Centralities in the city border: a method to identify strategic urban-rural interventions

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Abstract

City borders perform an essential role in connecting towns and their surroundings. Being more a fuzzy area than a thin line, these urban borders gather together residential, tertiary and infrastructural uses, places awaiting development, agricultural fields, brown-field sites, abandoned areas etc. all named as 'b-sites'. Within this context, we propose a method to identify places for strategic urban-rural interventions based on the assessment and identification of centralities in the urban-rural transition. Multiple centrality assessment is here presented as an innovative application considering both urban streets and rural road networks as a mixed network with identified central nodes. This innovative method has been tested in the city of Granada (Spain) allowing us to identify high centrality 'b-sites' where landscape project design and, urban-rural interventions could contribute to creating urban-rural transition continuity.

Keywords

Centrality, city border, street network, rural road network.

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Introduction

At the end of the 19th century and first decades of the 20th, both urban-rural transition territories and landscapes were dominant in planning disciplines. They constituted a frequently revisited topic in many theoretical approaches alongside urbanism history, even before urbanism was established as a discipline as it is nowadays. Currently, this topic is once again to be performed, driven by a certain sense of failure related to urban peripheries. In a few recent proposals, a great emphasis is ascribed to the relevance given to the mediation space between areas dedicated to agricultural and urban areas. Solutions of continuity should be proposed by enhancing new territories where spaces characterized by different kinds of complexity would also coexist. Within this context, collective use of open spaces appears to be crucial to maintain this kind of complexity, although these areas are not always clearly recognized within territories suffering transitions. We can recall some important events in urban and territorial planning history particularly interesting in both man-nature and urban-rural dialectic, and also in urban border and peri-urban milieu.

Piotr Kropotkin already highlighted in 1898 unparalleled scale transformations acting on nature through the human capacity of creating a new civilization which had not yet existed since ancient Greece (Kropotkin, 1898, p.19). This has been the origin of 20th century urbanism as an intellectual and professional movement that would react by confronting past mistakes in towns (Hall, 1996, p.16). During the last decades of the 19th century and the first four of the 20th, a wide variety of reflections emerged, sometimes as experimental approaches, all about the urban-rural dialectic and the power of nature as a measure to face congestion in great cities (Abarca-Alvarez and Campos-Sánchez, 2013). Congestion is not, of course, a recent problem. In fact, as described by Lewis Mumford (1966, p. 641) the so called "Great Ur" in Ancient Mesopotamia presented suburban settlements with the aim of guarding the harvest and refreshing the soul- at a six kilometre distance from the main state town. In *Notes on Virginia* (Jefferson, 1784 cited in White and White, 1967) Thomas Jefferson clearly declared that territories should be occupied and planners should refrain from building cities. This idea had its effect in 1862, when the *Homestead Act* allowed pioneers into the countryside to build small community-based villages. This back-to-the-land strategy was also dealt with by Theodore Roosevelt during the Great Depression. Within the framework of the *New Deal* in 1935, he set up the *Resettlement Administration* influenced by Rexford Guy Tugwell

(Myhra, 1974, pp.178-181). The project aimed at leaving towns, buying cheap land, building a whole community and then, getting people moved there to later demolish poor city degraded urban neighbourhoods, transforming them into parks (Hall, 1996, p. 138). All these measures temporally overlapped with the *Broadacre* proposal (Wright (1932; 1935; 1945): the idea of a family per acre, disseminating housing in nature together with both industrial decentralization and modern communication integration outfits.

In the same 1930s, in other geographical (and also intellectual) parts of the world, socialists would have a not so discordant view about territory. According to Svetlov and Gornyi (1970) the socialist distribution on territory is neither town nor field. Ochitovic and Kaganovic understood it in this way when they defended the creation of something new following the theories of Karl Marx and Friedrich Engels (Svetlov and Gornyi, 1970). In any case, it seems that there was no consensus between socialist ideologues (Ceccarelli, 1970) if the solution was to bring workers to the field rather than to bring farmers into an agro-city.

Together with all these ideas, other proposals focused on *nature* as a means for recovering values (Bozal, 1999). In 1915 Patrick Geddes predicted the importance of urban borders: "make the field gain on the street, not merely the street gain on the field" (Geddes, 2009, p. 212). At this point, Ebenezer Howard's *Garden City* (Howard, 1902) was the most inspiring proposal which consisted of surrounding towns with agricultural green-belts forming a sort of wall that would enhance the sense of internal unity and preserve the rural environment (Mumford, 1966, p. 681). Based on these concepts, the Green Belt movement would afterwards appear in the UK (Patrick Abercrombie in London) whilst the Radburn neighbourhood would appear in North-America (by Clarence Stein and Henry Wright).

Nevertheless, some contemporary authors point out that the opposition between rural and urban is already overcome due to city supremacy, since their inhabitants already have an urban mind-set (Corboz, 2004, p. 26). As Geddes stated about Boston, the city was not a place, but a mood (Geddes, 2009, pp. 88). Considering inclusive positivist approaches, we might find the *Azilia Garden* in Georgia, proposed by Robert Mountgomery in 1717 as a possible combination between the dream of both city and garden. The *Planetary Garden* by Gilles Clément, the happy heterotopia by Michael Foucault, and Frederick Law Olmsted and Calvert Vaux's proposals in New York *Central Park* are all examples of wide garden and parks reinventions, formalising nature-city integration concepts.

As is very clear, from a methodological point of view, work on spatial limits seems to be unavoidable. In *Manifeste pour le Tiers-paysage*, Gilles Clément describes how limits should be considered as an épaisseur (thickness), not as a *trait* (line), and also as a research territory integrating its imprecision as if it were its way of representation (Clément, 2007, p. 62). It is evident how in these settlement forms, which recently appeared in Europe, the linebetween urban and rural spaces fades, and the role of open spaces still remains pivotal (Fanfani, 2006). Duany and Plater-Zyberk (2003) offered in a very practical way both social and physical solutions for this so called 'gross' limit, found in their *Transect* on a urban section codification. Corboz (2004) and Dematteis (2004) have also explored these ideas of both semantic and informative values.

Something shared by the majority of the above mentioned proposals is the importance of both intensity and diversity in public spaces considered as social concentrators. Another important factor is the distance to be covered to join public spaces. The first regulations on the *Commons* set the prohibition of living more than 800m from the meeting house (Weeden, 1890), trying by this solution to avoid slackness in social duties. Considered in Anglo-Saxon urbanism a sort of a sacred distance, this famous middle-mile is also known as the "Golden ratio" in Clarence Perry *Neighborhood Units*. This famous length measure influenced the work of both Henry Wright and Clarence Stein and also, more recently, the *New Urbanism* movement.

Nevertheless, the opportunities to deal with the urban-rural transition seem to be only possible in new urban developments, rare as they are in the up-to-date European context. We therefore need to focus on these indeterminate and often forgotten places which characterize our peripheries. It is also mandatory to place human beings in the centre of the urbanistic dissertation, enhancing people's relationships between each other and the environment, creating a sense of putting down roots between people and the surrounding world (Alexander et al., 1976). As explained by Christopher Alexander, all this means participation. The main idea is to ease the organization of human interactions (Echeverría, 1999), focusing more on networks than on enclosed spaces with their internal sites and their boundaries. We need to ask ourselves how to generate these sorts of public domains which could both enhance interactions and generate a feeling of putting down roots for citizens. We need to restore the right to participate in and to enjoy urban life, i.e. "The right to the city" (Lefebvre, 1969), and we also need to bring it towards the city borders, near the urban-rural transition margin.

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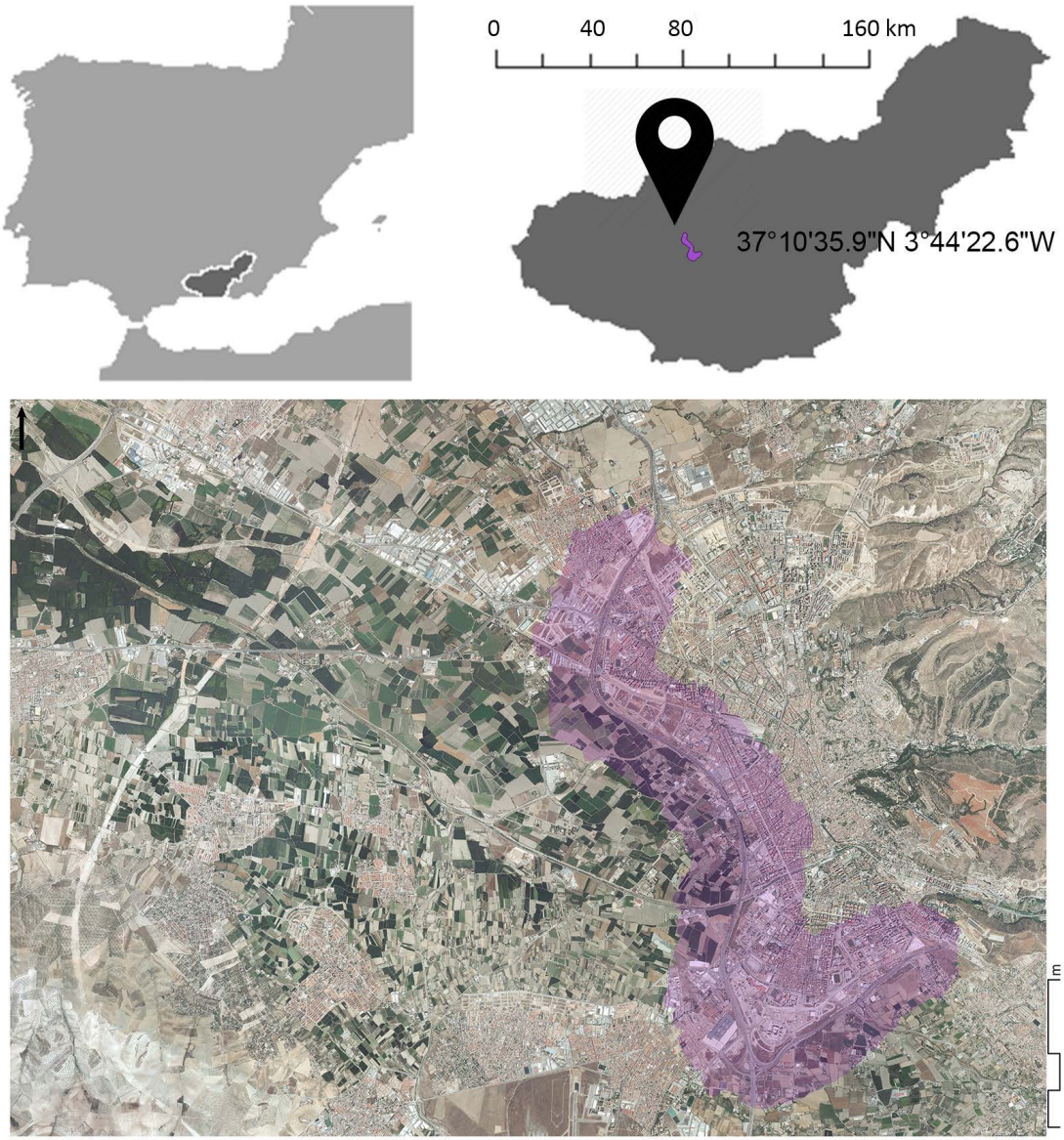
Fig. 1 – Location of the study area. Granada, Spain (source: authors).

Bearing in mind these previous reflections we can summarize the interest in the city border areas and urban-rural transitions as places of both complexity and opportunity. These are territories where many new elements and structures are superimposed upon the traditional landscapes (Antrop, 2004). These sites are also peri-urban, which may be considered as a new kind of multifunctional territory (Ravetz et al., 2013). Peri-urban areas have already been recognised by the European Landscape Convention (Council of Europe, 2000), already assigning importance both to everyday and even degraded landscapes. Nevertheless, the degradation processes usually characterizing these places lead them to be overlooked from both urban and rural perspectives. Their consideration as everyday landscapes allows us to envisage how important the local scale can be. At this scale, such territories appear to be characterized by many different uses and elements; residential units, industrial areas, abandoned agricultural plots, parks, infrastructures, abandoned both residential and industrial projects, agricultural landscape elements, remnant and spontaneous vegetation, etc. In many cases, these uses and elements make up places that fall out of the conventional urban or rural margins. They are degraded, underused or simply ignored places, which we have renamed as *'b-sites'*. These *'b-sites'* tend to be forgotten, since they are located in the city border areas and making them somehow to be considered as non-central places. The idea of being central and the concept of centrality have been especially important in urban and geographic studies (see e.g. Christaller, 1966). Choay (2006) explains how some elements have a power of attraction or dissemination in the urban context. This power may be explained by the nature or the element itself, but also by its location. At this point, centrality is one of the most studied concepts in network analysis (Agryzkov et al., 2016), which consists of the collection, management, analysis, interpretation, and presentation of relational data (Brandes et al., 2013). The application of network analysis had its origin especially in social networks and its application in urban and regional studies has been more recent (Porta et al., 2008; Sevtsuk and Mekonnen, 2012a). In fact, since the early studies of Hagget and Chorley (1972) on the application of network analysis in the geographic context, the main contributions have been mainly theoretical until the seminal work of Hillier and Hanson in 1984 about Space Syntax (Porta et al., 2006). Since that time, network analysis-based methods have been applied in towns as a way to understand and integrate the complexity of the urban tissues, through, e.g. centrality analysis. We might mention the work of Lämmer et al. (2006) analysing the cen-



trality of twenty German cities; Jiang (2007) studying forty American cities; Masucci et al. (2009) dealing with the London street system; Strano et al. (2013) comparing centrality between ten European cities; Agryzkov et al. (2014) analysing centrality in the city of Murcia, Spain. In any case, centrality is a key factor related to the urban form and central spaces benefit from the human and environmental diversity (Porta et al., 2007). At the same time, centrality is a multi-fold concept, meaning that many centralities may be assessed depending on how the 'being central' concept might be defined (Porta et al., 2008). Furthermore, exploring literature, spatial network analysis seems to be an 'urban issue'. Liu et al. (2015) have pointed out how much of the literature on network studies (in a spatial, geographical

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Fig. 2 – The graphical abstract method (source: authors).

dimension) has been developed within intra-urban contexts. No cases of its application, e.g., to mixed urban-rural networks has been found, and only the study carried out by Pérez-Campaña and Talavera-García (2016) has deepened the application to minor rural road systems. But both rural road networks within the agricultural context and urban networks can be recognized as constructs, as the result of a tight human-environment interaction. Moreover, urban-rural transition is characterized by the above mentioned mixed urban-rural road network. So, the core research questions consequently become: how can centrality measures be applied to an urban-rural road network? And could centrality measures be useful for detecting the more central 'b-sites' in a city border area?

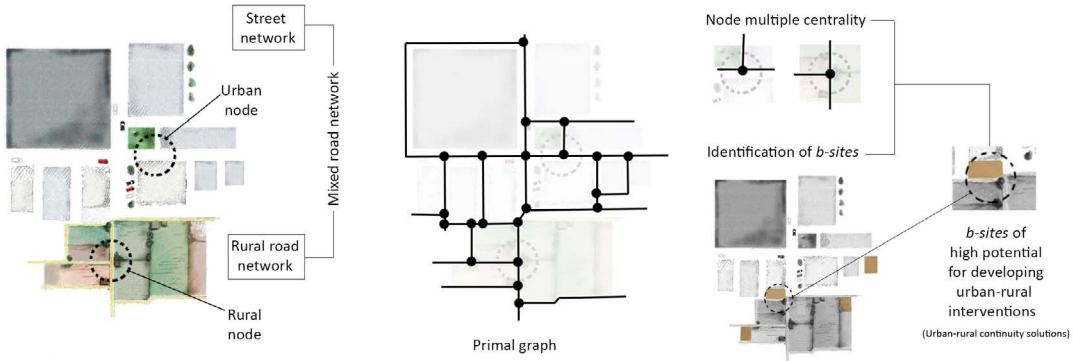
Then, considering that centrality analysis may be applied to any spatial system and at any scale (Porta and Latora, 2007), we propose a centrality-based method to identify, among those territories in transition, the so called 'b-sites' that gather the highest potential to constitute nodes for collective construction to bring both complexity and identity to peripheral territories.

Study area, materials and methods

We have selected the city of Granada and its surrounding *vega* as our study area. The Spanish term *vega* refers to an agricultural floodplain known for its great fertility, and it is considered a component of the landscape trio river-city-*vega*. These kinds of spaces have been historically used by man because of their geomorphology, topography, edaphology, productivity and water resources (Pérez-Campaña, 2015). The *Vega* de Granada (fig. 1) is an ancient, deeply historical agricultural area where the general structure of the irrigation system goes back to Al-Andalus (Trillo, 2005). This structure meets urban fabrics in the city border, configuring a particular city-*vega* transition. In figure 1 we locate the city of Granada, with the west and south bordering the agricultural *vega*. The underlined delimitation in the picture is not meant to be a city border identification, rather to be a spot containing the urban-rural transition inside the study area.

The cartographic materials used in the analysis have been obtained from the Environment Information Network of Andalucía (REDIAM) (accessed in January 2016). Cadastre maps (containing the land use of parcels and other linear elements of interest) have been downloaded from the electronic service of the Directorate of Land Registry of Spain (accessed in February 2016).

Urban and rural roads have been integrated into a mixed road network, thus, dealt with as a single network on which we have applied different cen-



trality measures; reach, closeness, betweenness, and straightness using the toolbox Urban Network Analysis for ArcGIS (see Sevtsuk and Mekonnen, 2012b). Concerning representation, the mixed urban-rural road network may be represented as a spatial graph (fig. 2). In a primal approach (see Porta et al., 2006) zero-dimensional geographic entities (intersections) may be turned into zero-dimensional graph entities (nodes), and one-dimensional geographic entities (segments of streets and rural roads) may be turned into one-dimensional graph entities (edges or links). We have computed the graph centrality measures for nodes of the network. Concerning the search radius, we have computed global measures (without specification of search radius). The equations linked to the measures are not reproduced here, since they may be found in Sevtsuk and Mekonnen (2012b). A brief description for each measure is included:

- Reach centrality: it may be interpreted as an alternative to real density measures (Sevtsuk and Mekonnen, 2012). The reach centrality describes the number of nodes that are reachable from a given node at the shortest path distance of at most a given radius. We have considered an 800m radius, which is an interesting distance related to pedestrian movements.
- Closeness centrality: being central in the sense of being close to others (Porta et al., 2008). Closeness measures the proximity of a node to other nodes in the network.
- Betweenness centrality: being central as being between others (Porta et al., 2008). Interactions between two nonadjacent nodes might depend on intermediate nodes that can have a strategic control of influence on them (Porta et al., 2006). It is defined as the fraction of the shortest paths between pairs of other nodes in the network that pass by each node.
- Straightness centrality: being direct to the others (Porta et al., 2006). It measures the circuity or directness by comparing the length of the shortest paths between nodes with crow-fly distance from a node of interest to all the other nodes in the network (Latora and Marchiori, 2007).

Once the centrality measures have been computed, we have identified, through photo-interpretation and field work, the existing 'b-sites' in the study area. The results of the centrality measures are put together with the identified 'b-sites', allowing the centrality-based interpretation of the urban-rural transition and the potential of these 'b-sites' as places where strategic interventions of a different nature would be undertaken. The graphical abstract of the method is represented in figure 2.


Reach centrality
- +
0 500 1,000 2,000 m


Closeness centrality
- +


Betweenness centrality
- +


Straightness centrality
- +

opposite page
Fig. 3 – Centrality measures on the mixed road network (source: authors).

Results

Centrality assessment results are presented in figure 3. Numeric values are not included, since we have focused on comparative purposes through the classification of values in five quintiles. Reach centrality clearly shows the highest values in dense, urbanized town areas, contrasting with the lowest areal node density in the *vega*. Closeness centrality has quite a similar pattern, nonetheless some *vega* nodes are more closeness-central than e.g., other northern and southern urban nodes. Betweenness and straightness show a more complex, nevertheless interesting result. High central nodes may be found in many different locations along the mixed urban-rural road network, including both urban and rural nodes. Some centrality shafts might be seen in connecting central nodes between city and *vega*, and also between the city of Granada and the southern conurbation. Straightness centrality presents a more aggregated pattern, with also some central nodes in the *vega*.

Concerning the location of 'b-sites', different nature areas have been identified alongside the city border. Some examples are included in the pictures in figure 4. These 'b-sites' present a very different nature both public and private, and also sometimes include interesting elements such as ditches from the *vega's* ancient irrigation system and barns for tobacco dryers. When we superimpose the centrality measures over the 'b-sites', we are able to identify those located in or near high centrality nodes. A-'b-site' interesting area which gathers high values for all types of centrality has thus been found.

Discussion

The above mentioned results have been obtained thanks to an innovative centrality-measure application applied to a mixed urban-rural road network. The method itself involves overcoming urban-rural limits, understanding the continuity of places and, in this particular case, also comprehending the real urban-road continuity towards rural ones and vice versa. The already mentioned approach allows us to find out centralities within the city border, normally considered as non-central, but surely crucial to understand urban-rural transition. As a fundamental concept in network analysis, centrality has a long economic geography and city planning tradition, investigating the territorial relationships among communication flows, population, wealth, and land uses (Wilson, 2000). These analyses help us to understand some structural aspects of the studied networks. For the case of urban street spatial networks, Crucitti et al. (2006) highlights the need for in-depth investigation about correlations between structural properties and dynamics, such as pedes-

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Fig. 4 – 'b-site' locations relating to high centrality nodes (source: authors).

trian and vehicular flows and retail commerce vitality. If we translate these ideas into a mixed urban-rural road network, we might obtain informed indications for the urban-rural intervention proposal of reusing and sharing open spaces. We might think of a wide variety of activities, ranging from temporal to more permanent designs (according to the 'b-sites' own nature), including e.g. urban and peri-urban agriculture projects, gardens and parks, sporting activities, seasonal markets, outdoor exhibitions, etc. In any case, these proposals would take advantage of being located in central places. The results obtained for the city of Granada have shown a high number of 'b-sites' located along the urban-rural transition (figg. 1 and 4). Central places in the city border areas, strategically located to connect urban and rural structures and processes have been discovered. A large definite area for 'b-sites' has also emerged as a strategic place from the point of view of all the centrality measures analysed in this paper (see fig. 4; Presence of multiple centralities). This place reaches a high number of centrality nodes, meaning that within it a high node number is reachable from each other node within a radius of 800 m, which has interesting connotation regarding pedestrian accessibility. It is also a place with high closeness centrality values, thus, these 'b-sites' are located near urban-rural road network nodes that are crucial for the rapid spread of information. Betweenness centrality also shows high values. It means that this part of the network is important to maintain flows, since the nodes involved are on the path toward many other urban and rural nodes. All this is related to the network connectivity. As far as straightness centrality is concerned, we may observe in figg. 3 and 4 how higher values are located in the network urban part. It seems obvious, as the measure assumes that a straight path (more frequent in street networks) between nodes also implies better connections. It seems significant to observe that this area is also important, since the two incoming railway lines (from the north and west) meet near here. The centrality of 'b-sites' should be integrated together with other factors to finally decide on the best location of an eventually given intervention. We suggest taking into account:

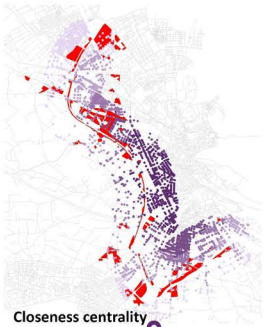
- The landscape-node heterogeneity in the mixed urban-rural road network. A detailed analysis of existing landscape elements and uses might provide crucial information to be incorporated to the proposal. Furthermore, recent research from Pérez-Campaña and Talavera-García (2016) suggests the existence of correlations between centrality and landscape heterogeneity at node level related to the whole Granada *vega* rural-road network.

Pictures by Talavera-García

Location of *b-sites*

Google Street View images

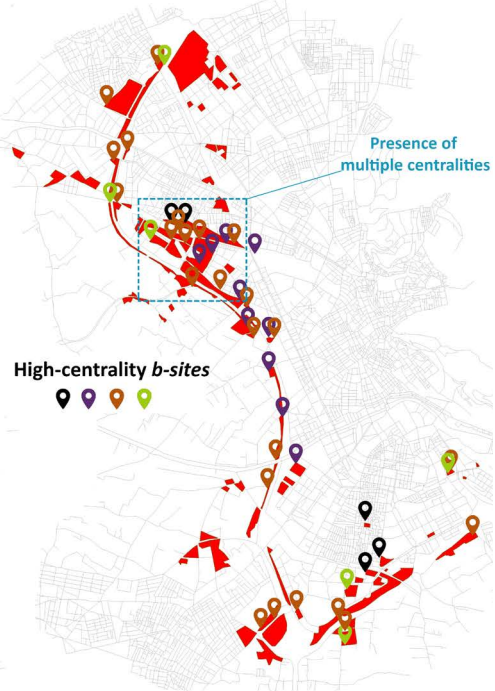
Reach centrality



Closeness centrality

Betweenness centrality

Straightness centrality



- The green connectivity between city and *vega*. Ecological connectivity metrics might be combined with centrality measures, which may provide new understanding within their relationship. At this point, Liu et al. (2015) have shown the existing correlations between landscape patterns and road centrality in a metropolitan area.
- The existing spontaneous uses of 'b-sites', which may inform about activities to be encouraged or discouraged.

In any case, the centrality analysis applied to urban-rural transition opens up new possibilities to comprehend these places and to take advantage, in many different ways, of the central nodes within the network. Two interesting questions regarding multiple centrality assessment are pointed out by Porta et al. (2006). The first concerns how some centrality indices are able to capture the urban structure 'skeleton' with a subsequent impact on spatial and collective behaviours (Porta et al., 2006, p. 705). The second considers the difference regarding the distribution of centrality into self-organized cities compared to planned cities as identified by the authors (Porta et al. 2006, p. 705). They are both two thought-provoking considerations if considering multiple centrality assessment as an approach to gain insight into urban-rural transitions characterization of peri-urban areas and also agricultural landscapes. As it has been previously mentioned, centrality measures seem to be an urban matter; nonetheless they might be useful for a better understanding of different natural spatial networks.

This method is not limitation-free. Many of such limits are common to centrality measures in urban context applications, such as the border effect due to the selection of specific network parts to be analysed. Nevertheless, multiple centrality assessment reveals itself to be an interesting approach to be applied at different scales to non-urban networks (or at least non-completely urban ones).

Conclusions

An innovative multiple centrality assessment application related to a mixed urban-rural network as an approach for providing a useful framework for informed decision-making on open space reuse and sharing has been presented in this paper. Different centrality measures: reach, closeness, betweenness and straightness have been computed in a selected area near the borders of the city of Granada. The results obtained have been superimposed onto the existing 'b-sites', i.e., marginal use places such as abandoned fields, brown-field sites, interstitial areas with no formal use, etc. All this work has allowed us to identify 'more central' 'b-sites' within the mixed urban-rural road network. In taking ad-

vantage of the above mentioned centrality, different proposals could be undertaken with the aim of repairing, enhancing and designing or even re-designing those sites. The above analysed centrality approach does not have to be considered as a definitive tool, rather a way of providing new information to be related to other factors with the aim of offering solution endurance, which is so important, especially in the city border areas.

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