polarize in the future. We also find that the cultural system plays a marginal role in the territory's socio-economic organization. This situation makes a case for a more active role of cultural policy in shaping future local developmental models in rural areas and in acting as an agent of social cohesion.

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1. Introduction

Cultural and creative production systems have an intrinsic ecosystemic nature due to the complex structural interdependencies that link different components and value chains belonging to different sub-sectors [1]. However, tracking such interdependencies is difficult, as many of the relationships and feedback loops between different system components are not easily observable, let alone directly measurable. This is also due to the fact that in all cultural sectors there is typically a large share of small and micro companies and freelance professionals which are especially challenging to track, leading to extreme structural

fragmentation [2]. Consequently, policy design in cultural and creative fields presents special difficulties [3] and often fails to properly conceptualize and anticipate the effects of policy measures [4] and to assess their effectiveness and impact [5], especially on the smallest and potentially most economically and socially fragile (but often largely representative in quantitative terms) parties [6].

Also due to this structural complexity, it is difficult to assess what are the conditions that enable a cultural and creative ecosystem to thrive [7]. Large metropolitan areas typically host a vast and diversified population of cultural institutions, companies, and professionals [8], but population size in itself is not necessarily a sign of cultural vibrancy [9]. Conversely, relatively small towns may have a limited population in absolute quantitative terms, while providing clear and well-known examples of cultural vibrancy and successful cultural place branding [10]. Moreover, the cultural and creative sectors may operate as a silo in the local economy, that is a largely self-referential system, or may to the contrary be strongly integrated with other production sectors and social spheres [11]. Furthermore, cultural and creative activities may

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be characterized by strong agglomeration [12] or instead may be widely spread across the territory [13]. They can rely upon the leadership of major institutional or corporate players [14] or build upon a dense, bottom-up web of local informal players and vernacular creativity [15]. All such features have been studied individually, but a comprehensive approach to cultural vibrancy and to its socio-economic and spatial correlates has been missing, with the result of failing to get a deep understanding of its situated enabling conditions [16]. A sophisticated statistical tool, the Cultural and Creative Cities Monitor (CCCM) developed by the Joint Research Center provides important insights into such complexity [17], showing that different cities with a strong cultural and creative profile may excel in different dimensions, and such excellence may also entail possible tradeoffs [18]. Moreover, the local structural conditions that support such dimensions of excellence may be strengthened or undermined by policy choices, also outside the cultural and creative sphere [19], or by the capacity to respond effectively to large external shocks such as the global pandemic [20]. A bustling local cultural and creative economy need not be matched by a rich availability of high-profile cultural institutions, and vice versa. Availability of world-class cultural heritage need not be accompanied by a welcoming environment for young creative professionals. A rich and diversified program of cultural activities might not imply the presence of favorable conditions to launch or grow a creative business, and so on. There is not a single recipe for cultural vibrancy, and different local systems may be characterized by very different combinations of local conditions and variables. Although the CCCM offers a very useful tool to explore such variability in the European context, it does not allow us to understand what are the underlying factors driving such tradeoffs and their evolution over time. We therefore need to expand our toolbox to be able to not only describe such phenomena, but also to analyze and infer their time and spatial patterns.

A promising route to a full characterization of the various structural facets of cultural vibrancy may be in our view a geo-computational approach to the analysis of cultural and creative ecosystems that reconstructs their fine-grained articulation on the basis of the inherent territorial organization of their observable components. This approach is especially useful in contexts where cultural statistics are difficult to obtain through institutional channels (see [21], for an application to the cultural dimension of green spaces), and where their collection and processing takes time, making it difficult to maintain a close mapping and monitoring of the evolution of the cultural and creative systems dynamics. In this paper, we consider one such case to illustrate the full potential of our approach at a sub-regional scale. In particular, we study the cultural and creative systems dynamics of two districts in Western Kosovo, Gjakove and Peć.

The interest of this case study lies in the fact that not only Kosovo is under-researched in terms of cultural vibrancy studies (and cultural policy studies altogether), but also because of a few interesting characteristics: it is a country for which cultural data are scarce; it is characterized by a major ethnic divide between the Serbian- and Albanian-language communities; and is located in one of the most critical geopolitical areas of Europe. Our geo-computational approach allows us to build a map of the districts' cultural (permanent) activities and facilities, and to use it as a basis to forecast the evolution of the corresponding spatial patterns of cultural vibrancy. Moreover, by means of a suitable ANN approach, we are also able to reconstruct the architecture of the structural relationships between the local cultural and creative sectors and the wider social and economic spheres, assessing their level of integration, and developmental role, in the districts' whole socio-economy.

Our analysis enables us to characterize the cultural and creative ecosystem of the two Western Kosovo districts as a currently marginal, structurally disconnected part of the local socio-economy. The various components of the cultural and creative ecosystem are less reciprocally interdependent than they are with other parts of the socio-economic system. Moreover, such non-cultural components to which they

connect are typically among the least dynamic and innovative. In a sense, we cannot properly speak of a full-fledged cultural and creative ecosystem yet, but rather as a series of sectoral 'enclaves' which poorly communicate with each other and that need a finalized policy action to become more inter-related. In particular, the connection between cultural and educational sectors is tenuous and the cultural sectors are not anchored to the local socio-economic 'core' that builds upon traditional agricultural, commercial and service sectors. Another important finding is that currently cultural facilities are not working as effective social hubs, as they are not closely related to variables that describe social cohesion or exchange. We also find that the viability of cultural facilities and activities is critically related to the capacity to raise funding from paying visitors, as the availability of public funds is extremely limited. This clearly poses a serious problem of participation and inclusion for the less affluent, and thus of effective social engagement and impact. As to the dynamic evolution of the geographical profile of cultural vibrancy, we find that the two main hubs of cultural vibrancy are shifting toward the two main urban centers, Peja in the North and Djakovica in the South, which function as gateways to the main extra-territorial poles of attraction, namely Serbia and Albania. Moreover, such hubs show a tendency to move further closer to the borders with Serbia and Albania, respectively. This is a clear proof that the local dynamics of cultural vibrancy are currently shaped by the influence of the two nearby countries which also represent the two (often conflictual) ethno-cultural poles of Kosovar culture. On the other hand, the country's capital city and lively cultural hub, Pristina, exerts very little influence on such dynamics. The cultural ecosystem under study is therefore mostly driven by external forces related to the regional geopolitics and needs to acquire a better capacity of self-organization and cooperation between local players, in the absence of which the two Western districts are unable to count on cultural and creative sectors as a significant local socio-economic developmental driver.

State-of-the-art local development policies need to respond to the increasing structural interdependency that characterizes complex economies and societies. Cultural policies are therefore not only relevant for the cultural and creative sector but may generate important cultural spillovers and even crossovers [22] with other major sectors. In this regard, as culture and creativity often provide an important contribution to social cohesion and conflict resolution in contexts marked by ethnic tensions, failing to seize such opportunities is especially critical in a context such as the Kosovar one.

Our methods and results provide a constructive approach to analysis and cultural policy design in territories with scarcity of cultural data and with poor tradition and experience in cultural policy. Specifically, we develop a methodology for a data-driven approach to culture-led local development policies. Such approach moves from the recognition of the intrinsically nonlinear nature of the underlying processes, that is difficult to tackle through closed-form mathematical modelling, thus calling for computational methods as a foundation of evidence-based policy design, implementation, monitoring, and assessment.

The remainder of the paper is organized as follows. [Section 2](#) contains the methods. [Section 3](#) describes the data. Results are presented in [Section 4](#). [Section 5](#) offers a final discussion and concludes.

2. Methodology

Geo-computational approaches to social phenomena are today flourishing thanks to the massive application of sophisticated techniques from computational physics, machine learning, spatial network analysis, etcetera [23]. Our approach combines several techniques, and builds upon three essential tools:

- a) The Theory of Impossible Worlds (TIW), which allows the fusion of two completely different data sets, such as the cultural facilities and activities datasets in our Western Kosovo districts case;

- b) The Topological Weighted Centroid (TWC), which allows to make inferences about the time evolution of the geographical distribution of cultural activities and facilities;
- c) The Maximum Regular Graph (MRG) generated by the Auto-Contractive Map (AutoCM), a specific Artificial Neural Network, to capture all the most relevant many-to-many nonlinear relationships among all the observed values of the variables characterizing the local socio-economy.

The overall research design behind our approach is shown in Fig. 1 below.

2.1. The Theory of Impossible Worlds (TIW) approach

One of the most challenging goals in machine learning research is the data fusion between datasets with completely different attributes (variables) and observations (records). In the classical theory of possible worlds [24,25] and its later developments, an item can be transferred from a source world (dataset A) to a destination world (dataset B), if, and only if, at least one of its attributes is shared by both worlds. Thus, according to the classical theory, it is impossible to connect two datasets with void intersection among their attributes (properties) and with void intersection among their records (items). We are to going to present a method to make such ‘impossible’ transfer actually feasible. We have named this approach Theory of Impossible Worlds (TIW for short; [26]).

As in human reasoning we often use mental models drawn from the analysis of a certain phenomenon to metaphorically infer properties of a completely different phenomenon [27], it would be intriguing to be able to perform the same kind of inferences in the machine learning domain.

TIW does exactly this, helping us empower machine learning environments with the capacity to ‘fuse’ different databases and variables belonging to different phenomena into a same cognitive space, so that it becomes possible to examine each phenomenon from the structural viewpoint of the other. If this leads to a significant improvement in our capacity to carry out pattern recognition in the specific domains of the source phenomena, then this way of proceeding makes sense and is conceptually useful. This approach proves to be particularly attractive in social sciences where most interesting phenomena are not amenable

to deep empirical analysis for lack of data on joint occurrences, but where partial data for sub-phenomena of interest are often available.

ANNs Auto Encoders have shown an increasing relevance in Deep Learning strategies [28–34]. An ANN Auto Encoder (AE) can execute a non-linear data projection of the attributes of the original dataset using its hidden units as new set of coordinates.

The number of the hidden units of the AE defines the dimensionality of the projection space. The sum of the squared differences between each input vector of the dataset and its corresponding output vector defines the accuracy of the new hidden coordinates: the closer this quantity to zero, the higher the accuracy of the hidden coordinates.

The mode of operation of TIW can be broken down into the following steps (see Fig. 2 below):

Step 1: Datasets Selection

We need to choose at least two or more datasets, preferentially with void intersection among their attributes and also (if necessary) with void intersection among their records.

Step 2: Training Phase

We train independently the two or more datasets using two or more Auto Encoders having the same number of Hidden units (one Hidden layer is sufficient).

Step 3: Weights and other Features Extraction

We save the weights matrices of the two or more Auto Encoders trained, as well as the values of the Hidden units of all the records of each dataset, after the training phase.

Step 4: Point of View of Each Dataset on the Others

We input each Hidden unit of a dataset into the Hidden layer of another dataset, and we generate the output vector using the decoding matrix of weights of the latter (the second matrix is an Auto Encoder with 1 Hidden layer). In this way the rewrite the first dataset with the output variables of the other. We repeat this procedure for each pair of datasets (if the datasets are only two, we need to repeat this procedure just once).

Research Design: Activities + Facilities

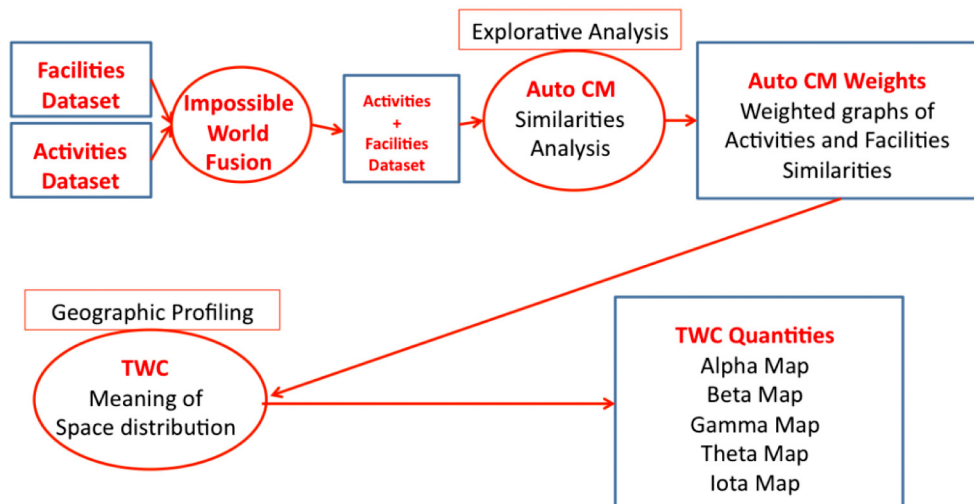


Fig. 1. Research design.

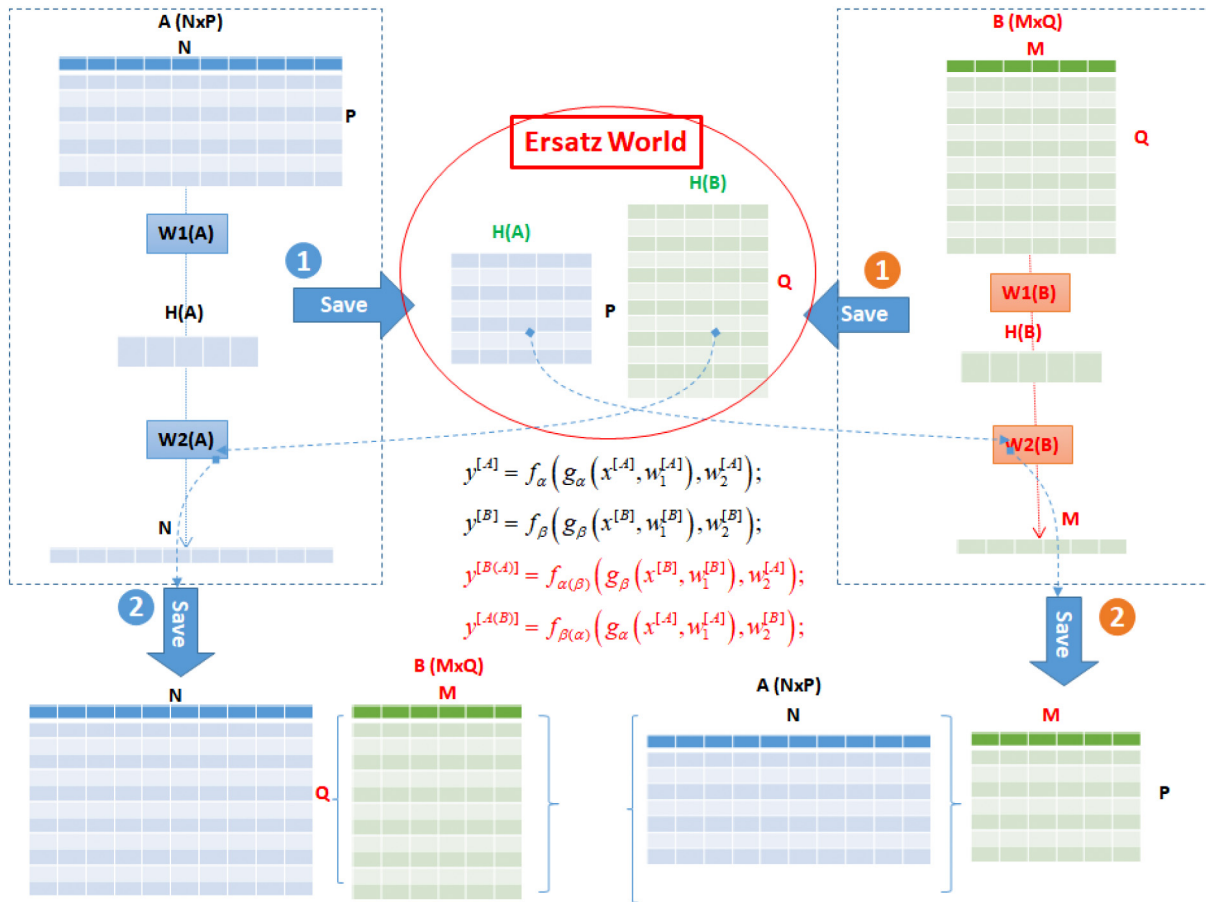


Fig. 2. Synthetic representation of TIW.

Step 5: Records Fusion

We concatenate the Hidden units of each dataset into one new dataset (which is possible because all the datasets included into the experimentation were trained with the same set of Hidden units). Thus, we may use a further Auto Encoder, or a Principal Component Analysis, or an analogous algorithm, to calculate the distance and/or the strength of association among the records of all the datasets, using the hidden units of each as coordinates in H-dimensional space (H = Number of Hidden units used during the previous training phase). At the end of this procedure, we get a square matrix of the distances (i.e., of the strengths of association) between each pair of records (irrespectively of the dataset to which they originally belonged).

Step 6: Graph Fusion

We can apply a graph filter (Minimum Spanning Tree, Maximum Regular Graph or analogous) to the new square matrix of similarities to generate a weighted tree or graph among all the records simultaneously.

Step 7: Multi-Dimensional Scaling Comparison

We can measure the differences and the similarities of any original dataset with respect to the same dataset re-written with the attributes of the other dataset(s), using a multi-dimensional scaling algorithm on both (PCA or analogous). Surprisingly, we will observe that the new variables of each dataset present the same clustering patterns shown in the original dataset. Thus, despite the transfer from one

world to another, the geometry of the original dataset is preserved in the new world.

Step 8: Quantitative Validation of the Trans-World Data Transfer

If the dataset used in the experimentation has a target vector (that has not been used in any of the previous steps), we can also measure the effectiveness of the trans-world transfer by means of a K-Fold Cross Validation protocol: evaluate the classification accuracy of each dataset with the original attributes (default measure) with the accuracy we got using the same dataset with the new attributes that are specific of the other datasets.

TIW has a strong potential for applications in the social sciences, as it allows to synergize the informational content of non-conformable databases covering related phenomena. But it can also allow the application of powerful 'metaphorical' thinking to databases covering very different phenomena but that may benefit from multiple 'viewpoints'. In the cultural field, an important such example is that of cultural crossovers as defined by the New European Agenda for Culture [22]: those between culture and health; culture and innovation; culture and environmental sustainability; culture and social cohesion, etcetera. Likewise, TIW may be very useful in cases where abundant data exist for two separately relevant phenomena whose relationship is currently not covered enough by specific studies (e.g., financial indebtedness and health; gender differences and leadership styles, etcetera).

We can therefore sum up the main features of TIW as follows:

- TIW allows the fusion of datasets with void intersection of variables and records.

- Such fusion generates new datasets that represent the point of view of each dataset about the other(s): that is, how each dataset would look like if it had the attributes of the others.
- The fusion process also shows that a transfer of an abstract knowledge content from a dataset to another one is in principle possible.
- The new datasets provide also new, useful information about each of the source datasets: they improve performance in pattern recognition tasks. Moreover, they also improve the speed of ANNs convergence.
- The new datasets make it possible, by means of the shared hidden vectors, to represent in one single weighted graph all the variables and all the records of all fused datasets.
- Each new dataset may be used for dynamic scenarios simulation, highlighting the metaphoric resonances between any given dataset and the others.

The other building blocks of our methodology, namely the TWC approach and the AutoCM approach, have been extensively presented elsewhere and will not be described in detail here (see e.g. [35]). We limit ourselves to a few basic considerations about how they fit into the research design.

2.2. Analytical strategy

The basic conceptual premise of our analysis is that the geographical distribution of the cultural items across the territory follows an implicit space grammar that can be reconstructed from the structural properties of the distribution. Such grammar reflects the mutual relationships of the various items within the cultural system and its relationships with the other social and economic systems. To reconstruct such grammar we have to pursue two separate, complementary tasks: understanding how the spatial distribution of activities helps us build a heat map of cultural vibrancy across the territory, and how such vibrancy evolves over time; and understanding how cultural activities are related to the wider socio-economic context of the territory to understand the level of functional integration of the former, by analyzing the multidimensional similarities across the cultural and socio-economic data. The first task will be carried out by applying the so-called TWC (Topological Weighted Centroid) methodology [36–38]. The second, by making use of the Maximum Regular Graph generated by the AutoCM Artificial Neural Network [39,40].

2.3. The TWC approach

The TWC approach has been applied to predict the outbreak and epidemic spread of infectious diseases from the spatial distribution of the early cases [36,41–44], or the probability of future terrorist attacks from previously observed ones [45]. It has also been applied to the analysis of cultural and creative ecosystems of the Veneto region in Italy [46] and of the Halland region in Sweden [35], building upon the notion of pseudo-diffusion processes: the most geographically vibrant parts of the ecosystem tend to become more ‘contagious’ in terms of cultural activity than less vibrant ones. Consequently, we can create heat maps of cultural vibrancy that evolve over time.

The Topological Weighted Centroid (TWC) can be defined as the point that minimizes the sum of all the pseudo-distances between itself and each of the observed points of the distribution. The TWC thus represents the ‘epicenter’ of the diffusion process that shapes a certain distribution of items in space. In our specific case, the TWC represents the ‘outbreak’ point of the pseudo diffusion process of the cultural activities and facilities mapped in the geographical space. A whole set of different TWCs can be computed depending on how the pseudo-distance is defined and on how the minimization is carried out. The reader is referred to Buscema et al. [45] for technical details. The various TWCs, named Alpha, Beta, Gamma, Theta, and Iota, have been shown to carry information as to the evolution over time of the distribution of observed items

from the original outbreak point (Alpha, ‘yesterday’), to the status quo (Beta, ‘today’), to various future stages (Gamma, Theta, Iota), whose actual timescale depends on the specific phenomenon being studied and needs to be calibrated accordingly. The whole set of TWCs is illustrated in Fig. 3.

2.4. The Auto Contractive Map (AutoCM) approach

By crossing geo-referenced information with socio-economic data from cultural and creative sectors and the overall regional socio-economy, through the AutoCM analysis we can build MRG (Maximum Regular Graph) network maps of the functional relationships between system variables to ‘contextualize’ the various components of the cultural and creative sectors within the broader socio-economic local organization, to understand e.g. whether they are functionally connected to the most innovative, knowledge-intensive and growth-oriented parts of the local economy or to more stagnant ones. This allows in turn to simulate the impact of both cultural and socio-economic policies on the spatial and functional structure of the cultural and creative ecosystem.

2.5. The methodology at work

The process starts from the facilities and activities datasets which are fused by means of TIW into a whole dataset, which is fed to the AutoCM to carry out the similarity analysis generating the AutoCM weights. Such weights enable the building of the MRG, which maps the structure of the most relevant connections between each cultural and socio-economic variable, and therefore provides a graphic, easily accessible and interpretable visual representation of the functional role of each element of the cultural and creative ecosystem within the broader local socio-economic organization. At the same time, the geographical profiling of the cultural ecosystem is carried out by the TWC component, generating a sequence of heat maps (Alpha, Beta, Gamma, Theta, Iota) that describe the future evolution of the cultural vibrancy of the system in the absence of external policy interventions. The predictive capacity of such maps has been successfully tested in supervised prediction tasks such as those for epidemics and terrorist attacks cited above, and has been further validated in the previously cited studies on the cultural and creative ecosystems of Veneto and Halland. The insights deriving from one layer of the analysis may be usefully exploited to better understand the results of the other, and vice versa.

2.6. Policymaking implications

The previous analysis offers valuable background information for participative policy design, to provide policy makers with a reliable evidence base for future investments and policies, and to stimulate local stakeholders to be proactive in reinforcing positive momentums or in bouncing back from slumps through specific targeted interventions. This approach also provides a basis for a better, more functional, and effective integration of cultural activities in the overall smart specialization strategy of the territory, according to the logic of System-Wide Cultural Districts [47–49], where cultural production and participation become a nexus of key structural interdependencies across many different sectors, promoting trans-sectoral innovation.

3. Data

We study the cultural ecosystem of two districts in Western Kosovo, namely Gjakove and Peć, which include seven municipalities: Deçan, Junik, Klina, Gjakove/Djakovica, Rahovec, Peć/Peja, Istog, for a total of approximately 318,000 inhabitants.¹ They are geographically the most

¹ In what follows, to ease exposition, we refer to Gjakove when we speak of the district, and to Djakovica when we speak of the city; and likewise to Peć when we speak of the district and Peja when we speak of the city.

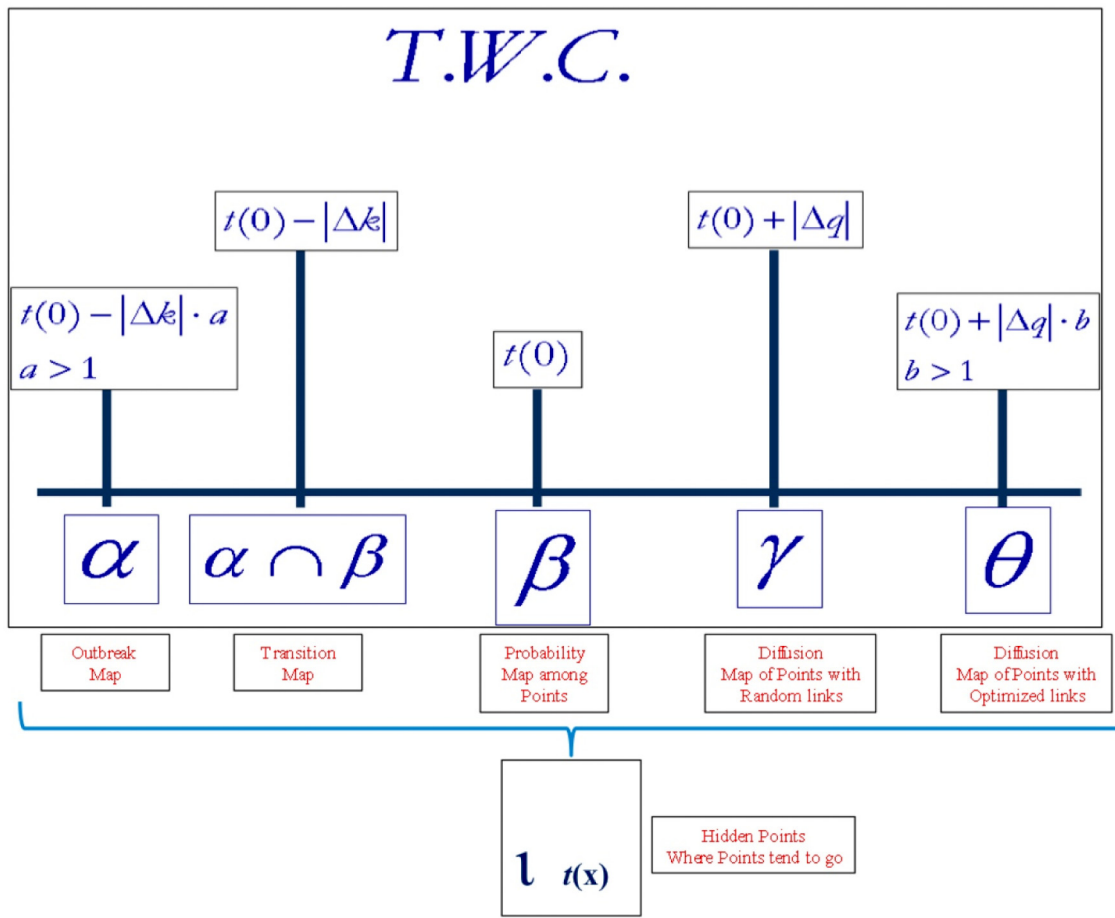


Fig. 3. The whole set of TWCS.

Western districts of Kosovo, and are an example of a predominantly rural area, with small towns and relatively few inhabitants (Peć in particular is the least populated of the seven districts of Kosovo). None of Kosovo's major cities are located in these districts: the country's capital Pristina, and the two second-tier cities of Gjilan and Prizren are all in the Eastern (the former two) or in the Southern (the latter) parts of the country. The districts under study host two third-tier towns, namely Djakovica, in the Gjakove district, and Peja, in the Peć district, both of which are the districts' respective capitals. Both districts are characterized by an Albanian ethnic majority.

The districts' specialization profile is in agriculture and forestry, and the local cultural and creative sectors are small and under-developed. Therefore, very little statistical evidence is available and there is little interest in cultural policy by local administrations. Of particular relevance is the presence of two of the four Medieval Monuments in Kosovo listed as World Heritage Sites, in Deçan (Visoki Dečani) and Peja (Patriarchate of Peć Monastery).

We have chosen these geographically marginal and not densely urbanized Kosovar districts rather than the more central and populated ones to study the dynamics of cultural vibrancy in a rural, socio-economically under-developed territory. In many such cases, the lack of effective culture-led development processes is the result of a vicious circle: under-developed and poorly integrated cultural and creative sectors fail to catalyze enough public interest to attract public investments and to acquire relevance in the policy agenda. As a consequence, little initiative is taken and awareness of the critical factors that prevent such development and availability of data are both scarce, so that there are little chances that the under-development issue may be

properly tackled. Therefore, the local cultural and creative system persists in a state of under-development, closing the circle. In the specific case under study, an additional important element is the one related to the multicultural context and to the underlying ethnic tensions, which may play a further role in conditioning the dynamics of cultural vibrancy, calling once more for a deeper understanding of the forces at play to enable the design of targeted cultural policies.

To stress the need to raise awareness in the local community as to the importance of gathering data to gain an understanding of the

Table 1
Activity and facility categories.

Facilities (377)		Activities (111)
Archeology	Museum	Community Center
Bazaar	Natural (cave)	Crafts
Bridge	Natural (lake)	Cultural event
Cave	Natural (landscape)	Dance
Cinema	Natural (National parks)	Education (focused in culture)
Community centre	Natural (ski resort)	Fashion design
Craft	Natural (thermal water)	Gastronomy
Cultural Centre	Natural (Urban park)	Natural (Sport activity)
Education	Natural (waterfall)	Radio & TV
Gallery	Other	Traditional dance
Gastronomy	Religious	
Library	Residential	
Mill	Theatre	
Monument		

Table 2
List of the collected socio-economic variables.

TOTAL DEMOGRAPHY	PopDens	Construction EMPLOYMENT SECTORS	EmpConstrMale	Unused agricultural land AGRICULTURE	NumAgriEconNoUsed							
	PopUrb		EmpConstrFema		HaNoUsed							
	PopRur		EmpCommMale		Forest AGRICULTURE	NumAgriEconForest						
	PopMale		EmpCommFema		Non-agricultural land AGRICULTURE	HaForest						
	PopFema		EmpH&RMale		Hotel & Restaurant EMPLOYMENT SECTORS	Wheat MAIN CROPS / AGRICULTURE LAND USAGE	NumAgriEconNoAgri					
	Pop0-14		EmpH&RFema		Hotel & Restaurant EMPLOYMENT SECTORS	Wheat MAIN CROPS / AGRICULTURE LAND USAGE	NumAgriEconWheat					
	Pop15-65		EmpT&RMale		Transport & storage EMPLOYMENT SECTORS	Corn MAIN CROPS / AGRICULTURE LAND USAGE	HaWheat					
	Pop65+		EmpT&RFema		Transport & storage EMPLOYMENT SECTORS	Corn MAIN CROPS / AGRICULTURE LAND USAGE	NumAgriEconCorn					
	PopIota		EmpFinanMale		Financial intermediation EMPLOYMENT SECTORS	Barley MAIN CROPS / AGRICULTURE LAND USAGE	HaCorn					
	EmpMale		EmpFinanFema		Financial intermediation EMPLOYMENT SECTORS	Barley MAIN CROPS / AGRICULTURE LAND USAGE	NumAgriEconBarley					
Employed Economically active (working force)	UnEmpMale	Employment SECTORS	EmpRestMale	Non-agricultural land AGRICULTURE	NumAgriEconRye							
Employed Economically active (working force)	UnEmpFema		Real estate, leasing and services to enterprises EMPLOYMENT SECTORS		EmpRestFema	HaRye	NumAgriEconOat					
	InactMale		Public administration and social security protection EMPLOYMENT SECTORS		EmpEduMale	HaOat	NumAgriEconBean					
	InactFema		Education EMPLOYMENT SECTORS		EmpEduFema	Beans MAIN CROPS / AGRICULTURE LAND USAGE	HaBean					
	Work15-64Male		EmpPAFMale		Healthcare & social services EMPLOYMENT SECTORS	EmpPAFMale	Potatoes MAIN CROPS / AGRICULTURE LAND USAGE	NumAgriEconPota				
	Work15-64Fema		EmpPAFfema		Healthcare & social services EMPLOYMENT SECTORS	EmpPAFfema	HaPota	NumAgriEconLuc				
	Work15-64AJ		EmpPAAJ		Other community, social or personal activities EMPLOYMENT SECTORS	EmpPAAJ	Lucerne (Alfalfa) MAIN CROPS / AGRICULTURE LAND USAGE	HaLuc				
	Illiterate EDUCATION OF THOSE EMPLOYED (15-64)		EduIllMale		Other community, social or personal activities EMPLOYMENT SECTORS	EmpEduMale	Clover MAIN CROPS / AGRICULTURE LAND USAGE	NumAgriEconClov				
	Elementary education EDUCATION OF THOSE EMPLOYED (15-64)		EduIllFema		Household and family services EMPLOYMENT SECTORS	EmpEduFema	Mixed weeds MAIN CROPS / AGRICULTURE LAND USAGE	HaClov				
			EduElemMale		Activities of organizations and external bodies EMPLOYMENT SECTORS	EmpHeMMale	Green corn MAIN CROPS / AGRICULTURE LAND USAGE	NumAgriEconMixW				
		EduElemFema	TOTAL EMPLOYMENT SECTORS	EmpHeMFema	Pumpkin MAIN CROPS / AGRICULTURE LAND USAGE	HaMixW						
EduElemAll		TOTAL EMPLOYMENT SECTORS	EmpOtherSocialMale	Peppers MAIN CROPS / AGRICULTURE LAND USAGE	NumAgriEconGreCo							
EduHSMale			Other community, social or personal activities EMPLOYMENT SECTORS	EmpOtherSocialFema	Tomatoes MAIN CROPS / AGRICULTURE LAND USAGE	HaGreCo						
EduHSFema			Household and family services EMPLOYMENT SECTORS	EmpOtherSocialAll	Onion MAIN CROPS / AGRICULTURE LAND USAGE	NumAgriEconPum						
EduHSAJ			Activities of organizations and external bodies EMPLOYMENT SECTORS	EmpHouseMale	Cabbage MAIN CROPS / AGRICULTURE LAND USAGE	HaPump						
EduVocEdMale			TOTAL EMPLOYMENT SECTORS	EmpHouseFema	Watermelon MAIN CROPS / AGRICULTURE LAND USAGE	NumAgriEconPepp						
EduVocEdFema				TOTAL EMPLOYMENT SECTORS	EmpVocEdMale	Total land size MAIN CROPS / AGRICULTURE LAND USAGE	HaPepp					
EduVocEdAll					TOTAL EMPLOYMENT SECTORS	EmpVocEdFema	Bufalo LIVESTOCK	NumAgriEconToma				
EduBScMale	TOTAL EMPLOYMENT SECTORS					EmpBScMale	Sheeps LIVESTOCK	HaToma				
EduBScFema						TOTAL EMPLOYMENT SECTORS	EmpBScFema	Goats LIVESTOCK	NumAgriEconOni			
EduBScAll							TOTAL EMPLOYMENT SECTORS	EmpBScAll	Pigs LIVESTOCK	HaOni		
EduMScMale		TOTAL EMPLOYMENT SECTORS						EmpMScMale	Horse, Mule & Donkey LIVESTOCK	NumAgriEconCabb		
EduMScFema								TOTAL EMPLOYMENT SECTORS	EmpMScFema	Poultry LIVESTOCK	HaCabb	
EduMScAll									TOTAL EMPLOYMENT SECTORS	EmpMScAll	Other LIVESTOCK	NumAgriEconWaim
EduPhDMale										TOTAL EMPLOYMENT SECTORS	EmpPhDMale	Bee hive LIVESTOCK
EduPhDFema			TOTAL EMPLOYMENT SECTORS								EmpPhDFema	TOTAL LIVESTOCK
EduPhDAll				TOTAL EMPLOYMENT SECTORS							EmpPhDAll	HaTotLand
EduTotMale					TOTAL EMPLOYMENT SECTORS						EduTotMale	NumAgriEconSheep
EduTotFema	TOTAL EMPLOYMENT SECTORS										EduTotFema	NumAgriEconGoat
EduTotAll						TOTAL EMPLOYMENT SECTORS					EduTotAll	NumAgriEconPigs
EmpAgrMale							TOTAL EMPLOYMENT SECTORS				EmpAgrMale	NumAgriEconHors
EmpAgrFema		TOTAL EMPLOYMENT SECTORS									EmpAgrFema	NumAgriEconPol
EmpAgrAll								TOTAL EMPLOYMENT SECTORS			EmpAgrAll	NumAgriEconOther
EmpFishMale									TOTAL EMPLOYMENT SECTORS		EmpFishMale	NumAgriEconBee
EmpFishFema										TOTAL EMPLOYMENT SECTORS	EmpFishFema	NumAgriEconTot
EmpFishAll			TOTAL EMPLOYMENT SECTORS								EmpFishAll	
EmpMinMale				TOTAL EMPLOYMENT SECTORS							EmpMinMale	
EmpMinFema					TOTAL EMPLOYMENT SECTORS						EmpMinFema	
EmpMinAll	TOTAL EMPLOYMENT SECTORS										EmpMinAll	
EmpProcMale						TOTAL EMPLOYMENT SECTORS					EmpProcMale	
EmpProcFema							TOTAL EMPLOYMENT SECTORS				EmpProcFema	
EmpProcAll		TOTAL EMPLOYMENT SECTORS									EmpProcAll	
EmpEnrMale								TOTAL EMPLOYMENT SECTORS			EmpEnrMale	
EmpEnrFema									TOTAL EMPLOYMENT SECTORS		EmpEnrFema	
EmpEnrAll										TOTAL EMPLOYMENT SECTORS	EmpEnrAll	
EmpEneMale			TOTAL EMPLOYMENT SECTORS								EmpEneMale	
EmpEneFema				TOTAL EMPLOYMENT SECTORS							EmpEneFema	
EmpEneAll					TOTAL EMPLOYMENT SECTORS						EmpEneAll	

underlying issues, the study starts from a participatory mapping by a team of local collaborators, covering the local cultural and creative sectors, by collectively building a georeferenced GIS database of all the main cultural and creative facilities and permanent activities in the region. We consider 10 different categories of (permanent) cultural activities, and 27 categories of cultural facilities, mapping a total of 377 facilities and 111 activities, all of which geo-localized, as of 2017. The activities categories are: Community Centre, Crafts, Cultural event, Dance, Education (focused on culture), Fashion design, Gastronomy, Natural (Sport activity), Radio & TV and Traditional dance. The facilities span the following categories: Archaeology, Bazaar, Bridge, Cave, Cinema, Community centre, Craft, Cultural Centre, Education, Gallery, Gastronomy, Library, Mill, Monument, Museum, Natural (cave), Natural (lake), Natural (landscape), Natural (National parks), Natural (ski resort), Natural (thermal water), Natural (urban park), Natural (waterfall), Other, Religious, Residential, Theatre. Table 1 summarizes the above information.

The list and classification of the categories of facilities and activities that are part of the local cultural system have been agreed with local stakeholders and administrative representatives through rounds of meeting and discussion, leading to specific criteria of inclusion. On the basis of the agreed conceptual framework, the collection of the data related to the activities and facilities that matched the selection criteria has been carried out in 2017.

For each mapped item, a number of attributes were also collected. As to facilities, we collected the following specific attributes: Protection

status, Ownership (Private tenant, Private owner; Public or Religious), Usage (Utilised, Partially utilised or Unused), Type, divided into Cultural (Craft, Radio&TV, Education, Library, Theatre, Cinema, Gallery, Museum, Community centre, Religious, Archaeology, Monument, Mill, Bridge, Bazaar) and Natural (urban parks, national parks, lake, ski resort, landscape, cave, waterfall, thermal water), Date of establishment, Condition (Ruins only, Poor, Average or Good), Management (Government, Religious, NGO or Private), Funding (Pay for entrance/service) and Source of funding (Income; Public; Local donors; Religious community; International donors).

As to the activities, the attributes were: Timeframe, Managing Institution (Ministry, Municipality, NGO, Private business/Individual), Average age of users/visitors, Number of users/visitors, Funding (pay for entrance/services) and Source of funding (income, donors). Assigning a specific activity or facility to the most suitable category has not been straightforward in some instances. In dubious cases, a specific disambiguation procedure has been carried out.

We also collected all the available socio-economic information from existing city, regional and national statistics, and were able to reconstruct the main socio-economic characteristics of the two districts such as demography, educational and occupational levels, land use, for a total of 302 socio-economic attributes (see Table 2).

Fig. 4 reports the geo-referenced mapping of the activities and facilities.

The activities (in yellow) and the facilities (in red) have a characteristic distribution. Facilities are more concentrated on the most Western

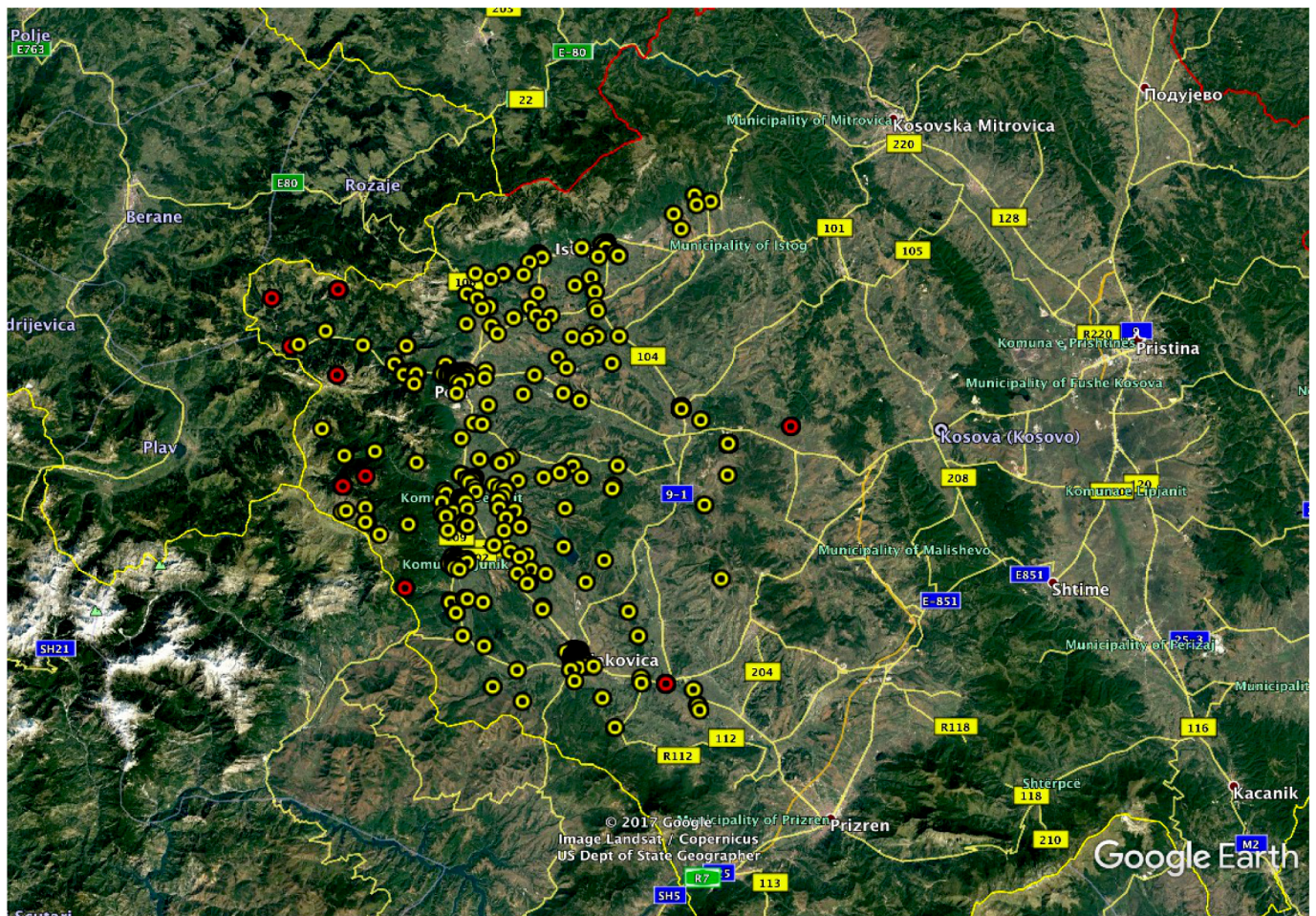


Fig. 4. Map of the activities and facilities.

side of the territory, whereas activities are more evenly spread, and generally gathering along the main mobility routes. The map represents the status quo, but it tells us nothing about its likely short-term and long-term evolution, about its integration with the other spatially embedded economic and social systems of the territory, and about its contribution to the territory's local development. To this purpose, we now carry out an analysis by means of the methodology introduced in Section 2.

4. Results

4.1. TWC analysis

In order to analyze the spatial organization of cultural activities and facilities in our two Western Kosovo districts, we first merge activities and facilities into a fused spatial distribution with 488 cultural items that combine both categories.

The past pattern of cultural vibrancy behind the currently observed distribution of items, as described by the TWC Alpha, is shown in Fig. 5.

The TWC Alpha represents the 'outbreak point' of the distribution of the cultural items. It can be considered as the center of gravity of the original cultural dynamics of the system (its "yesterday", to distinguish it from the observed status quo). To provide a meaningful interpretation of TWC Alpha, we have to place it in the context of the observed distribution of cultural items, as shown in Fig. 6.

As it can be seen from Fig. 6, TWC Alpha sits in the middle of the area with the highest density of activities, which means that the outbreak of the pseudo-diffusion process is still closely related to the densest part of the observed spatial distribution of the items. However, looking at the TWC Beta, we see that, despite the observed distribution suggests that the cultural vibrancy of the territory is organized around the geographically central (but demographically minor) towns of Deçan and Junik, the current momentum is moving the centroid down to the South, toward the capital of the Gjakove district, Djakovica. Even if this momentum

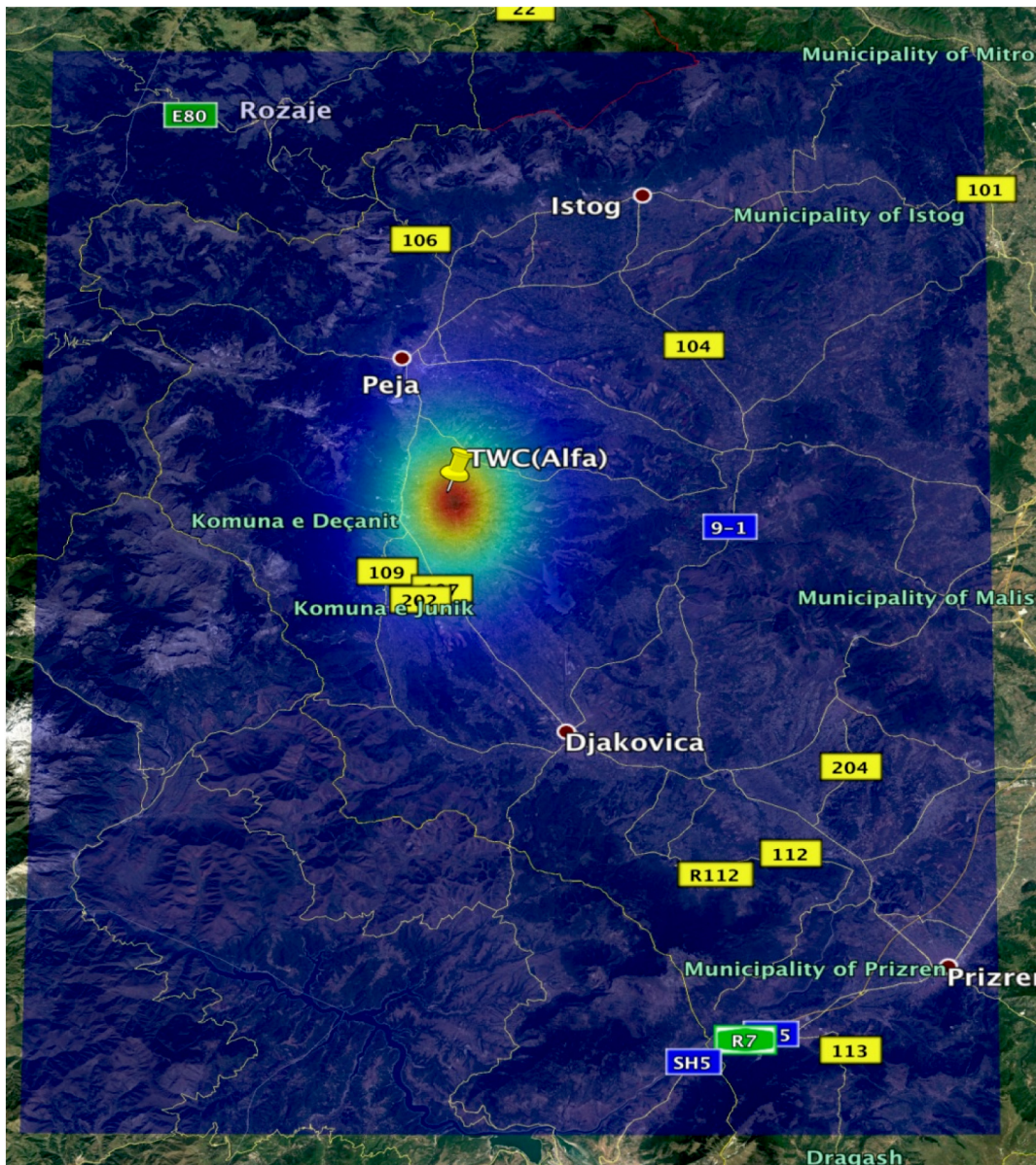


Fig. 5. TWC Alpha.

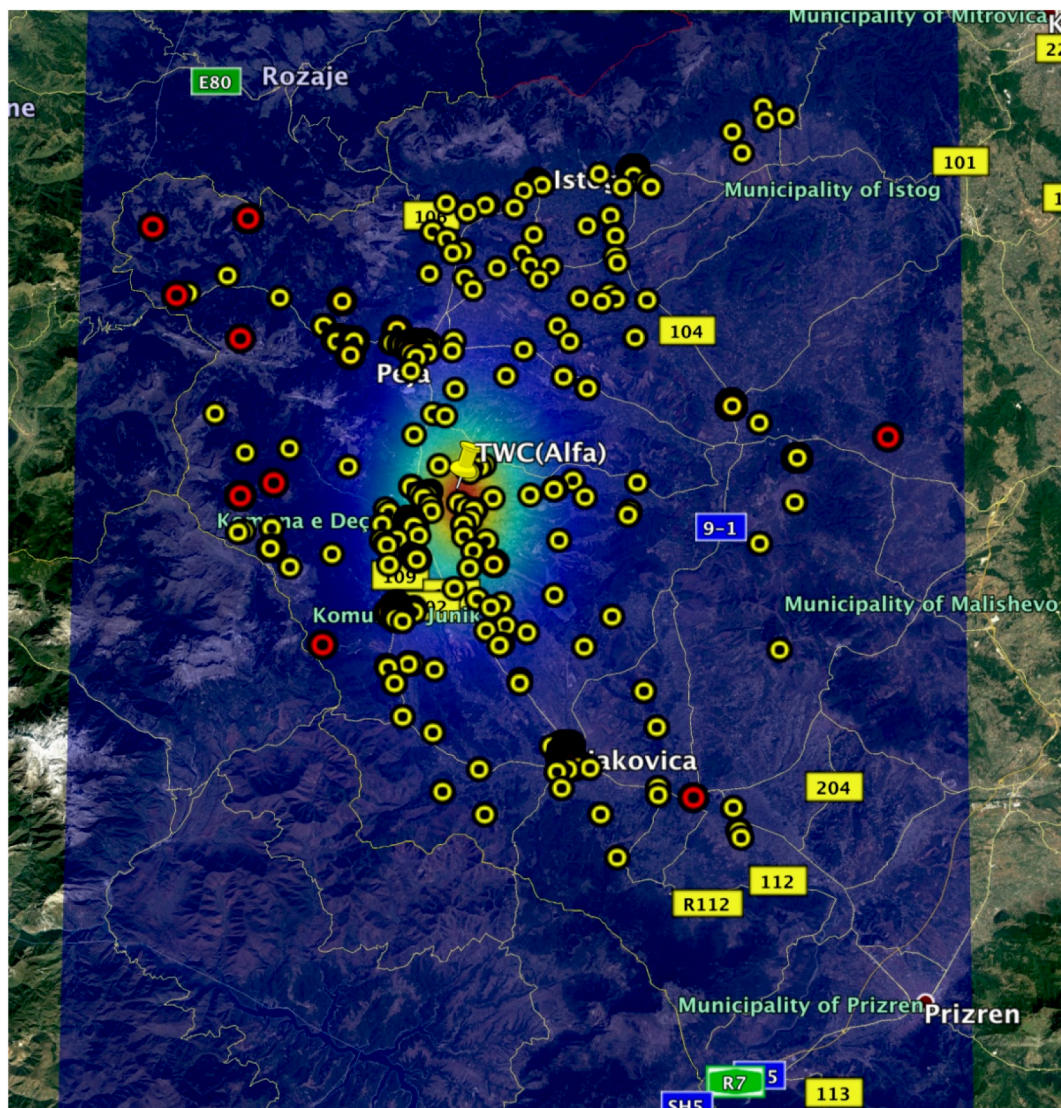


Fig. 6. TWC Alpha and the observed distribution of cultural items.

is not yet fully legible from the observed distribution of items that largely reflects the past dynamics of the process, we may expect that the focus of cultural activity will move away from the original area and shift toward the South. The fact that this new stage represents a clear break from the past is shown in Fig. 7, where, by reporting the currently observed distribution of items, it becomes clear that Djakovica sits in a relatively marginal position as to the currently observed cultural vibrancy. (See Fig. 8.)

This is an interesting remark, as Djakovica is the largest town in its district, and the second largest in the territory under study after Peja. However, none of these cities plays a key role in the original pattern of cultural vibrancy. This is relatively surprising, as generally cultural and creative activity tends to be concentrated in the main urban centers of a territory, also thanks to their trans-local networking [50]. However, in rural contexts the incentives to agglomeration in more densely populated areas might not be strong enough as the urban settlements are of small dimension, and the main logic of aggregation might rather be related to other factors [51], such as, in the case of Deçan, the presence of major heritage sites. However, the shift of the centroid of vibrancy toward Djakovica signals that the attraction pull of the district's main urban center is starting to exert its effect.

It can be seen in fact that the TWC Beta identifies two distinct centroids, but the stronger one according to the heat map is in fact Djakovica, whereas the weaker one is closer to TWC Alpha. There is in other words a 'spatial phase transition' which gradually shifts the center of activity toward a different area of the territory through an intermediate step that is marked by the weaker Beta centroid.

An interpretation of this movement toward the South is the stronger connectivity that is established with Albania, and with its capital city Tirana in particular, as a consequence of the recent (at the time of observation) opening of the new highway connecting Kosovo and Albania. As we have seen, the distribution of cultural activities tends to reflect the structure of the main transport routes, and the opening of a new, key infrastructural facility which increases the 'gravity' effect of the Southern Albanian pole has a consequent effect on the dynamics of cultural vibrancy.

In Fig. 9, however, we have the TWC Gamma, that describes the medium-long term situation, which shows that the current shift toward the South is eventually bound to be temporary.

The TWC Gamma shows that the main focus of the heat map in the medium-long term moves back North, in a position that is again close to the original TWC Alpha. After a first moment in which the new

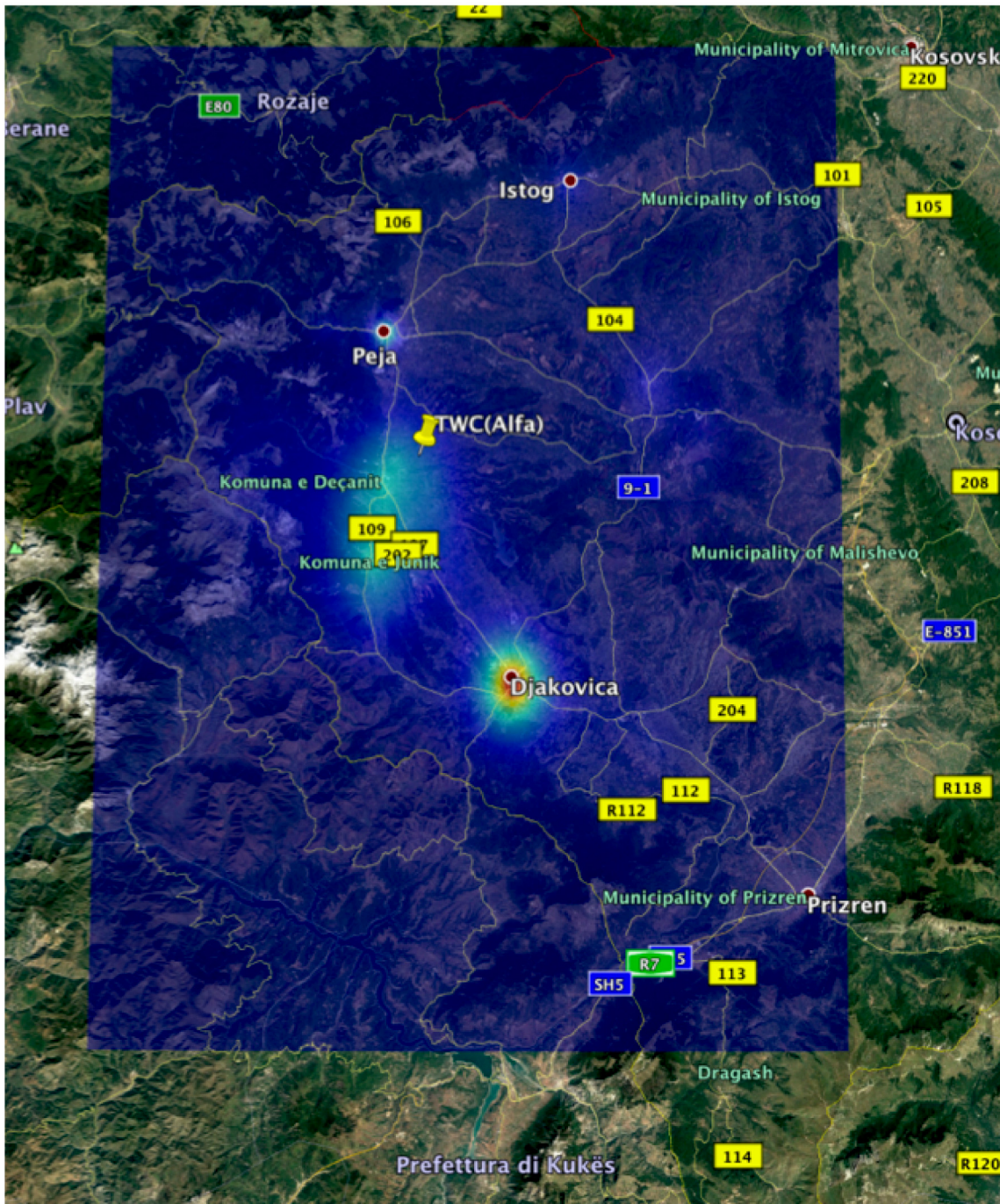


Fig. 7. TWC Beta.

mobility route toward Albania exerts a significant gravity effect, cultural vibrancy is pulled back to its original center of attraction. There must therefore be another ‘force’ that pulls in the opposite direction with respect to the attraction exerted by the Albanian pole. To understand its nature, we can notice that there are actually three TWC Gamma centroids: in addition to the main one close again to Deçan, there are two weaker ones, one still in Djakovica, the other further North, in Peja, that is, the other major urban center of the territory under study. The two weaker centroids show the two forces being balanced, namely the cultural attractions exerted by the nearby countries of Albania and Serbia, respectively. The Kosovo region has in fact a complex

identity that derives from the mix (and often the clash) of its Serbian and Albanian components, so that the two countries function as competing cultural attractors along a North-South axis of influence. Despite that the Peć district is also characterized by an Albanian cultural majority, its geographical position makes it especially susceptible to the attraction pull of the Serbian socio-economy. It is meaningful to notice that whereas the international borders of the Peć district are with Montenegro and Serbia, those of the Gjakove district are with (mostly) Albania and Montenegro. The strong attraction of Serbia implies that even if there may be a temporary shift of the centroid of vibrancy toward Albania because of a strengthened mobility

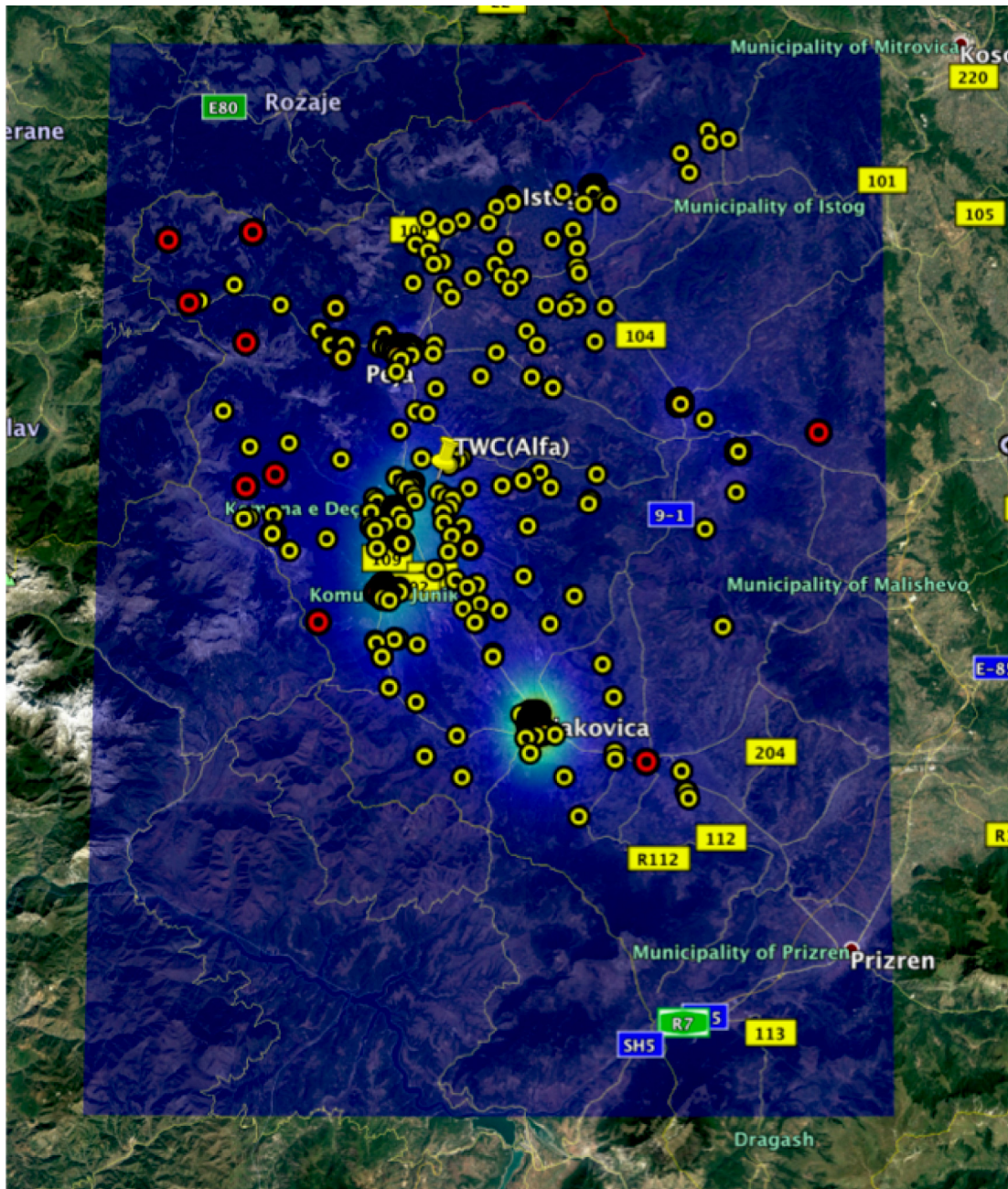


Fig. 8. TWC Beta and the observed distribution of items.

connection, the old situation of geographical balance is going to be eventually restored.

In fact, as shown in Fig. 10, the distribution of observed items is denser toward the route connecting to Serbia than toward that connecting to Albania, also as a consequence of the different size and economic weight of the two countries, so that the cultural attraction exerted by Serbia has historically been stronger as reflected in the observed spatial pattern of activities.

By looking at the TWC Theta in Fig. 11, however, which gives us a picture of the longer-term scenario, we see how, despite that there are still three different centroids, there is now a prevalence of the Northern and Southern ones, suggesting that the future cultural dynamics lead to a growing polarization between the Serbian vs. Albanian areas of influence. Instead of being the attractive core of the whole

distribution, the central town of Deçan now works as a sort of ‘separatrix’ between two different basins of attraction for the two stronger centroids, Peja (which is mostly under the attraction pull of Serbia) and Djakovica (which is mostly under the attraction pull of Albania). This also suggests that, by concentrating in the territory’s main urban centers, the dynamics of cultural vibrancy could be able to better exploit the developmental effects of urban agglomeration on cultural and creative production.

Once again, the higher density of observed activity around the Serbian-oriented pole with respect to the Albanian-oriented one is clearly legible once the TWC Theta is mapped against the current observed distribution of items in Fig. 12.

Notice how all three TWC Theta points sit along the main transportation route. Finally, the TWC Iota, shown in Fig. 13, gives us a clue of

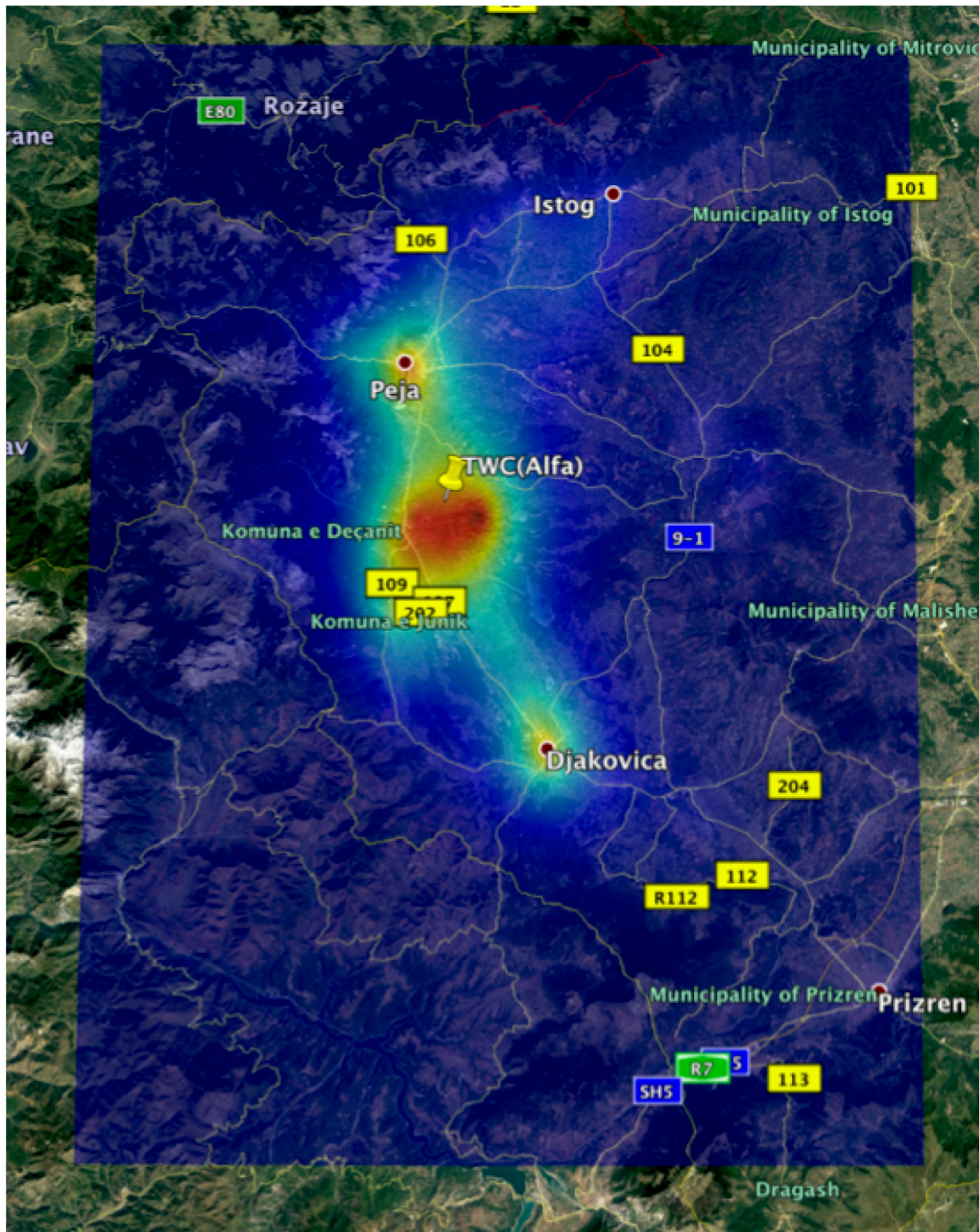


Fig. 9. TWC Gamma.

the ‘hidden’ points that determine the future shifts of the heat maps, that is, those points that better reflect the deep structural forces at play behind the dynamics represented by the sequence of centroids as previously discussed. The position of the two TWC Iota points clearly confirms our previous interpretation: the two hidden points position themselves at the opposite sides of the territory, in the far North and in the far South, confirming that the main factors shaping vibrancy are the gravity effects from the competing cultural attraction of the Albanian vs. Serbian poles.

The Iota map indicates which is the more relevant Iota point, marked by the arrow, that is, the one representing the cultural attraction force exerted by Serbia, which, if no explicit policy interventions occur, is going to overcome that exerted by Albania. The stronger Iota point is close to the border with Serbia. The weaker Iota point is adjacent to the main route that connects Kosovo to Albania. They respectively lie beyond Peja and Djakovica in the direction of the international border.

Some considerations are in order. First of all, as made clear by the insights from the TWC Iota map, the reason why cultural vibrancy is

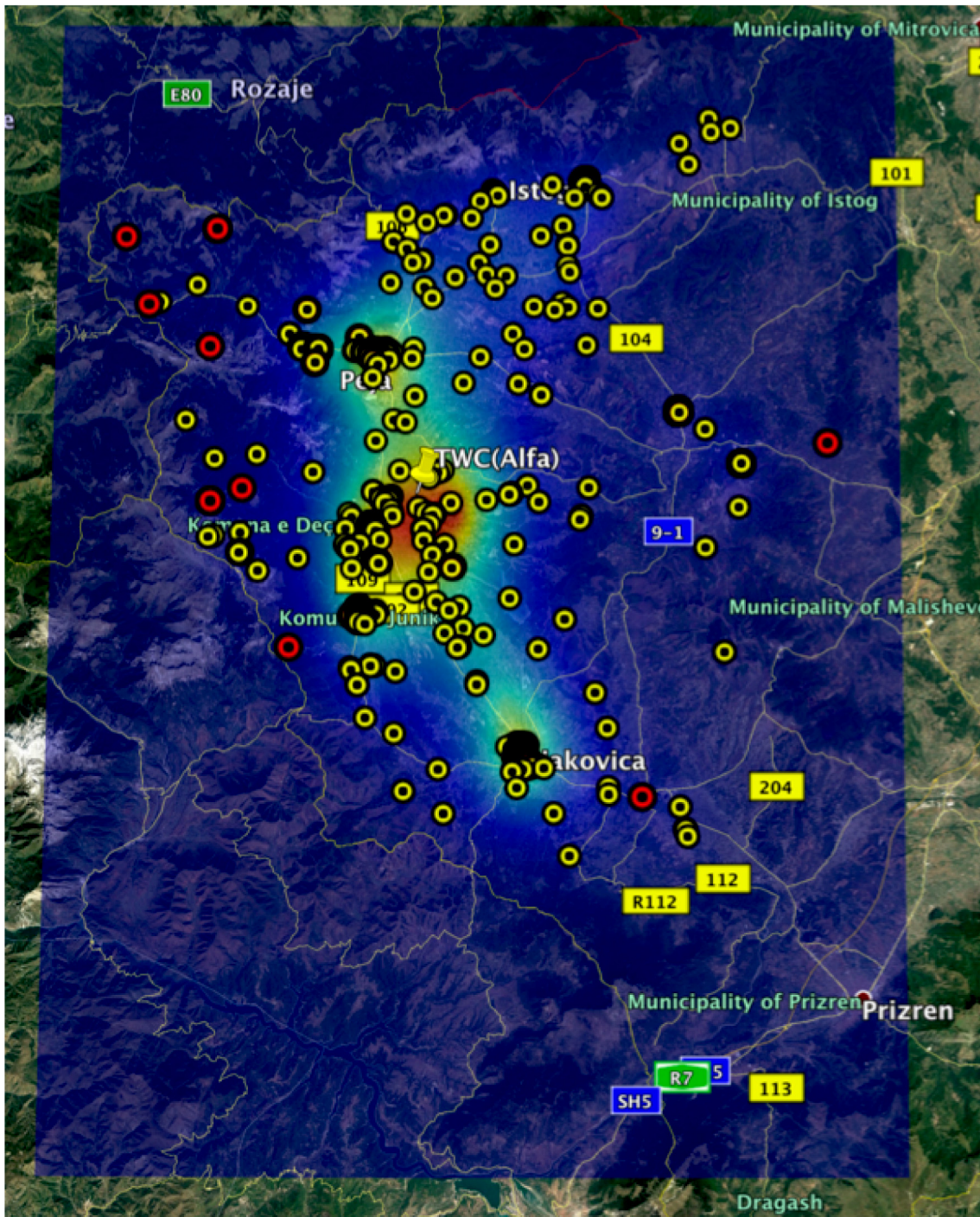


Fig. 10. TWC Gamma and the observed distribution of cultural items.

polarizing into the two main urban centers of the territory is not primarily the emergence of favorable urban agglomeration effects, but the fact that Peja and Djakovica are the urban hubs that connect the territory to the Serbian and Albanian poles, respectively. The hidden attractors are, as already observed, moving in the direction of the respective borders with Serbia and Albania. We cannot rule out that such polarization might indirectly also stimulate some form of local agglomeration of cultural and creative production, but in the affirmative case that would be more a by-product of the geopolitical forces at

work than a result of the structural evolution of the local cultural and creative sectors.

A second important consideration, that is consistent with the former, is that, in our analysis, the whole dynamics of evolution of cultural vibrancy entirely takes place on the North-South axis, that is, from the interplay of the attraction forces of Serbia vs. Albania. There is practically no discernible influence on such dynamics of the country's capital city, Pristina, located in the East, as no East-West axis emerges from the analysis. Despite that Pristina is by far the country's largest city and capital,

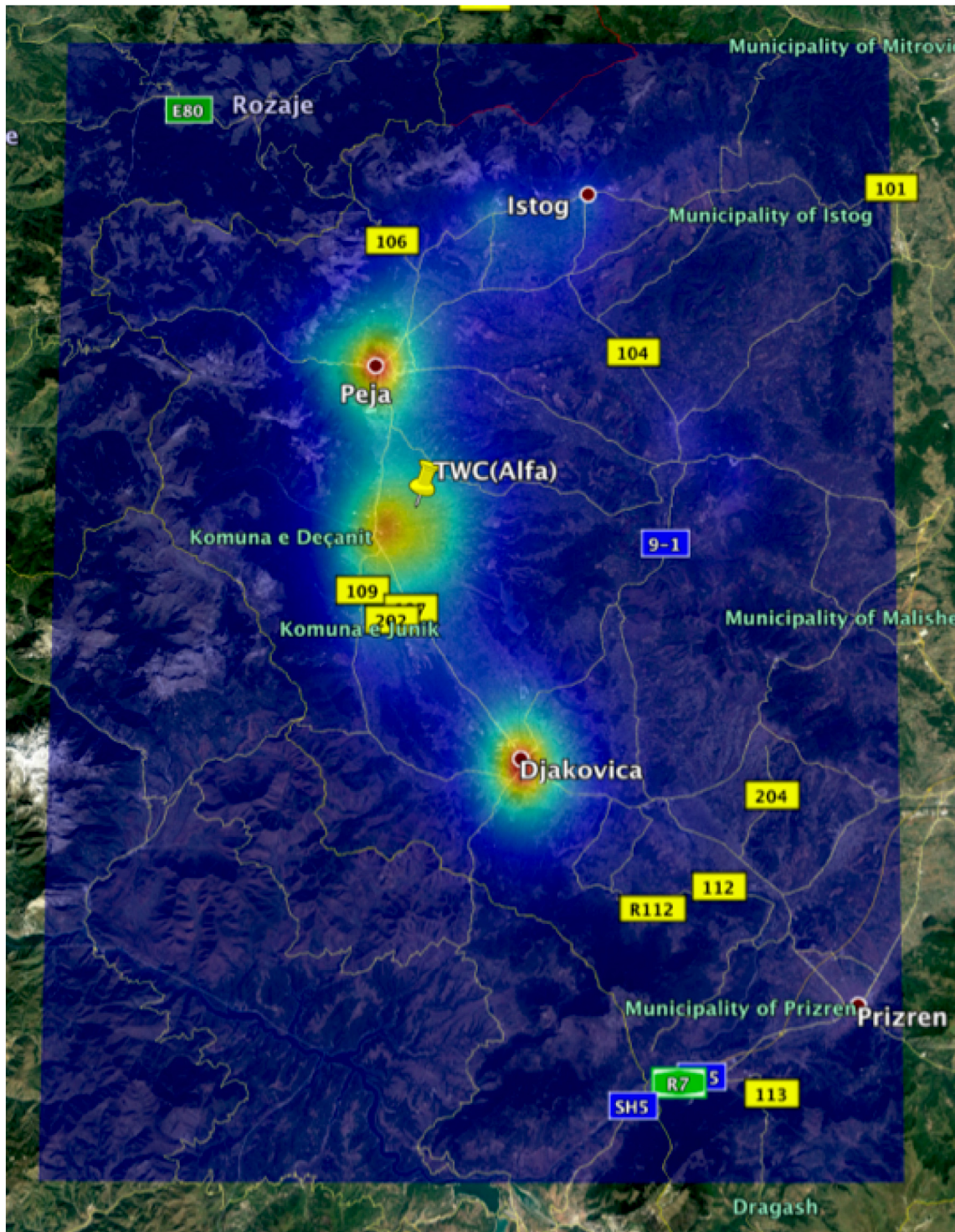


Fig. 11. TWC Theta.

and that it hosts a rich and diversified cultural scene, also as a result of specific policy initiatives [52], it seems to have very little capacity to influence the spatial grammar of cultural vibrancy of the two Western districts under study, possibly also as a consequence of the fact that no specific cultural policy action has been undertaken in such territory. It is also useful to observe that Pristina has a largely Albanian ethno-cultural majority with a strong socio-spatial ethnic segregation between different groups [53], so that one of the reasons might be that, in the

context of the ethno-cultural divide characterizing the country, the capital city could be seen more as a secondary center of attraction of the Albanian cultural pole rather than as the primary center of attraction of the country. However, such finding once more emphasizes that the spatial grammar of cultural vibrancy in the two Western districts under study is mainly driven by geo-political and economic factors, and only to a lesser extent by the inner evolution of local cultural and creative sectors.

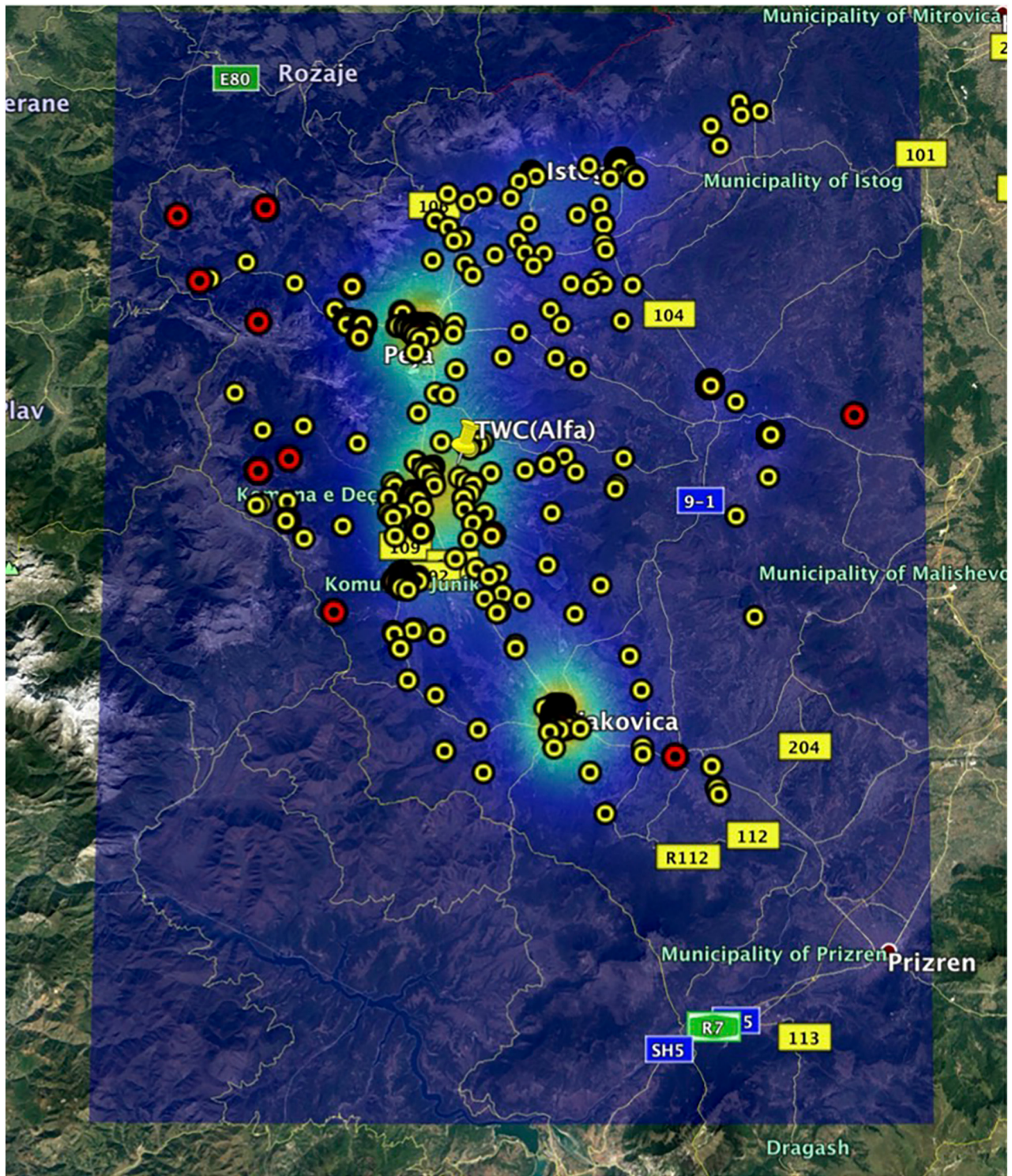


Fig. 12. TWC Theta and the observed distribution of cultural items.

4.2. AutoCM analysis

To integrate the previous analysis of the spatial dynamics of cultural vibrancy, we have now to consider how the cultural system is positioned within the wider socio-economic system of the territory, to understand what is the relative importance of the cultural dynamics just analyzed in the context of the local socio-economic development

process. To this purpose, we proceed to the analysis of the structure of the interdependencies across the socio-economic variables collected and described in Section 3 above, by means of the AutoCM ANN. First of all, we need, as anticipated above, to carry out the data fusion of the attributes of the two types of observations, activities and facilities, and of the socio-economic variables, into a single database. By combining the three, we obtain, as illustrated in Fig. 14, a total of 302

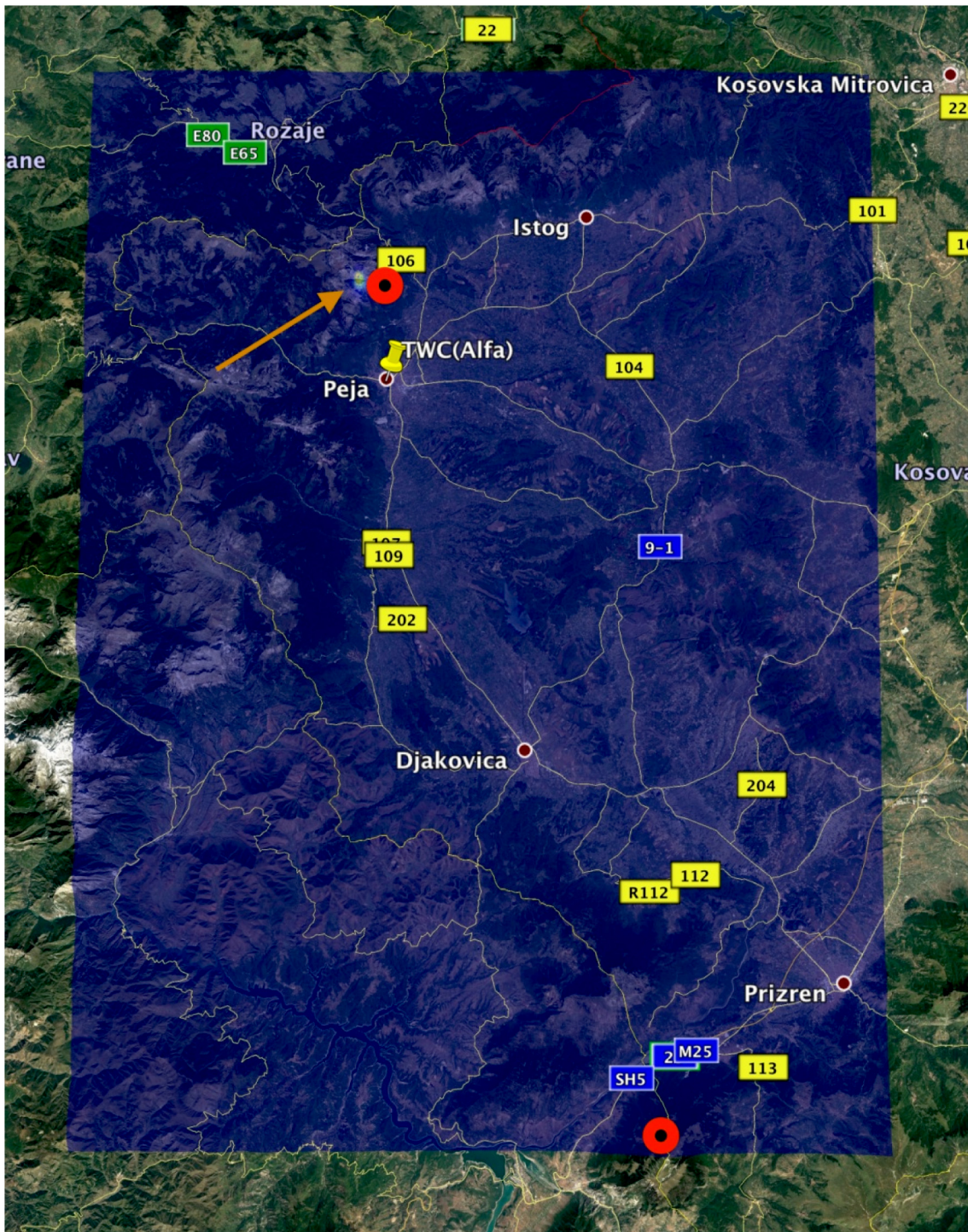


Fig. 13. TWC Iota and the hidden attractors.

different attributes, for which we can explore their multi-dimensional similarities. The map of such similarities will allow us to check to what extent culturally related attributes play a more or less central role in the organization of the map, and therefore are more or less pivotal in the functional socio-economic organization of the territory.

To check what is the most efficient algorithm to analyze the multi-dimensional similarity across our 302 attributes, we first compare the relative coding performance of various alternative algorithms by

means of the MST Index as introduced in Buscema and Sacco [54]. We compare AutoCM with a set of commonly used alternative ANN algorithms and widely used measures of similarity, and find, as shown in Fig. 15, that AutoCM consistently outperforms all of them according to the two complementary measures of performance introduced in Buscema and Sacco [54]. The choice of AutoCM as the most appropriate algorithm for the analysis is therefore empirically supported for this database.

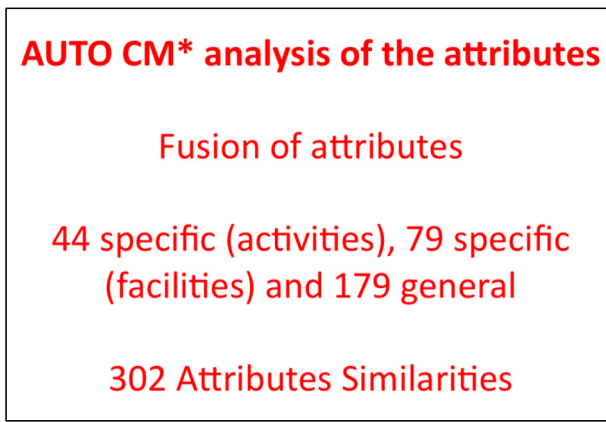


Fig. 14. Data fusion of the attributes.

Fig. 16 reports the MRG drawn by AutoCM in the analysis of the multi-dimensional similarities across the 302 attributes.

Even if the figure may look complex to read at first glance, it gives a relatively intelligible representation of the structure of the interdependencies across the 302 variables. In particular, the ‘diamond-like’ structure toward the top-left of the graph shows what is the core set of variables which jointly represent the most deeply integrated and cohesive component of the territory’s socio-economy. Moreover, there is also a ‘linear backbone’ moving from bottom-left to top-right around which the various branches of the graph are organized, which also plays an important organizational role.

The logic behind the links connecting the variables is that two connected variables are relatively more similar to one another in the context of the overall structure, so that the graph can be seen as a representation of the structure of the key interdependencies across the variables, although specific causal links cannot be established. The variables that sit toward the center of the graph have a more important organizational role than those that sit in the more peripheral

branches. Likewise, the structure of their connectivity also provides information about their organizational role, which may have a local vs. global relevance according to the specific connectivity indicator that we are considering. We can notice for instance that the attribute ‘Community center’ sits close to the center of the graph and is highly connected (directly connected to 8 other attributes). Its links with ‘Fashion design’ and ‘EmpExBodyAll’ (employment in organizations and external bodies) are especially relevant as the latter sit along the main backbone.

To have a closer look at the micro-structure of the MRG, consider Fig. 17. Here, the attribute “Cave” is an important node connected to many attributes, including another important one, namely “17(2nd_half)Estab” (a historical building of the second half of the 17 century). While “Cave” refers to one of the natural resources of the region, the latter attribute refers to an important piece of the local historical heritage, which is in turn a highly connected, locally central node. Other cultural variables are connected as well to these two nodes, which shows how many significant variables of the cultural system tend to be connected to other variables from the same sphere of natural and cultural heritage and resources rather than to key variables of the socio-economic system.

Another closeup of the MRG as reported in Fig. 18 shows instead the strong relationship and internal cohesion of variables relating to the agricultural system. The territory seems to be characterized by a siloed socio-economic structure rather than by complex interdependencies between different areas of activity.

The analysis of the two main ‘diamonds’, shown in Fig. 19, shows that the central variables in the system are mostly related to the areas of education/employment and demographic/work. Cultural variables are practically absent from the organizational core.

5. Discussion and conclusions

In this study, we develop a computational approach to evidence-based policymaking [55]. In particular, we have analyzed the spatial dynamics of cultural vibrancy of two districts in Western Kosovo, Gjakova and Peć, and the role played by the cultural and creative sectors in the wider architecture of their socio-economic system. Our methodology and results provide a basis for participative policy making, directly involving local residents in data collection and ideally again in evidence-based policy design and assessment. The latter could only be applied to a limited extent to the Kosovo policy cycle, due to difficulties in the active involvement of local administrations and to serious, well-known ethno-cultural tensions.

However, our study provides a clear picture of the geographical dynamics of cultural vibrancy at the territorial scale, and accurately reconstructs the effect of the dynamic clash of the ‘cultural pulls’ from the two nearby countries, Serbia and Albania, which heavily polarize Kosovo’s cultural and social life and cause strong political tensions. In particular, we find that the dynamics of cultural vibrancy for the two districts are essentially driven by the competing gravity forces exerted by the two external cultural poles represented by Serbia and Albania, that also reflect the region’s main ethnicities, and whose mutual relationship is complex and often conflictual. On the other hand, the attraction pull exerted by Kosovo’s capital and main city, Pristina, which is also a rich cultural hub with a lively local scene, is practically negligible. This indicates that the dynamics of cultural vibrancy of the two Western districts under study is not really determined by the operation of the local cultural and creative sectors but is mostly a by-product of external forces.

These results suggest that the rural, most Western areas of Kosovo do not have at the moment a strong endogenous drive toward cultural production and participation. This conclusion is reinforced by the analysis of the role of the cultural system within the wider socio-economic system of the two districts, which shows that culture occupies a rather marginal position and is playing a modest role in the overall structural

Fusion: attributes of Activities & Facilities 302 Attributes – Similarities Algorithms Comparison

Main		Global	
Dataset=AllVar(302x100)	Fitness	Dataset=AllVar(302x100)	Fitness
(CM)(I)	0,9558	(CM)(I)	0,2953
(CM_F)(I)	0,9528	(CM_F)(I)	0,2713
(TWC_B)(I)	0,9385	(MA)(I)	0,2581
(COS)(I)	0,9085	(TWC_B)(I)	0,2307
(CE)(f)(I)	0,9072	(CE)(f)(I)	0,2286
(ATDM)(I)	0,9047	(COS)(I)	0,2247
(MA)(I)	0,8910	(JA)(I)	0,2225
(TWC_A)(I)	0,8735	(LC)(I)	0,2211
(JA)(I)	0,8731	(TWC_A)(I)	0,2175
(LC)(I)	0,8707	(EU)(I)	0,1874
(EU)(I)	0,8698	(PP)(I)	0,1849
(SOM)(I)	0,8499	(SOM)(I)	0,1718
(IN)(I)	0,8408	(ATDM)(I)	0,1583
(RBF)(I)	0,8256	(RBF)(I)	0,1499
(PP)(I)	0,7561	(IN)(I)	0,1410
(PDF)(B)(I)	0,6382	(PDF)(B)(I)	0,0744

Fig. 15. Selection of the best algorithm.

Auto CM Similarity among the 302 Attributes

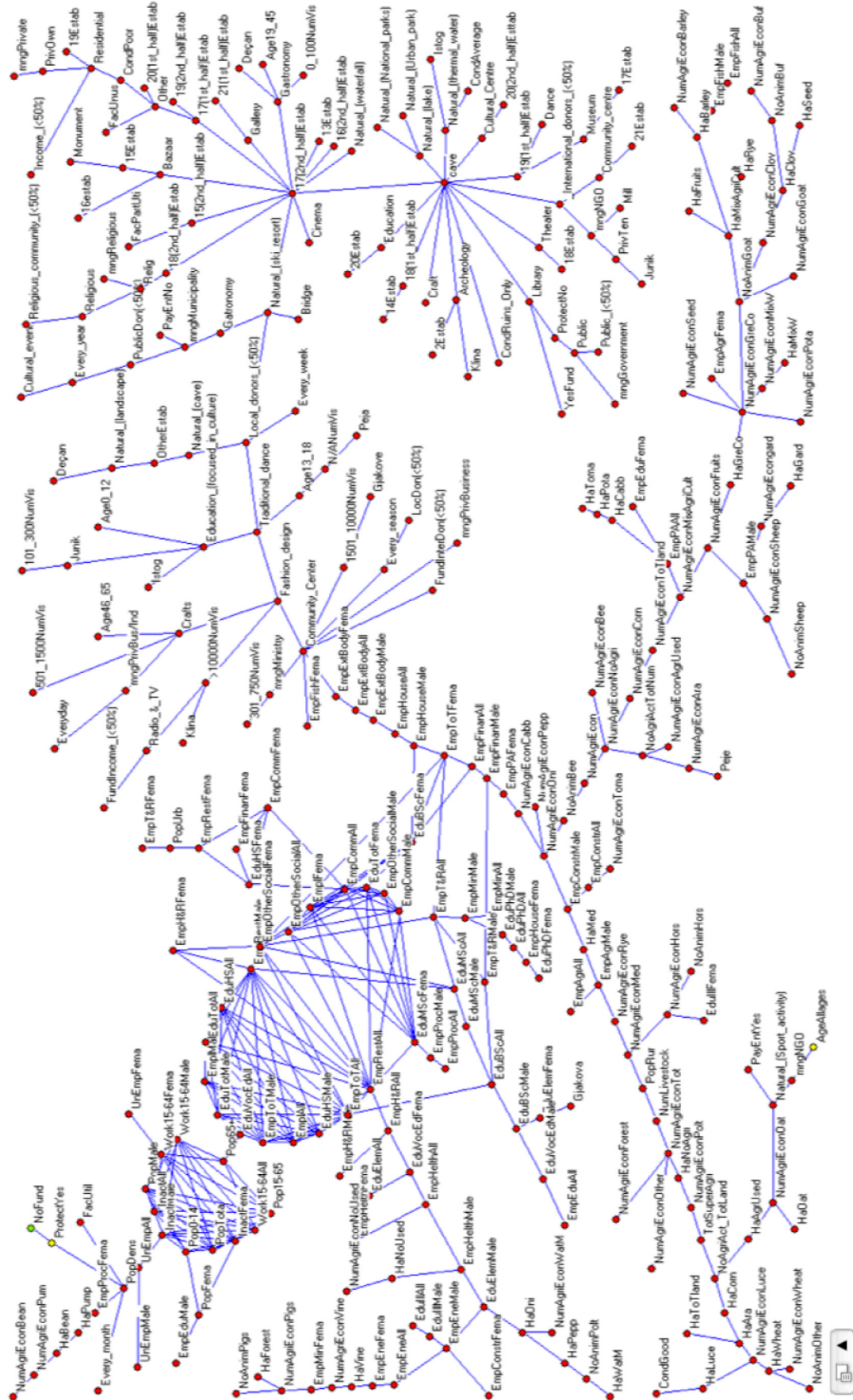


Fig. 16. MRG of the 302 attributes.

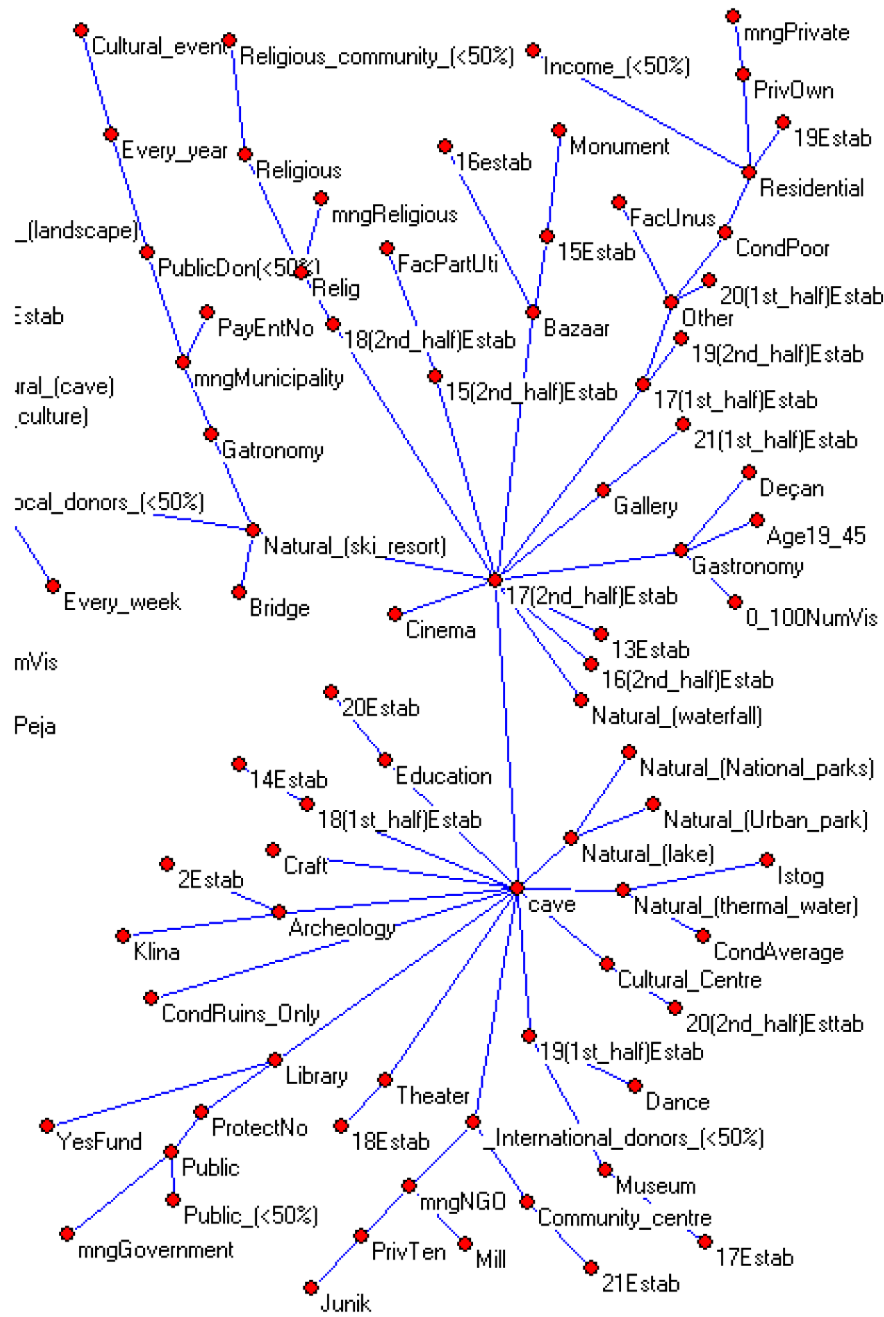


Fig. 17. Closeup on MRG detail.

organization. The functional marginality of the local cultural and creative sectors, and their substantial problems of participation and inclusion due to lack of public funding for culture – a situation that might also exist in other areas of the country – are the main issues to be addressed by future cultural policy initiatives.

This means that the local regional developmental model is currently very poorly related to its cultural assets, and it is remarkable that this kind of information may be obtained simply from the analysis of the observed distribution of cultural items and from the analysis of the multi-dimensional similarities among the variables that describe its socio-economic structure.

And yet, especially for a culturally divided and conflictual country like Kosovo, a smart approach to cultural policy, not only in the

main urban hubs but also in less densely populated and more rural territories, might play an important role in pursuing new forms of social cohesion and intercultural dialogue between its conflicting cultural identities. A possible way to achieve this goal is to counter the ongoing spatial polarization by rebooting the power of attraction of the historically established, geographically central hub around Deçan – and possibly also to facilitate the emergence of a new East-West axis that antagonizes the current North-South dynamics and reinforces the connection to Pristina and to the Eastern, more populated, and culturally more vital part of the country. The role that the cultural resources of the territory can play in this process have to be explored more closely. Cultural and natural heritage need to play a more significant role in the socio-economy of the two districts, as the relevance of

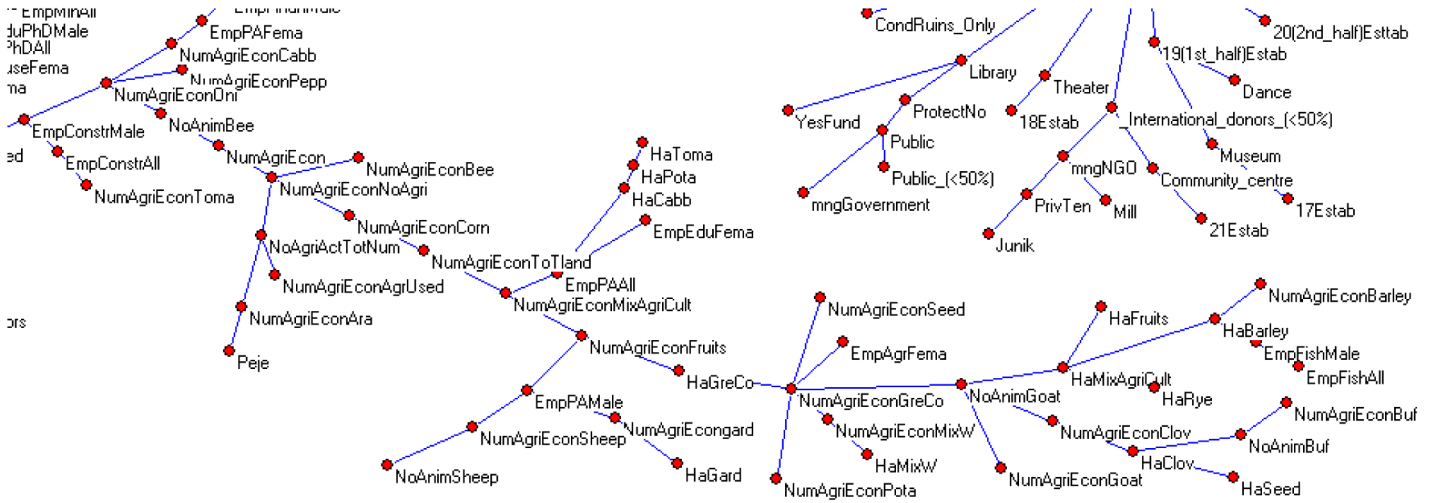


Fig. 18. Closeup on MRG detail.

culture seems to be currently confined to very traditional and economically marginal forms of tourism. Not only in geographical, but also in functional terms it is important that cultural policy stimulates the cultural system of the territory to develop more complex forms of production and participation that leave a deeper socio-economic mark and interact more strongly and fundamentally with the main developmental drivers.

Another important issue is the potential role that culture can play in contexts with strong ethnic tensions such as Kosovo. Despite that nationalistic and even xenophobic attitudes may be supported and even reinforced by the appeal to heritage, expressions and traditions which are claimed to be uniquely representative of a given culture and population [56], culture may also play a very important, opposite role

in fostering intercultural dialogue and cohesion through mutual communication and exchange [57], and even in conflict resolution and healing from trauma [58]. Rural areas are typically most susceptible to cultural isolationism and prejudice because of the scarcity of real, direct exchange with people from different ethno-cultural backgrounds [59]. Promoting the development of cultural and creative sectors in areas such as the two Western Kosovo districts studied here may therefore become not only a way to boost the local economy and to make space for local creative talent and entrepreneurship, but also to create opportunities for better socio-cultural dialogue and integration of people from different ethno-cultural backgrounds – an issue of truly global relevance today.

Our findings may contribute to the promotion of evidence-based, participative cultural policy design which is of special importance in

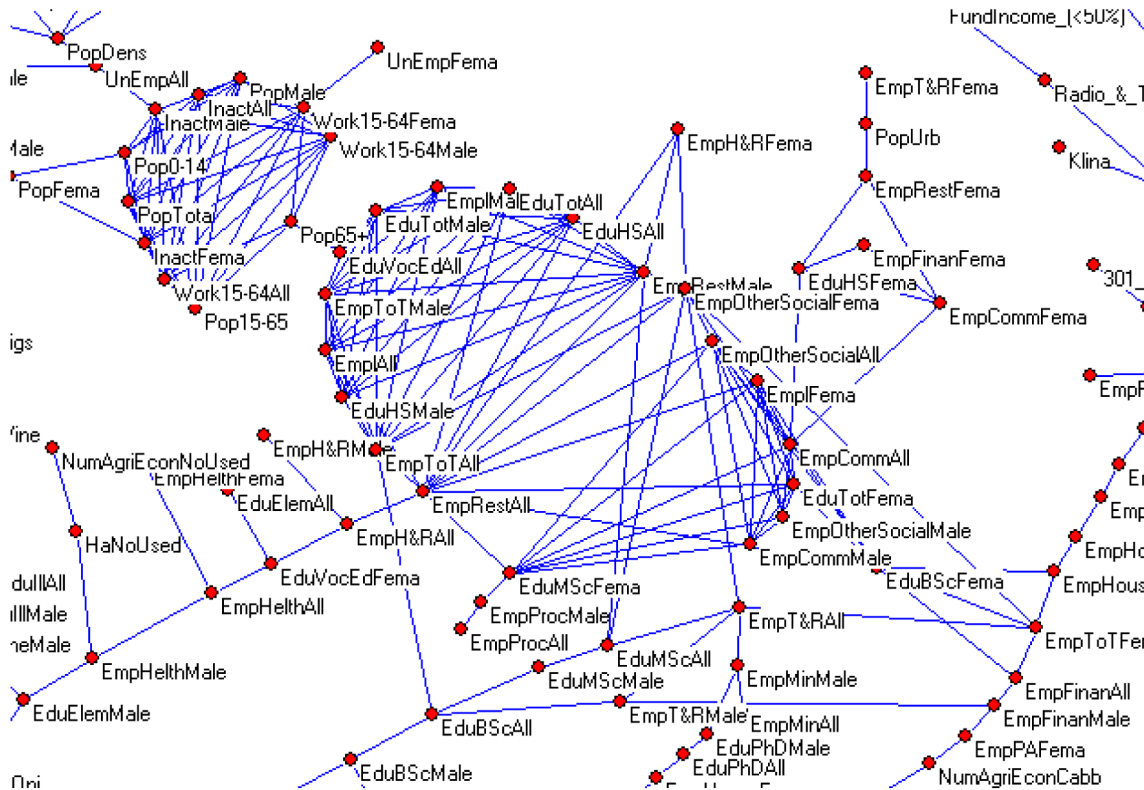


Fig. 19. Closeup on MRG detail.

socio-economically and educationally deprived regions. It could also pave the way to peer-learning platforms on cultural development projects by public administrations, building on sophisticated data analysis and simulation techniques, as a recognition of the complex, nonlinear nature of spatial phenomena such as cultural vibrancy, and of the need to tackle them by means of suitable toolboxes. The methodology and results presented here are potentially scalable to similar territorial contexts. As we gather more evidence on different case studies at the local scale, we could get a much deeper understanding of the main facilitating and countervailing conditions at play behind culture-related development processes.

CRediT authorship contribution statement

Conceptualization: MB, GF, CG, PLS.
 Methodology: MB, GF, PLS.
 Software: MB, GM.
 Formal analysis: MB, GM.
 Investigation: MB, GF, CG, GM, PLS.
 Data curation: GF, CG.
 Writing, original draft MB, GF, CG, GM, PLS.
 Writing, review and editing MB, GF, CG, GM, PLS.
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Data availability

Data will be made available on request.

Declaration of competing interest

The authors declare no conflicting interest.

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References

- [1] Sacco PL, Crociata A. A conceptual regulatory framework for the design and evaluation of complex, participative cultural planning strategies. *Int J Urban Reg Res*. 2013; 37:1688–706.
- [2] Lazzaro E, Noonan D. A comparative analysis of US and EU regulatory frameworks of crowdfunding for the cultural and creative industries. *IntJ Cult Policy*. 2021;27: 590–606.
- [3] Wyszomirski M. From public support to the arts to cultural policy. *Rev Policy Res*. 2004;21:469–84.
- [4] Garcia B. Cultural policy and urban regeneration in Western European cities: lessons from experience, prospects for the future. *Local Econ*. 2004;19:312–26.
- [5] Belfiore E, Bennett O. Beyond the 'toolkit approach': arts impact evaluation research and the realities of cultural policy making. *J Cult Res*. 2010;14:121–42.
- [6] McGuigan J. Rethinking cultural policy. Maidenhead: Open University Press; 2004.
- [7] Cerisola S, Panzera E. Cultural and creative cities and regional economic efficiency: context conditions as catalyzers of cultural vibrancy and creative economy. *Sustainability*. 2021;13:7150.
- [8] Scott AJ. Capitalism, cities, and the production of symbolic forms. *Trans Inst Br Geogr*. 2001;26:11–23.
- [9] Thiel J. Creative cities and the reflexivity of the urban creative economy. *EurUrbanRegStud*. 2017;24:21–34.
- [10] Richards G, Duif L. Small cities with big dreams. Creative placemaking and branding strategies. New York: Routledge; 2018.
- [11] Hartley J, Wen W, Li HS. Creative economy and culture. Challenges, changes and futures for the creative industries. London: Sage; 2015.
- [12] Stern MJ, Seifert SC. Cultural clusters: the implications of cultural assets agglomeration for neighborhood revitalization. *J Plan Educ Res*. 2010;29:262–79.
- [13] Sandbach K. Mapping the creative sprawl: the design sector in Western Sydney. *Cultural Trends*. 2021;30:241–62.
- [14] Scott AJ. The cultural economy of cities. Essay on the geography of image-producing industries. London: Sage; 2000.
- [15] Edensor T, Leslie D, Millington S, Rantisi NM, editors. Spaces of vernacular creativity. Rethinking the creative economy. London: Routledge; 2009.
- [16] Waitt G, Gibson C. Creative small cities: rethinking the creative economy in place. *Urban Stud*. 2009;46:1223–46.
- [17] Montalto V, Tacao Moura CJ, Langedijk S, Saisana M. Culture counts: an empirical approach to measure the cultural and creative vitality of European cities. *Cities*. 2019; 89:167–85.
- [18] Alberti V, Montalto V, Panella F, Sacco PL. Cultural and creative vs. cultural or creative: reconceptualizing culture-led urban development. Ispra: Joint Research Center; 2022. Preprint.
- [19] Montalto V, Panella F, Sacco PL. What does Brexit mean for UK cultural and creative cities? *Eur Urban Reg Stud*. 2021;28:47–57.
- [20] Escalona-Orcao A, Barrado-Timón DA, Escolano-Utrilla S, Sánchez-Valverde B, Navarro-Pérez M, Pinillos-García M, Sáez-Pérez LA. Cultural and creative ecosystems in medium-sized cities: evolution in times of economic crisis and pandemic. *Sustainability*. 2021;13:49.
- [21] Zapata-Caldas E, Calcagni F, Baró F, Langemayer J. Using crowdsourced imagery to assess cultural ecosystem services in data-scarce urban contexts: the case of the metropolitan area of Cali, Colombia. *Ecosyst Serv*. 2022;56:101445.
- [22] European Commission. A new European agenda for culture, Brussels. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2018%3A267%3AFIN>; 2018.
- [23] Chin WCB, Wen TH, Sabel CE, Wang IH. A geo-computational algorithm for exploring the structure of diffusion progression in time and space. *Sci Rep*. 2017;7:12565.
- [24] The frame problem in artificial intelligence. In: Brown FM, editor. Proceedings of the 1987 Workshop, April 12–15, 1987, Lawrence KS, USA; 1987.
- [25] Lewis David K. On the plurality of worlds. Oxford: Blackwell; 1986.
- [26] Buscema M, Sacco PL, Della Torre F, Massini G, Breda M, Ferilli G. Theory of impossible words: toward a physics of information. *Chaos*. 2018;28:055914.
- [27] Lakoff G, Johnson M. Metaphors we live by (new edition). Chicago: University of Chicago Press; 2003.
- [28] Bengio Y. Learning deep architectures for AI. *MachLearn*. 2009;2:1–127.
- [29] Hinton GE, Salakhutdinov RR. Reducing the dimensionality of data with neural networks. *Science*. 2006;313:504–7.
- [30] Le QV, Ranzato MC, Monga R, Devin M, Chen K, Corrado GS, Dean J, Ng AY. Building high-level features using large scale unsupervised learning. Proceedings of the 29th International Conference on Machine Learning, Edinburgh, Scotland; 2012.
- [31] Raina R, Madhavan A, Ng AY. Large-scale deep unsupervised learning using graphics processors. Proceedings of the 26th International Conference on Machine Learning, Montreal, Canada; 2009.
- [32] Vincent P, Laroche H, Lajoie I, Bengio Y, Manzagol PA. Stacked denoising autoencoders: learning useful representations in a deep network with a local denoising criterion. *J Mach Learn Res*. 2010;11:3371–408.
- [33] Zhao J, Mathieu M, Goroshin R, LeCun Y. Stacked what-where auto-encoders; 2015. arXiv preprint, arXiv:1506.02351.
- [34] Zhao J, Mathieu M, LeCun Y. Energy-based generative adversarial network; 2015. arXiv preprint, arXiv:1609.03126.
- [35] Buscema M, Ferilli G, Gustafsson C, Sacco PL. The complex dynamic evolution of cultural vibrancy in the region of Halland, Sweden. *IntRegSciRev*. 2020;43:159–202.
- [36] Buscema M, Grossi E, Breda M, Jefferson T. Outbreaks source: a new mathematical approach to identify their possible location. *Physica A*. 2009;388:4736–62.
- [37] Buscema M, Breda M, Catzola G. The topological weighted centroid, and the semantic of the physical space—theory. In: Buscema M, Grossi E, editors. Artificial adaptive systems in medicine. London: Bentham; 2009. p. 69–78.
- [38] Buscema M, Sacco PL, Ferilli G, Breda M, Grossi E. Analyzing the semantics of point spaces through the topological weighted centroid and other mathematical quantities: the hidden geometry of the global economic order. *ComputIntell*. 2015:532–67.
- [39] Buscema M, Grossi E, Snowdon D, Antuono P. Auto-contractive maps: an artificial adaptive system for data mining. An application to Alzheimer disease. *Curr Alzheimer Res*. 2008;5:481–98.
- [40] Buscema M, Sacco PL. Auto-contractive maps, the H function, and the maximally regular graph (MRG): a new methodology for data mining. In: Capecchi V, et al, editors. Applications of Mathematics in models, artificial neural networks and arts. Springer Science+Business Media B.V.; 2010.
- [41] Buscema M, Breda M, Grossi E, Catzola L, Sacco PL. Semantics of point spaces through the topological weighted centroid and other mathematical quantities: theory and applications, Chapter 4. In: Tastle WJ, editor. Data mining applications using artificial adaptive systems. New York: Springer Science+Business Media; 2013. p. 75–139. https://doi.org/10.1007/978-1-4614-4223-3_1.
- [42] Buscema M, Massini G, Sacco PL. The Topological Weighted Centroid (TWC): a topological approach to the time-space structure of epidemic and pseudo-epidemic processes. *Physica A*. 2017;492:582–627.
- [43] Buscema M, Della Torre F, Breda M, Massini G, Grossi E. COVID-19 in Italy and extreme data mining. *Physica A*. 2020;557:124991.
- [44] Grossi E, Buscema M, Jefferson T. The topological weighted centroid, and the semantic of the physical space—application. In: Buscema M, Grossi E, editors. Artificial adaptive systems in medicine. London: Bentham; 2009. p. 79–89.
- [45] Buscema M, Sacco PL, Massini G, Della Torre F, Brogi M, Salonia M, Ferilli G. Unraveling the space grammar of terrorist attacks: a TWC approach. *TechnolForecastSoc Chang*. 2018;132:230–54.
- [46] Ferilli G, Sacco PL, Buscema M, Tavano Blessi G. Cultural geography as a pseudo-diffusion process. The Region of Veneto Case. *Economies*. 2015;3:100–27.
- [47] Sacco PL, Ferilli G, Tavano Blessi G, Nuccio M. Culture as an engine of local development processes: system-wide cultural districts I: theory. *Growth Chang*. 2013;44: 555–70.

- [48] Sacco PL, Ferilli G, Tavano Blessi G, Nuccio M. Culture as an engine of local development processes: system-wide cultural districts II: prototype cases. *Growth Chang.* 2013;44:571–88.
- [49] Sacco P, Ferilli G, Tavano Blessi G. Understanding culture-led local development: a critique of alternative theoretical explanations. *Urban Stud.* 2014;51:2806–21.
- [50] Batten DF. Network cities: creative urban agglomerations for the 21st century. *Urban Stud.* 1995;32:313–27.
- [51] Duxbury N, Campbell H. Developing and revitalizing rural communities through arts and creativity: a literature review. Vancouver BC: Creative City Network of Canada; 2009.
- [52] Krasniqi S, Krasniqi EH. Pristina's development strategy of 2013–2016: an analysis of the situation in the educational, cultural, youth, and sport sector. *Eur Sci J.* 2015;11: 114–24.
- [53] Demaj U. Symbolic identity building, ethnic nationalism and the linguistic reconfiguration of the urban spaces of the capital of Pristina, Kosovo. *Ethnicities.* 2022. online first article, <https://journals.sagepub.com/doi/abs/10.1177/14687968221097810>.
- [54] Buscema M, Sacco PL. MST fitness index and implicit data narratives: a comparative test on alternative unsupervised algorithms. *Physica A.* 2016;461:726–46.
- [55] Buscema M. Why mathematical computer simulations are the new laboratory for scientists. *Subst Use Misuse.* 2015;50:1058–78.
- [56] Gustafsson A, Karlsson H. A spectre is haunting Swedish archaeology – the spectre of politics: archaeology, cultural heritage and the present political situation in Sweden. *CurrSwedish Archaeol.* 2011;19:11–36.
- [57] Gonçalves S. We and they. Art as a medium for intercultural dialogue. In: Gonçalves S, Majhanovich S, editors. *Art and intercultural dialogue.* Leiden: Brill; 2016. p. 1–23.
- [58] Meineck P. Post-conflict resolution and the health humanities: the Warrior Chorus program. In: Crawford P, Brown B, Charise A, editors. *The Routledge companion to health humanities.* London: Routledge; 2020. p. 54–9.
- [59] Witteveen D. The rise of mainstream nationalism and xenophobia in Dutch politics. *JLaborSoc.* 2017;20:373–8.