A DIVERSITY-BASED APPROACH TO THE SPATIAL DEVELOPMENT OF SOCIO-ECOLOGICAL SYSTEMS

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Abstract. Although the concepts of sustainability and resilience have been in place for many years, their meaning and interpretations continues to be a subject of controversies, impeding their practical implementation. The spatial interpretation and consequences of the policies drawn on these concepts, despite the theoretical issues related to them, are of particular interest. This article is a critical comprehensive review carried out in order to emphasize the uncertainties. The article analyzes the human development in relationship to its spatial consequences and relationship with diversity (inner, environmental and overall), focusing on the concepts governing spatial development. The results show that policies are being developed upon unclear concepts, while the human pressure on the environment increases and affects the global sustainability and resilience.

Key words: resilience, stability, sustainability, equilibrium, polycentricity, disparities, cohesion.

1. Introduction

After more than 25 years from the creation of the 'sustainability' concept (Brundtland, 1987) and 25 years from the United Nations Conference on the Environment and Development, where a large number of countries adopted the principles of sustainability as grounds for their future development, criticisms show that development did not become sustainable in any country or region (Bass, 2007), while others go further, attacking the core of the concept (Georgescu-Roegen, 1991) or its means of implementation (Latouche, 1994; Owens, 1994).

One of the consequences is that when sustainability seemed to fail, other concepts of the future were developed. Since some of them were not embraced, they were tied back to sustainability. For example, the term 'smart city' was created in the 1990's (Albino *et al*., 2015); from the 2010, the 'smart sustainable city' replaced it (Al-Nasrawi *et al*., 2015).

Similarly, the concept of resilience was developed and is used by different authors as a side of sustainability, in opposition to it or as a complement of it (a broader discussion is presented below).

At the same, sustainability itself was 'enriched' by adding a cultural pillar to the three traditional ones – economic, social, and environmental (Basiago, 1999; Littig and Grießler, 2005; Gibson, 2006; Murphy, 2012; Petrişor and Petrişor, 2014), due to its potential for economic growth (Hawkes, 2001), through an intense lobby by the United Cities and Local Governments, who recognized it officially in 2010 (Petrişor and Petrişor, 2014; Todoran and Patachi, 2015).

Despite these changes, the author of the concept considers that its definition, focused on satisfying present and future needs at the same rate (Brundtland, 1987) should not be changed, but more attention should be paid to balancing the attention paid to all its pillars and their interconnectedness (Bugge and Watters, 2003).

In addition to the pillars, sustainability acquired in time a spatial dimension, manifested through the 'spatial sustainable development' and concepts dealing with the local sustainability – 'sustainable communities' or 'self-standing village' (Petrişor and Petrişor, 2014). Spatial sustainable development was defined as "*development providing for a territorial balance of satisfying at the same rate the economic, social and environmental needs of present and future generations*" (Petrişor, 2008b), and aimed to "*ensure the coherence of socio-economic objectives in relationship with the territory and its ecological and cultural functions, aiming to enhance the quality of present and future generations' life by creating sustainable communities able to manage and use resources efficiently, exploiting the innovative ecological and social potential of the economy and guaranteeing the welfare, environmental protection and social cohesion*" (Colignon, 2009). The later statement ties together all the other concepts related to the spatial development. However, there are authors who consider that the goals of spatial sustainability are not a simple translation of the sustainability objectives to the level of territorial units (Petre, 2016).

Regardless of addressing issues like traditional agro-ecosystems, rangeland sustainability, grassland ecosystems, institutional diversity, linguistic diversity, bio-cultural diversity, rural communities, traditional ecological knowledge or, in a broader context, diversity (specific to humankind or natural systems) and sustainability, scientists agree that diversity and its conservation are crucial to sustainability (Altieri, 1987; Becker and Ostrom, 1995; Berkes *et al*., 1995; Tilman *et al*., 1996; Huston, 1997; Flather and Sieg, 2000; Scott *et al*., 2000; Marques, 2001; Singh, 2001; McDaniel and Borton, 2002; O'Riordan and Stoll-Kleemann, 2002; Holling, 2004; Johns and Sthapit, 2004; Komiyama and Takeuchi, 2006; Petrişor, 2008a, 2009, 2012, 2013a, b, 2014a, c, 2016; Petrişor and Sârbu, 2010; Petrişor and Ianoş, 2012).

Petrişor (2014a) discussed diversity from a joint geographical and ecological perspective, tied together by its statistical interpretation; his conclusion, in line with others (Kaennel, 1998; Magurran, 1998) is that there is a 'diversity of diversities', as suggested in the previous paragraph.

Starting from this conceptual framework – the spatial dimension of sustainability and its relationship with diversity – this article aims to constitute a critical review aimed at understanding *what is meant by sustainability from a spatial viewpoint*. Although ecology acknowledges that studies should be carried on socio-ecological systems (Petrişor, 2014b), separate analyses will be carried out for the human realm and for the natural systems, introducing the joint perspective wherever it is covered by the literature. In order to derive the 'big picture', the analysis attempts to answer several questions:

1. What are the *spatial* consequences of socio-economic development on the relationship with the natural systems?
2. What is the relationship between socio-economic development and diversity (of the natural systems, of socio-economic systems, and overall)?
3. What are the particular concepts related to spatial development which translate the sustainability principles and how do they relate to diversity?

These questions will be answered not only in relationship to sustainability, but also to other related concepts, such as resilience, discussed in the next section.

2. The key concepts

2.1. Socio-ecological systems

The environment is perceived as a hierarchy of socio-ecological systems, with the different levels characterized by different temporal and spatial scales (Wiens, 1989), which include, in addition to the abiotic environment and the natural, life support systems (Haberl *et al.*, 2009), people and other species, and their relationships; the components of social systems are people, their habitat, and their rules, including cultural and institutionalized ones; the relationships include governance, social and economic relationships (Cumming, 2011).

2.2. Diversity

In very general terms, diversity refers to dissimilarities between objects of the same class, making them distinguishable one from another, while preserving the common features of the class (Petrişor, 2014a).

Diversity has two sides, a qualitative and a quantitative one; the first refers to the number of classes of objects, and the second to how the members of these classes are distributed (Dragomirescu, 1998; Magurran, 1998; Petrişor, 2014a). The second side is usually associated with another concept, 'dominance'. While there are more indices and models (*e.g.*, Shannon-Wiener, Simpson, McArthur) (Magurran, 1998), the maximum diversity occurs when the members are evenly distributed across classes, and reduces when most members belong to the same class (Fig. 1).

The diversity of the living world is called biodiversity, and when the socio-economic systems are considered in addition to the natural ones, the resulting concept is termed 'eco-diversity' by geographers, and 'geodiversity' by geographers (Petrişor, 2012, 2014a; Petrişor and Sârbu, 2010).

In natural systems, diversity is assessed at several spatial scales using concepts termed α, ß, γ, δ, ε diversity (Petrişor, 2008a); they correspond to different geographical and territorial levels, such

as the Nomenclature of Territorial Units for Statistics (Petrişor, 2009, 2012). Some authors classify biodiversity as compositional, structural and functional (Kaennel, 1998), others consider functional and response diversity (Elmqvist *et al.*, 2003).

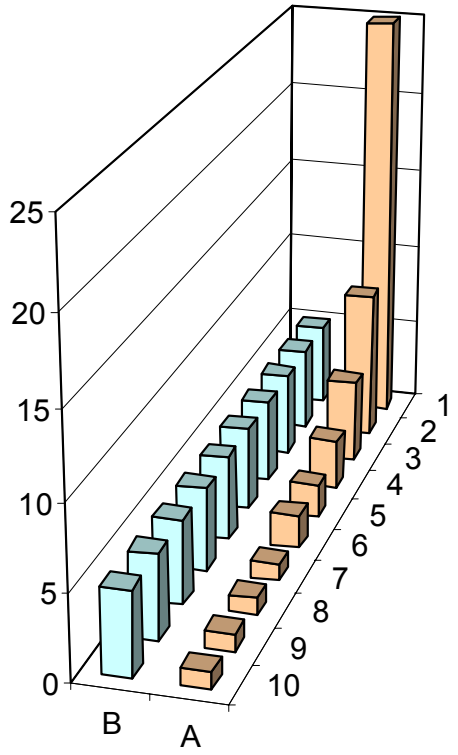

Fig. 1. Diversity: the image assumes a total of 50 members belonging to 10 classes. The maximum diversity is found in B, where each class has 5 members, and reduces in cases like A, where most members belong to few classes. Source: created by the author using hypothetical data.

A particular attention is paid to human diversity – ethnic, religious, linguistic or cultural (Swenden, 2012; Nemeş and Serac, 2012), often named ethno-cultural diversity; culture includes: (1) whatever is not born within humans, (2) mental abilities and communication, (3) arts and creativity (Claval, 2003). Diversity has dual economic and cultural dimensions (Graham and Hart, 1999; Stan, 2013; Stan *et al.*, 2013; Buhociu *et al.*, 2013a; Popa and Hărmănescu, 2013), and cultural differences result into a different value granted to biodiversity (Camino *et al.*, 2016). However, human diversity is not determined geographically or spatially (Barbič, 1998).

Diversity is a condition for sustainability (Holling, 2004), increasing the adaptive potential when selection is acting (Heylighen, 1999).

2.3. Ecosystem services

Ecosystem services are the benefits offered by ecosystems to the human society (Zakri and Watson, 2003; Watson and Zakri, 2005), or the "*ability of robust ecological systems to provide, directly or indirectly, products and services fundamental to the healthy functioning of human societies*" (Young, 2010), and classified as provisioning, regulating and cultural services (Cilliers *et al.*, 2013). The quality of ecosystem services reflects their normal functioning, as yield depends on the carrying capacity (Ianoş *et al.*, 2009) and biodiversity (Niemelä *et al.*, 2010). Ecosystems services were not studied in cities as much as in the natural ecosystems (*e.g.*, wetlands) (Gómez-Baggethun and Barton, 2013), although the urban services, including transport, housing, and medical aid, up to jobs and financial markets depend on them (Ernstson *et al.*, 2010a).

2.4. Equilibrium and stability

In general, stability can be interpreted as constancy, ability to return to an equilibrium state, or persistence (Grimm *et al.*, 1992). Ecologists changed gradually the perception of equilibrium moving from the static equilibrium, characterized by a stationary state of equilibrium, to the dynamic one, characterized by numerous basins and states of equilibrium (Petrişor *et al.*,

2016c). Currently, most ecologists, but also professionals of other fields, embraced the model of adaptive cycles, proposed by Holling (2004). In this model, resilience, also called 'panarchy', connectedness and adaptive potential are axes of the adaptive cycle (Holling, 2004). In panarchy, resilience is the effort required to move a system from one basin of attraction into another, and differs from the time taken to return to a previous equilibrium state after the system is disturbed (Matthews and Selman, 2006). Furthermore, the 'equilibrium' has different meaning for superior systems, which tend to stabilize and conserve, and the inferior ones, which tend to experiment and revolt (Holling, 2004; Petrişor *et al.*, 2016c). The model of dynamic equilibrium interprets sustainability as resilience (Ahern, 2013). An apparently similar, but unrelated concept is the 'territorial system of ecological stability', in fact a Czech concept of ecological network in response to fragmentation (Mackovcin, 2000).

2.5. Resilience and sustainability

2.5.1. Sustainability

In addition to the definition and pillars presented in section 1, it has to be stressed out that, from the perspective of dynamic equilibrium of socio-ecological systems, sustainability represents the maintenance of a system in a desirable basin (Matthews and Selman, 2006). The interconnectedness of its pillars is demonstrated in a study by Sandu and Bănică (2015), showing that the environmental performance decreases when the social and economic sides are imbalanced. From a practical perspective, sustainability is monitored through indicators computed at the local level (Pawlewicz, 2015).

2.5.2. Resilience

Based on the change in understanding equilibrium (Petrişor *et al.*, 2016c), resilience changed its perception from a measurement of stability (Harrison, 1979) – preservation of structure, functions and integrity (Chelleri, 2012) to an axis of the adaptive cycle (Holling, 2004) or ability to dynamically return to equilibrium (Muradian, 2001). In this modern interpretation, resilience is a common feature of the dynamic environments characterized by unpredictability (Şerban *et al.*, 2015), and, therefore, involves change (Chelleri, 2012). In this regard, Zaucha *et al.*, 2014 define 'evolutionary resilience' as the ability to change, adapt and crucially transform in response to stress. In engineering several related concepts were defined, merely mathematically; robustness is the ability to tolerate perturbations, resilience is – in a similar way to ecology – the ability to return to a previous state after the exposure to fluctuations, and anti-fragility is the ability to benefit from variability (Gkoumas *et al.*, 2016).

Cumming (2011) identifies several types of resilience: ecological, social, and socio-ecological. Ecological resilience allows for delivering ecosystem services (Ahern, 2013) and is enhanced by higher diversity (Folke *et al.*, 2002; Elmqvist *et al.*, 2003; Cumming, 2011; Şerban *et al.*, 2015); social resilience can be increased by higher diversity, but also by economic, cultural, institutional and educational means (Cumming, 2011). Socio-ecological resilience increases by growing social and ecological resilience, but the two are not always compatible (Cumming, 2011). At the same time, the spatial resilience accounts for the variation of resilience with the spatial scale (Cumming, 2011). However, there

is no link between the resilience *in* cities and the resilience *of* cities in a territorial context (Ernstson *et al.*, 2010a). Last but not least, it has to be stressed out that environmental indicators are used to assess the resilience, similarly to sustainability (Carpenter *et al.*, 2001; Sandu and Bănică, 2015), despite the fact that resilience continues to remain a fuzzy concept, requiring always a contextual definition – resilience *of* what to *what* (Carpenter *et al.*, 2001; Cumming, 2011).

2.5.3. Relationships between resilience and sustainability

Although some authors overlap or closely relate the two concepts, since both assume entities interacting across different temporal and spatial scales (Ernstson *et al.*, 2010a; Mierzejewska, 2015c), showing that the initial definition of resilience was modified to include socio-ecological systems and coupled dynamics, and in this way it determines or is a condition for sustainability (Folke *et al.*, 2002; Chelleri, 2012), there are different opinions. Bănică and Muntele (2015) believe that "*the approach of resilience is more sustainable than the one of sustainability, opposing long-terms benefits to short-term efficiency when the probability of confronting hazards increases*", and, therefore, resilience is the key to managing an imbalanced world instead of balancing it through sustainability. The two are embedded in the concept of 'sustainable resilient city' (Chelleri, 2012), meaning a city that preserves biodiversity and also ensures the connectivity (Ahern, 2013).

3. Spatial consequences of socio-economic development

During its history, under the demographic pressure, humanity showed a clear sprawling trend, associated with the race for resources, but also with the anthropization and urbanization processes, and the organizing influence over the territory according to the needs of communities (Petrişor and Sârbu, 2010). The share of urban population is constantly increasing (Grimm *et al.*, 2008). The continuous expansion of human settlements, in conjunction with the need to interconnect them through the road infrastructure, resulted into the replacement of natural systems with artificial ones, and also in their simplification and fragmentation (Marzluff and Ewing, 2001; Petrişor and Sârbu, 2010; Petrişor, 2012), and, in a broader sense, to all the phenomena known as 'global changes' (Dale, 1997; Dale *et al.*, 2009, 2011): land cover and use changes, climate changes, and modifications of the energy flows. Although environmental changes were attributed to the demographic pressure (Li *et al.*, 2015) or economic activities (Jongman, 2002; Petrişor *et al.*, 2010, 2014, 2015b, 2016b), urbanization appears to be a more important global cause of fragmentation than agriculture (Marzluff and Ewing, 2001), determining changes of the land cover and use (Grimm *et al.*, 2008; Crăciun, 2015; Gavrilidis *et al.*, 2015; Vâlceanu *et al.*, 2015; Xi *et al.*, 2015), which ultimately result into environmental conflicts (Herspeger *et al.* 2015; Grădinaru *et al.*, 2014; Tudor *et al.*, 2014; Iojă *et al.*, 2011, 2014), and affect the global resilience (Andersson *et al.*, 2014).

Fragmentation acts in a similar way in social and natural systems (Cumming, 2011). As a result, urban sprawl is the main threat to non-urbanized areas (La Greca *et al.*, 2011), but is also visible within the cities. Urban ecological systems are characterized by the low

connectivity of natural patches, reduced biodiversity, succession and invasion (Niemelä, 1999; McMahon, 2000; Benedict and McMahon, 2001; Gibb and Hochuli, 2002; Luck and Wu, 2002; McKinney, 2002; Schneider and Woodcock, 2008; Poelmans and Van Rompaey, 2009; Niemelä *et al*., 2010; Taylor Lovell and Taylor, 2013; Andersson *et al*., 2014; Petrişor, 2015a; Petrişor *et al*., 2016a). The process of fragmentation is correlated to sprawl (Razin and Rosentraub, 2000; Fernández-Juricic and Jokimäki, 2001; Melles *et al*., 2003; Irwin and Bockstael, 2007; Zhao *et al*., 2015).

As a consequence of fragmentation, nature is reduced to four categories – remains of the natural systems, extension of natural systems, landscaped or managed areas, and spontaneous, invasive or ruderal species (Qureshi and Breuste, 2010; Breuste *et al*., 2013); due to the low diversity, urban systems are unable to generate the primary yield, and less stable (Petrişor, 2015a). However, the few natural areas are important in maintaining ecosystem services for the human population (Buhociu *et al*, 2013b; Acasandre and Crăciun, 2015; Enache and Popa, 2015), especially if their connectivity is ensured by creating corridors and greenways (Niemelä, 1999; Clergeau *et al*., 2016).

In Europe, the rural landscapes were affected by homogenization and fragmentation (Jongman, 2002) and sprawl influenced by the historical structure of cities (Poelmans and Van Rompaey, 2009).

For practical purposes, the analysis revealed several key principles. The proper planning and management of urban areas, respecting the environment (Ianoş *et al*., 2009), can offer lessons for living in harmony with nature (Fernández-Juricic and Jokimäki, 2001; Ersoy *et al*., 2015; Mierzejewska, 2015b; Badiu *et al*., 2016). The need for interdisciplinary cooperation becomes stronger when sustainability issues are addressed (Boştenaru-Dan, 2005; Wu, 2006; Ungureanu and Bănică, 2008; Bănică, 2010; Pintea and Achim, 2011); Ahern, 2013; Ianoş *et al*., 2013; Petrişor, 2013b; Meiță *et al*., 2014; Constantinescu and Platon, 2015; Frone and Constantinescu, 2015).

4. Socio-economic development and diversity

The dynamics of natural systems and man-dominated systems are different, but interconnected in the end through the extended trophy levels (Petrişor and Sârbu, 2010). Based on the consumption of energy, natural systems increase their diversity in order to increase their stability (Ianoş *et al*., 2011; Petrişor and Sârbu, 2010; Petrişor, 2014c) However, the relationship between diversity and stability is not linear, but characterized by thresholds (McCann, 2000; Muradian, 2001); mature systems have lower diversity, but better interconnectedness (Ashton, 2009). The interpretation of resilience as 'persistence under stress' and stability as 'return to equilibrium' can explain the relationship between diversity and stability – the system moves, in fact, to a new domain of stability (Holling, 1973).

Man-dominated systems exhibit a reduced diversity of the natural species (Petrişor, 2013a); among others, their fragmentation reduces the ability of natural patches to provide ecosystem services (Ernstson *et al*., 2010a) and ultimately results into the loss of

resilience, since the natural and man-dominated systems are interrelated (Folke *et al.*, 2002). Human activities reduce bio-diversity, but increase overall diversity (Petrişor and Sârbu, 2010; Matthews, 2014; Ibáñez *et al.*, 2012), because the process of urbanization increases patch fragmentation and diversity, expressed as larger perimeters or smaller patch sizes (Grimm *et al.*, 2008). As a matter of fact, economic geography and community ecology use similar measures of diversity and dominance (Ashton, 2009) and diversity indices used in natural systems can be applied to the socio-economic world (Petrişor and Ianoş, 2012). For example, the diversity of ecosystem services was measured using a method adapted from the measurement of genetic diversity (Martinez, 1996).

5. Core concepts of spatial development

Although sprawl was referred extensively in the previous chapters, sustainability also implies a control of the development process, including its spatial dimensions. Europe serves as a good example though the existence of spatial development policies. However, what is generally called 'spatial planning' has different meanings. For example, the French concept of 'aménagement du territoire', does not necessarily overlap with 'spatial planning', the commonly used translation, because its essence is to manage the national territory top-down (Faludi, 2004, 2006), although interventions from the upper level over the economic activities may have negative consequences (Farole *et al.*, 2011). For example, the displacement of population for industrial activities with environmental impact had environmental and social consequences (Braghină *et al.*, 2010, 2011; Danciu and Radoslav, 2015; Cocheci *et al.*, 2015; Dimen *et al.*, 2015). Furthermore, the distribution of funds did not account for the spatial heterogeneity, which is a consequence of multiple basins of equilibrium (Ramajo *et al.*, 2008). As a reaction to the core-oriented regional policy of the European Union, many peripheral countries attempted to support the economic development of their most dynamic centers (Luukkonen, 2010). The resilience of regional economies depends on the innovative capacity of existing local firms and the ability to establish new firms (Salvia and Quaranta, 2015), and spatial complexity is negatively correlated with regional specialization (Şerban, 2013; Şerban *et al.*, 2015).

In the 'natural' regional development, large urbanized centers attract business, which spread out later to the adjacent territories. For example, creative industries tend to cluster geographically (Bialic-Davendra *et al.*, 2016). The process of dispersion due to the attraction of and radiation from regional centers also determines the environmental impact (Garcia *et al.*, 2007). The consequence is that disparities have increased between countries before 1990 and within after (Niebuhr and Stiller, 2003; Farole *et al.*, 2011; Munteanu and Servillo, 2013). The developed areas are strong metropolitan areas concentrated in the former pentagon and capital cities and other European engines situated in less central regions (Lennert and Robert, 2010; Săgeată, 2015). Disparities are perceived by social scientists as 'negative' and recommended to be eliminated (Florescu and Mitrea, 2015; Saraceno, 2013; Sîrodoev *et al.*, 2015), although they have a beneficial long-term effect despite the

negative short-term impact, increasing the efficiency (Farole *et al*., 2011). In general, territorial diversity is beneficial, as it enhances competitiveness and results into differentiated, tailored policies (Saraceno, 2013). Nevertheless, territorial imbalances set a strong pressure over the urban areas and create an unethical uneven spatial distribution with negative environmental consequences (Ianoş *et al*., 2010; Peptenatu *et al*., 2010, 2011, 2012).

The European Union strategy for spatial development contains only a general message, 'territory matters' (Walsh, 2012) despite the fact that the pattern of development (compact vs. dispersed) influences the sustainability of development (Mierzejewska, 2015a). As a result, there is a conflict between the political goals of cohesion and the heterogeneity of the European Union (Graham and Hart, 1999), as the core-periphery model of the European Union did not change (Graham and Hart, 1999; Benedek, 2015). Essentially, the European spatial policy focuses on two interrelated concepts, which act together like the drivers of stability in an ecosystem: *polycentricity* provides for diversity, boosting the development of new centers, even of local importance, while *cohesion* gives coherence to the entire system, intervening when polycentricity results into serious imbalances with negative consequences; *e.g.*, the possible case of a center that develops at the expense of stopping the development of all surrounding ones (Petrişor and Petrişor, 2014).

Starting from the fact that the poles of development play a central role in eliminating disparities (Humeau *et al*., 2010; Novotná *et al*., 2016), the European Spatial Development Perspective is paying tribute to Europe's diversity by focusing on polycentric development, which joins two opposing concepts competition and cohesion (Faludi and Waterhout, 2005; Waterhout *et al*., 2005; Doucet, 2006). Polycentricity deals at the same time with morphological and functional aspects without limiting its meaning to the existence of physical connections (Meijers, 2008), and aims to favor development in some regions through foreign direct investments and spatial planning (Tewdwr-Jones and Mourato, 2005). The concept can be applied at different spatial scales, but its interpretation changes (Davoudi, 2003).

Cohesion aims to reduce disparities and balance economic development, emphasize environmental sustainability and reinforce territorial cooperation (Medeiros, 2012) through the integration of sectoral policies (Stead and Meijers, 2009; Tewdwr-Jones and Mourato, 2005), but pays more attention to territorial differences than to the urban ones (Vanolo, 2010). Territorial cohesion is the spatial dimension of socio-economic cohesion (Doucet, 2006; Faludi, 2004; Davoudi, 2005).

The two concepts are interrelated, since both are built on the premise that Europe needs a more equal distribution of globalization and integration gains than the current one (Peters, 2003), but also connected to diversity and sustainability (Faludi, 2006; Tache *et al*., 2016b). The goals for a 'balanced and sustainable development' translate into polycentric development (Davoudi, 2003; Faludi, 2006). The implications go both ways; Faludi (2005) considers that polycentricity leads to territorial cohesion, while Medeiros (2012) argues that cohesion aims to establish a polycentric

development (Medeiros, 2012). Moreover, cohesion relies on diversity, strengthening it (Servillo *et al.*, 2012). Overall, the process of spatial development can be seen as a consequence of the different strategies of systems, according to the panarchy theory (Holling, 2004; Petrişor *et al.*, 2016c) – urban systems and local economies can experiment, whereas the superior system, namely the European Union, tends to stabilize and reduce the differences.

In an analogy with the ecological principles, the optimal territory size is affected by the availability of resources and intruders; the most suitable models for assessing economic relationships in a territorial framework are those assessing the relationship between residents and settlers (Adams, 2001). Continuing the analogy, the instruments for assessing the biological diversity can be applied to socio-economic systems (Petrişor and Ianoş, 2012).

If the last example is carried further, Fig. 2 presents two hypothetical territorial systems; one of them is mono-centric and characterized by the dominance of one city, four times more influential than the others (with equal influence), and the other one is polycentric, with all centers of equal importance. If the Shannon-Wiener index is computed based on this data (using $\Sigma p_i \times \ln(p_i)$, where p_i is the share (proportion) of each component) and the total sum is the same for comparability purposes (*i.e.*, $4 + 4 \times 1 = 1.6 \times 5 = 8$), its values are 1.4 in the first case and 1.6 in the second; this example shows that, even with very simple systems, the methods from ecology can be successfully used for assessing the polycentricity.

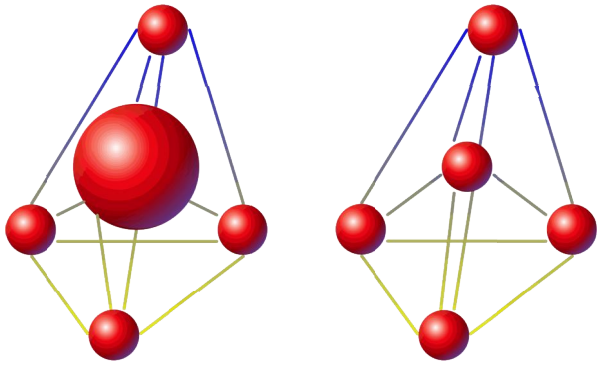

Fig. 2. Spatial model of polycentricity; left – mono-centric development, characterized by the domination of a single center over the others; right – polycentric development, characterized by a network of centers. Source: created by the author using hypothetical data.

6. Conclusions

The analysis revealed the spatial side of the relationship between man and nature. Human activities affect the spatial configuration of the environment and its diversity. The diversity of the natural or human realm, measured in multiple ways (structure, functions, response etc.) is not necessarily correlated with the spatial diversity, although the methods used in ecology can easily be imported to other fields.

In summary, the main concepts are diversity, resilience and sustainability, as sides of a balanced development, the four pillars (economy, society, culture and environment), and the two concepts of spatial development – cohesion and polycentricity. Their interconnections are showed in Fig. 3.

The core concepts, resilience and sustainability, have an unclear relationship; they can be seen as sides of a common concept, contrasting or complementing concepts. Nevertheless, diversity enhances all of them. Cohesion and polycentricity are also tightly connected, although it is not clear which originates in the other.

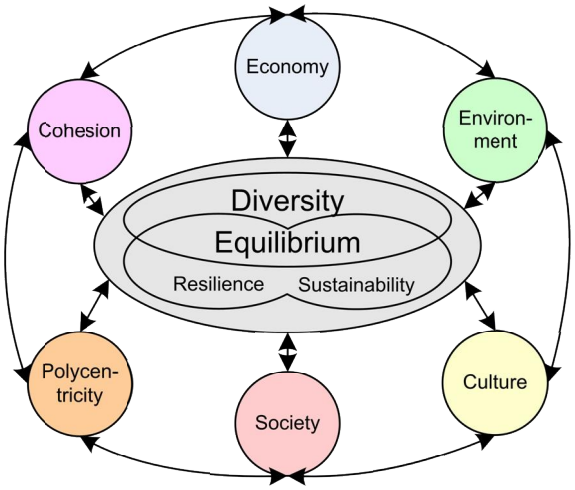

Fig. 3. Conceptual model of the balanced development (described in terms of diversity, resilience and sustainability), including its four pillars (economy, society, culture and environment), and the two concepts of spatial development (cohesion and polycentricity), as well as their relationships. The relationships forming the outer circle connect pairwise all the pillars and dimensions. Source: created by the author based on the analysis.

The goals for development are translated into concepts like 'sustainability' or 'resilience', with unclear and often conflicting differences. From a spatial perspective, the European Union developed two concepts which, in theory, are supposed to increase the resilience and sustainability – polycentricity and cohesion. Nevertheless, the content of these concepts consists of conflicting sides, and national or territorial differences impede their translation in policies.

Sustainability reflects the human tendency to organize the space. Top-down policies are applied to counter the territorial disparities appearing naturally. Their man-driven application applies ecological laws (dynamics through adaptive cycles) to the territorial systems, by re-distributing the resources through 'polycentricity' and 'cohesion' to other centers in order to maximize overall diversity and increase stability in an anti-entropic manner. More exactly, the hierarchically higher systems (European Union, national government) tend to stabilize the 'revolt' of the inferior ones (regions, cities) during the growth phase by maintaining a balanced development.

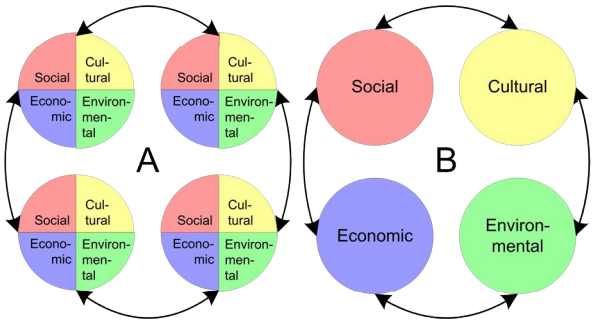

Fig. 4. Conceptual model of territorial balance. A – the four pillars are balanced within each pole; B – each pole is specialized, but overall there is a balance. Source: created by the author based on the analysis.

Future research should be directed towards a conceptual refinement of the core concepts; since the main focus of the article is the spatial development of socio-economic concepts, several key open questions are:

- How should the core concepts be defined in order to achieve a unitary vision? Perhaps their deconstruction would help towards a conceptual refinement, especially the elimination of conceptual overlaps.
- Are the terms 'balanced' and 'sustainable' similar when associated to development from the spatial viewpoint? If not, what is their relationship?
- What does 'balanced' mean with respect to the spatial perspective of development and the four traditional pillars? More exactly, in financial terms, does it mean that resources should be distributed equally over the four pillars in each place? Fig. 4 shows two models: A – each of the poles has an even distribution across

the four pillars; this corresponds also to a maximum diversity; B – each pole is specialized, but overall there is a balance of the poles. In the two models, the sum is the same, based on the idea of a Paretto-type optimum.

- What is the relationship between 'balanced' development, cohesion and polycentricity?

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