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On the 'complexity turn' in planning: An adaptive rationale to navigate spaces and times of uncertainty

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Abstract

Complexity sciences have been long ago acknowledged to be useful at conceptualizing a variety of phenomena relevant to planning. Nevertheless, the actual mechanisms that will prove adequate to tackle complex planning issues are still under debate. Considering that in today's so-called era of the Anthropocene such planning issues are more present and evident than ever, the need for further investigating the implications of complexity sciences into building planning approaches becomes very relevant. In this article, we use the concept of complex systems as an analytical framework challenging our understanding of planning and we argue in favour of a 'complexity turn' in planning through the adaptive rationale. We define the adaptive rationale as an additional, both normative and analytical, trajectory in planning theory, in the interplay between certainty and uncertainty. Finally, to assimilate this rationale into planning mechanisms capable to respond to contemporary social and ecological challenges, we call for issue-driven adaptive planning approaches conceptualized through normative sustainability and nourished by post-normal science.

Keywords

adaptive rationale, complex systems, normative sustainability, post-normal science, uncertainties

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Introduction

The gradual increase of the world's complexity has been accompanied by a parallel progress in the scientific understanding of this complexity. Starting from fields such as biology, physics and mathematics, scientists began exploring the complex systems' behaviour, forming complexity sciences and theories, already by the 1940s (Castellani, 2013). Since 1970, the technological progress, concerning especially modelling tools, has played a catalytic role in developing the knowledge on complex systems and disseminating their usefulness (Allen, 2012). As a result, today scientists accept that almost all natural and social systems are interdependent, mutually interacting complex adaptive systems (e.g. a rainforest, the global economy, the world wide web, the immune system and a city) (Waldrop, 1992).

It then becomes clear that many issues, planning aims to address, can be considered to some degree as problems of complex adaptive systems (CAS). Indeed, complexity has been useful at conceptualizing a variety of phenomena relevant to planning (e.g. Baggio, 2008; Hall and Clark, 2010; Liu et al., 2007; McGreevy and Wilson, 2017). For example, Jacobs (1961), inspired by the progress in the life sciences, was perhaps the first to establish the link between complexity sciences and cities, by referring to the latter as 'problems of organized complexity'. According to Weaver (1948), 'problems of organized complexity involve dealing simultaneously with a sizable number of factors, which are interrelated into an organic whole' (Weaver, 1948: 539). The characteristics and dynamic behaviour of this organic whole cannot be reduced to the simple adding together of the characteristics and behaviour of its individual parts, and thus these are difficult to predict. Since then, Jacob's claiming has been studied and confirmed (e.g. Allen, 1983, 1997; Pumain et al., 1989), recently mobilizing Batty (2010) to work towards a 'New Science of Cities' and Portugali et al. (2012) to discuss the development of the 'Complexity Theories of Cities' (CTC).

Nevertheless, it has taken time for planning to move beyond the question of whether some planning issues can be considered complex and start exploring 'methods of engagement and cognition' (Sengupta et al., 2016; Zellner and Campbell, 2015). Subsequently, the actual mechanisms that will prove adequate to tackle complex planning issues constitute a very relevant issue still under debate. If the 21st century is the 'century of complexity', according to Hawking's famous quote back in 2000, planning seems to evolve accordingly and a growing number of researchers discuss today various aspects of the complexity-planning relationship. For instance, Innes and Booher (2010), focusing on the social dimension of complexity, propose their collaborative planning approach; Chettiparamb (2014) discusses fractal organization to understand self-similarity in the organization of policies across scales; Moroni (2015), from an Austrian-Hayekian perspective on complexity, argues in favour of more generic frameworks for development based on urban codes. In a parallel – more developed but fragmented (Walker et al., 2013) – literature focused on issues of natural resources management, the issue is addressed by constructing forms of adaptive planning (Arnold, 2010; Kato and Ahern, 2008; Van Buuren et al., 2013), adaptive management (Arnold, 2010; Patterson et al., 2008; Terryn and Boelens, 2013; Westley, 2002), adaptive policy-making (Haasnoot et al., 2013), and adaptive governance (Dietz et al.,

2003). At the same time, organizations of international influence are nowadays referring to the need for reconfiguring planning practices and policies in order to more effectively address 'complex global challenges', attributing to the term 'complex' (more or less consciously) its contemporary scientific dimensions (European Commission (EC), 2013; Organisation for Economic Co-operation and Development (OECD), 2009; United Nations (UN), 2012). Thus, the discussion is ongoing and new planning approaches are being formed, without however constituting part of the mainstream reasoning in planning theory or concrete and broadly applicable action plans (Boelens and De Roo, 2014).

In this article, we attempt to integrate aspects of the complexity-planning relationship dispersedly found in the literature in order to identify them as evidence and characteristics of a systematic 'complexity turn' in planning. We conceptualize this complexity turn to take place through the adaptive rationale – an additional normative and analytical trajectory in planning theory. On the 'normative' point, through our analysis, we argue on the need for this adaptive rationale, as well as the subsequent adaptive planning approaches, to be embedded within the concept of normative sustainability. Normative sustainability acknowledges a hierarchical relationship between the economy, society and the environment and recognizes democracy, social equity and social justice, cultural diversity and multiculturalism, and the maintenance of biodiversity as overriding societal values and goals. Furthermore, considering that the economy depends on healthy societies and ecosystems, normative sustainability criticizes the supremacy of markets and calls for a view in which the economy is subordinated to social and ecological constraints (Becker et al., 1997; Moulaert and Parra, 2011; Parra, 2013). By incorporating such a concept in our analysis, we extend critical questions already identified for the relative concept of resilience (Cutter, 2016) to the new generation of planning mechanisms: Adaptive planning for whom and for what? On the 'analytical' point, we argue that the complexity sciences and the adaptive rationale could bring issues of substance and the question of the approach to science within planning back to the forefront of planning connecting to the wider discussion on the type of science capable to respond to the uncertainties, as well as the irreversible and out-of-control changes brought by the era of humans or Anthropocene (Minteer and Pyne, 2015). Although a controversial term, in the so-called Anthropocene era, the transformations taking place in the Earth system (e.g. climate change, biodiversity) are marked by increased complexity and uncertainty bringing new challenges to human viability and development. Our overall analysis integrates two aspects of complexity sciences often treated separately, which we call complexity sciences as 'extensions' or 'tools' of planning (mainly in terms of simulations) and complexity sciences as 'frameworks' for planning, and bridges the gap between the purely technical and the post-modern understandings of complexity in the planning field.

The article is structured as follows. We start by analysing the example of cities as CAS. Then, we discuss the relevance of complexity to the spatial sciences and, through the concept of uncertainties, the implications of complexity for planning. This analysis sets the basis for the adaptive rationale, which is discussed in the last section revealing the analytical and normative aspects of a possible complexity turn. The article is then brought to a close with concluding remarks.

Planning issues as complex systems: the example of cities

One of the main objects of research complexity scholars have dealt with is cities[1] (e.g. Allen, 2012; Byrne, 2003; Pulselli et al., 2005; Wensheng and Qiang, 2013). This could be attributed, in part, to the importance of cities (Allen, 2012; Portugali, 2012), being the living and working environment of over the half of the world's population and major generators, modulators, and recipients of global complexity. In addition, the city, being perceived as a territorial entity with its own history and specific characteristics that could remain generally unchanged for quite long time periods, is acknowledged to be an appropriate spatial level of reference for understanding various spatial processes through complexity (Pumain, 2006). Thus, we consider cities to be interesting, as well as useful examples of the way complexity is structured and manifested.

When referring to non-social complex systems such as natural ecosystems, the two main dimensions of complexity are considered to be space and time, while when referring to social complex systems the human factor is an additional dimension to be studied (Pumain, 1998). In fact, it is the human agency that largely defines the 'dual complex nature of cities' (Manson and Sullivan, 2006; Portugali, 2014): the city as a whole behaves as a complex system, but every human, part of this city, is also a complex system of self-organizing, adaptive behaviour. While in other kinds of CAS atoms and molecules can be described by their position in space only, every human has to be described by a number of extra features that play a role in his or her complex behaviour such as thoughts, intentions, cultural and socio-political norms, institutions, knowledge and interests (Portugali, 2006; Portugali, 2014). Subsequently, the social organizational structures, which are both emergent from and determinants of the individuals' actions, refer to collective entities (i.e. entities not reducible to the individuals' behaviour) characterized by some (complex) cognitive behaviour themselves (Bretagnolle et al., 2006).

Cities' human agents are integrated with natural (biodiversity, seasonal temperature variations, climate change, etc.) and artificial (human-made structures such as buildings, roads, etc.) systems, which constrain and promote human actions and can also produce actions of their own. In fact, cities are considered unique types of CAS in that their spatial aspects and elements are also taking part in the human interactions, adding another layer of complexity (Sanders, 2008). In cities, space is not only a (social) end product, as it appears in social theory (see for instance Lefebvre, 1974) but it feeds back to and participates in the process of a socio-spatial production (see also Massey, 2005). Thus, the city is emerging as a CAS through the interactions of people, but once emerged, space functions as an 'order parameter' that enslaves (in Haken's language of synergetics) people's behaviour in a circular feedback process of human behaviour–space (Portugali, 2006).

The urban complexity does not lie only in the three elements – humans, space (the way we defined it for cities) and time – but also in the way these elements are organized. If one envisions the city as a multilevel system of semi-lattice structure (Alexander, 1965), there are many levels of sub-systems of diverse spatiotemporal scales, able to interact vertically, horizontally and sideways. To give life to these sub-systems and the interactions within and between them, Coward and Salingaros (2004) follow the example of electronic systems and organize the city into 'modules', that is, clusters of activities that have greater

information exchange within the module than with other modules. The modules are referring to structured groups of links, where the actions carried out in different places in space communicate. This means that the term 'module' is more consistent with 'network' rather than with a spatially compact object or region (Batty, 2012; Coward and Salingaros, 2004). Thus, practically, the complex urban structure has to be understood not only with the strict visual arrangement based on the spatial footprint but also with the flow of information (Coward and Salingaros, 2004).

As recognized in second-order cybernetics, it is this flow of information that is crucial for self-organization and, subsequently, self-steering of the city-system (Karadimitriou, 2010). In the words of Portugali (2006), 'self-organisation is a process of information compression' (p. 658). The city's agents are continuously subject to a multiplicity of messages (to be perceived as results of 'informative perturbations' rather than

> information transmission – see Karadimitriou, 2010: 432) coming from other agents or from the broader environment of the city. They are then called to interpret or compress these messages and make a series of critical decisions from several possible alternatives in order to adapt their behaviour and feed back to their 'conversational partner' (Huys and Van Gils, 2010; Karadimitriou, 2010; Portugali, 2006).

Perceiving each human to be also a complex system, it can be argued that self-organization in the city-system is dual: self-organization of an individual social agent and self-organization as mutual adaptation between agents (Portugali, 2014). The result of these local processes is the emergence of new a macroscopic behaviour or patterns which are (almost) unpredictable, due to the non-linear, multilayered and diverse actions and reactions.

The processes of self-organization and emergence are constant (i.e. always present in a more or less intense degree), meaning that the city is out of equilibrium, in a creative, dynamic situation (Batty, 2008, 2012, 2017; Portugali, 2012). These processes determine also the co-evolution of the internal and external environments of the city, or else the co-evolution of the city and its (external) environment (Kauffman, 1993). In other words, co-evolution refers to the mutual and constant adaptation between all the systems shaping the city and its own ecosystem. It also refers to the long-term development of the city that, although restricted in an 'accessibility space'[2] (Bossel, 1999), it is largely unpredictable and necessarily about changes (either small adaptations or deeper ones, that is, transformations[3]).

With the latter concept of co-evolution we could go back in time, when Von Bertalanffy (1968) underscored the importance of open systems and their environments' role in their evolution, aiming at the study and understanding of living systems. In reality, we could accept that we are not referring to systems and their environments but to a living whole consisted of intersecting (complex adaptive) systems, the number and boundaries of which depend on the decisions we make for their study, according to our logical limits, perception and knowledge (Allen, 2001). A city could be perceived then as a socio-spatial entity of multilevel networks that compose its, subjectively and artificially defined, fuzzy limits, as well as an open-ended process, subject to gradual and continuous evolution (Bettencourt, 2013; Bretagnolle et al., 2006). The urban structures and processes are

connected through a nested hierarchy of scales that link the microscopic level to successively larger scales and finally to the biosphere (Allen, 1997). Such an 'open' understanding of cities seems necessary in the Anthropocene, when what happens in cities is increasingly disconnected from their physical form (Batty, 2017) and couples the understanding of cities to global flows of information, resources, and ecological systems, which largely define their development.

The relevance of complexity to the spatial sciences

Planning and, more generally, the spatial sciences[4] have formulated a particular relation with complexity. The first connections between space and complexity were already established around the mid-1970s not by planners, architects or geographers, but by physicists such as Prigogine, who used cities as an example to explain his theory of dissipative structures (Prigogine, 1977), and Allen, who revisited the classical location theory (Allen, 1981). From then on, researchers skilled in computational techniques (e.g. cellular automata, agent-based modelling and fractals) started constructing new methods and tools looking forward to establishing a complexity-informed theoretical basis for diverse spatial phenomena (e.g. Batty, 2010; Pumain, 2006).

However, researchers focused on the qualitative nature and social interpretation of the same issues remained sceptical in approaching the – 'hard sciences' originated – complexity sciences (Castellani, 2014; Portugali, 2012). They tended to be critical on whether ideas and concepts of complexity can be translated to the human sphere (Portugali, 2012). This scepticism seems that referred not to the essence of complexity but mainly to the controversial effectiveness of simulation modelling and, more generally, quantitative approaches, to problems involving the human behaviour (Portugali, 2012). It was only until the late 1990s that social sciences approaches engaged more systematically with complexity,[5] integrating some social substance into the research on complexity sciences (Castellani, 2014; Urry, 2005).

At this point, it has to be emphasized that complexity is not only about quantitative messages (Byrne, 1998, 2003; McAdams, 2008; Portugali, 2012). Timmermans (2012: 186), using qualitative methods and a CAS perspective to examine the non-linearity in processes of planning practices is finally wondering 'Are there other ways than computer modelling to obtain quantitative data that support the occurrence of these non-linear steps? And even more fundamental: do we need quantitative data to understand non-linearity in planning practice?' Nevertheless, as mentioned above, for years, socio-spatial systems' researchers focused on specific computational methodologies rather than the theoretical aspects of complexity, which were often neglected (Pumain, 1998). In fact, according to Portugali (2012), scholars working on urban complexity tended to ignore phenomena with not easily accessible quantitative data, thus, not useful for modelling simulations, restricting the potential production of knowledge and often making the contribution of complexity to seem outdated.

Today, there still is a remaining duality (Zellner and Campbell, 2015) reflecting perhaps a traditional gap between the quantitative, natural sciences–oriented, and the qualitative, social sciences–oriented, spatial sciences.[6] In fact, in a recent self-criticism on the CTC, Portugali (2012) observed a remaining trend of CTC to be narrowly defined as 'a

new generation of quantitative urban simulation models capable of describing, simulating and predicting urban scenarios in an efficient and accurate way'. Nevertheless, the distance between the aforementioned research trajectories has been certainly reduced by the many cross-disciplinary complexity-related concepts and investigations that formulate the broad 'sustainability sciences' field: resilience (Davoudi et al., 2012; Gunderson and Holling, 2002), social-ecological systems (Berkes and Folke, 1998), transitions (Rotmans and Loorbach, 2009; Van der Brugge, 2009), adaptive management (Kato and Ahern, 2008; Terryn and Boelens, 2013), adaptive governance (Folke et al., 2005), adaptive planning (Rauws and De Roo, 2016) and self-organization in bottom-up governance (Boonstra and Boelens, 2011).

The peculiar way in which complexity sciences have been integrated (or not) into the spatial sciences has not diminished their analytical power; they have important contributions to demonstrate, at least when it comes to the scientific analysis of socio-spatial systems (e.g. cities).[7] The situation is more complicated when it comes to planning, especially since this has lately evolved separately from the study of such systems (Batty and Marshall, 2012). 'In fact, design and planning as technical activities have tended to decline in significance, while planning practice has evolved as a form of negotiating, brokering, and facilitating which requires very different skills' (Batty and Marshall, 2012: 41; see also Zellner and Campbell, 2015). Therefore, when Van Wezemael (2010: 85) argues that 'spatial planning theory has quite some time ago reacted to the discovery of complexity, not least by putting communicative approaches and participatory methods at center stage' we cannot keep from questioning the degree to which such a movement is the result of a conscious integration of complexity sciences into planning, or if it mostly addresses the ambiguity (Zandvoort et al., 2018) and a quest for 'a more democratic and socially just planning process and practice' (Portugali, 2011b: 286). If we accept then that the contribution of complexity to planning has yet to be completely realized, could we perceive a more conscious integration of complexity sciences into planning as an opportunity for planning to evolve and further develop its scientific basis?

Implications for 'our understanding of planning'

Complexity, in the planning discourse, is still a fuzzy concept and it has been either unconsciously addressed,[8] or it has been used as a literal term, lacking its scientific dimensions. De Roo (2010), performing a parallelism between the fuzzy understanding of sustainability in planning and this of complexity, argues that 'while the fuzziness of sustainability affects actions and behaviour *in* planning, complexity influences our understanding *of* planning' (p. 2). Indeed, if we recognize the notion of sustainability as more of a political and normative stance towards planning problems, then it differs very much from the actual and potential role of complexity sciences' theoretical principles and practical methods in planning. Taking into account that complexity has diverse key messages to offer depending on the perspective and focus of each researcher, we will discuss a major implication for planning, which challenges its basis, nature and definition: acknowledging and accepting the uncertainties that complexity implies.

Acknowledging and understanding uncertainties

'Spatial planning is somewhere and long ago described as the best feasible mutual adaptation of space and society, such for the sake of society' (Van Veen Commission, 1973 according to Terryn and Boelens, 2013: 63), but also as a 'means through which we construct the future' (Byrne, 2003: 171). Hence, one could argue that in order for planning to be effective planners are called to absorb society's requirements and identify the way these can be integrated into space in the best, mutually profitable way (Allen, 2012; Terryn and Boelens, 2013). Following a first-order cybernetics approach to planning, the intervening planners observe, define and analyse the study area's past and present conditions to intervene in the present, aiming in the desired future (Karadimitriou, 2010). Combining the aforementioned socio-spatial complexity with such an understanding of planning, we can conclude that planning as a process and technical activity faces many challenges demanding a sequential understanding and processing of a series of complex presents so as to approach the desired future(s).

On this basis, uncertainty becomes a key concept in the planning process (Batty and Marshall, 2012; Byrne, 2003; Sela, 2016; Terryn and Boelens, 2013). The non-linear evolution of spatial processes is by itself enough to imply the uncertainties involved in their development trajectories. Moreover, one can understand that a complete understanding of each present and past and a perfect projection to and construction of the future are practically impossible, especially when considering the potential unforeseen disturbances too. The aforementioned inherent uncertainties of planning could be linked to two (of the three) kinds of 'unknowability' Marshall (2012) proposes as important consequences of complexity in planning: 'unknowability of the system as it is' and 'unknowability of effects of intervention' (p. 199). This means that an absolute knowledge of the system is very difficult to be achieved, and even if achieved, one would still be uncertain on how the system evolves with or without deliberate intervention (Marshall, 2012).

Things are getting more complicated when considering the uncertainty embedded in planning's goals for the desired future, what Marshall (2012) calls 'unknowability of optimal future state' (p. 200). To further argue on this kind of uncertainty, we will borrow from evolutionary biology the concept of fitness landscapes, which is used to visualize the development of a CAS over time (Kauffman, 1993; Richter and Engelbrecht, 2014). The fitness landscape for a specific system consists of an array of all the possible future states available to the system, illustrated as peaks and valleys. The peaks represent the 'well-adapted states' (Alexander, 2003: 17) or else 'an adaptive solution to a problem of optimization' (Lansing and Kremer, 1993: 104), where the fitness between the system and its environment is maximized. The valleys represent the less favourable states. The evolution of the system can be visualized as a journey across the fitness landscape with the tendency to locate the highest peak. When referring to complex socio-spatial systems – CAS such as cities – we are referring to a rugged (i.e. consisted of a number of different peaks), dynamic (i.e. changing peaks and valleys over time) fitness landscape. The potential optimal states are usually multiple (being socially contested, interpreted differently and subject to negotiation), continuously changing with time and thus possibly unreachable, and the journey towards there is certainly a challenge full of trade-offs (Portugali et al., 2012).

> A future city cannot simply be the built-out product of a creator's imagination, in the way a building can be. Nor is a city growing like an organism: there is no knowable optimal form of target organism to be steered towards. (Batty and Marshall, 2012: 44)

Thus, which should be today's objectives of planning and, more importantly, who can guarantee that they will still represent a well-adapted state for the future city?

We argue that this latter uncertainty challenges some of the dominant aims of planning, such as this of the 'sustainable city'. For instance, despite the various meanings given to the concept of sustainability, we could agree that the prevailing conception concerns the achievement of a desirable state, usually equated to some kind of equilibrium or balance into the long-term future. However, according to what we discussed so far, cities' viability and evolution seem to be dependent on their constant state of disequilibrium, while their well-adapted/sustainable states are changing and are likely to be unreachable. Indeed, when trying to go beyond the normative conceptualization of sustainability, sustainability concerns not a steady, subjective goal, but a dynamic concept that co-evolves along with societies' changing technologies, cultures, institutions, values and so on and is being continuously reassessed (Bossel, 1999; Swart et al., 2004). In other words, according to our arguments so far, sustainability could be perceived as the continuously changing space of alternatives or paths in which it is desired for a system to evolve in, in order to ensure its viability over time. Such an approach to sustainability means that it is difficult to specify the optimal outcome in the first place (Marshall, 2012) and that the trajectory followed towards the objective becomes more important than the objective.

Accepting uncertainties and integrating complexity

Accepting that the spatial processes and planning effects remain largely unpredictable and deconstructing planning's goals can easily raise doubts about the purpose and effectiveness of planning. In other words, there is the risk for complexity to be considered as an unmanageable obstacle and for planning to be perceived as futile (Allen, 2012; Huys and Van Gils, 2010; Karadimitriou, 2010). However, complexity sciences do not validate the principle of laissez-faire as a means to effectively not plan a prosperous future. Complexity puts in the centre of the debate the rules that lead a system to a well-adapted state, or else to a peak of a fitness landscape, especially when it comes to non-natural systems, where the blind natural selection is not the case (Alexander, 2003; Portugali, 2006). In biological systems, the optimization occurs via blind natural selection (Lansing and Kremer, 1993). Nevertheless, a socio-spatial system is not an organism or, more generally, a (purely) natural CAS (Batty and Marshall, 2012; Bettencourt, 2013; Marshall, 2012). As argued already, these are results, at least partly, of deliberate selection (Lansing and Kremer, 1993; Portugali, 2006), which is co-produced by their complex adaptive agents and their natural and artificial elements: 'Multiple futures are possible, but social actions can influence the possible futures that will actually come to pass' (Byrne, 2003: 174). Thus, how can such a CAS be (deliberately) led towards a well-adapted state? The identification of these rules that can lead to a good adaptation is according to Alexander (2003) the most important scientific endeavour of our era.

In addition, the fact that a socio-spatial CAS has the ability to self-organize does not mean that the system, if left free to organize itself, will eventually reach a well-adapted state, at least not for all the agents that take part in the self-organization process (see, for instance, the tragedies of the commons). To build on this thought, as we already explained, humans organize themselves in complex systems, different than other living entities such as bird flocks or ant colonies. They have the ability to understand and foresee, at least to a point, the development of the overall system and the consequences of their interactions; they have expectations and subjective opinions on the well-adapted states; they may prioritize their personal objectives over the group's objectives; and they are divided into strong and weak agents, following a hierarchy that has direct effect on their interactions (Boonstra and Boelens, 2011; Portugali, 2006). Subsequently, Karadimitriou (2010: 427-428) argues that 'in the absence of any form of collectively sanctioned attempt to influence them, the spatial expressions of society will still evolve, most likely in a direction serving elites. The Victorians were the first to discover that in a capitalist world largely structured around power relations it is not a matter of whether we need planning, but a matter of what sort of planning we need'. Sanders (2008) acknowledges the neutral nature of adaptation, self-organization and emergence and, sharing the same concerns with Alexander (2003), questions the positive interactions that could lead to positive emergent patterns and overall positive adaptation of the system.

Hence, complexity does not render planning futile but calls it to operate using appropriately chosen theories, methods and tools, acknowledging the evolutionary nature of socio-spatial change and accepting its limitations (Batty and Marshall, 2012; Huys and Van Gils, 2010; Karadimitriou, 2010). The so far failures of planning should not be attributed to the complexity of socio-spatial processes, but to the fact that the planning theories and methodologies have been based mainly on a simplified perception of the reality (De Roo, 2010). This simplified perception regards either the denial of complexity and of uncertainty's existence, or the reflective action to restrict these 'barriers' by intensifying the processes of planning and control, deepening in more detailed methods and models, and ignoring the inherent uncertainty of complex spatial processes (Roggema, 2012). Today, the understanding of socio-spatial systems via the complexity sciences can of course bring new knowledge to the process of planning. The new technologies and the sophisticated computer simulation models will for sure ally in such a practice, as they become gradually capable of avoiding past forced simplifications (Allen, 2012; Bretagnolle et al., 2003). However, as it emerged from the aforementioned, more knowledge does not necessarily reduce the uncertainty embedded in complex spatial problems. Complexity refers (mainly and also) to a special category of uncertainties that cannot be approached through stochastic methods or by building scenarios, but instead have to be accepted as such (Roggema, 2012). These are uncertainties embedded in planning's objects, goals and methods that call planners to recognize their ignorance, as they are difficult to be assessed, being evidence of not fully understandable, at least until now, processes.

In light of these conclusions, we agree with those scholars who argue for a radical change in planning via complexity sciences insist that planning's aim should not be to reduce uncertainty and control complexity, but to understand and harness them to use new adaptive planning rationales and methodologies that will co-adapt and co-evolve with the dynamic spatial processes (Allen, 2012; De Roo, 2007; Terryn and Boelens,

2013; etc.). Keeping normative sustainability as a political stance we perceive complexity as a scientific basis, contributing to the shaping of planning methodologies that will make planning coexist with the uncertainties and participate in positively shaping complexity (Eraydin, 2013; Huys and Van Gils, 2010; Roggema, 2012). We are thus looking forward to a new field of study in which planning is not an external element of control, trying to impose a (dys)functional and (un)natural order in an otherwise spontaneous and complex urban process, but is taking part in this complexity as an integral element in its dynamics, positively influencing but also adapting to the systems' evolutions (Boonstra and Boelens, 2011). In such a field, planning will become a simultaneously flexible and robust process that will not aim at maximizing the planning result in line with the predefined goals but in optimizing the planning process according to the changing needs along open trajectories (De Roo, 2007; Hillier, 2010).

On a 'complexity turn' in planning

The above reframing of planning leaves much freedom (and thus challenges) to researchers when trying to translate it in planning approaches. Besides, both the theoretical and practical integrations of complexity sciences in planning are major challenges, especially when considering that planning has originally evolved from a mix of philosophies and methods referring to determinism, reductionism and positivism (Byrne, 2003; Eraydin, 2013; McAdams, 2008). It is well-known that for years, the conventional view of planning concerned a regulatory mechanism that recognized the elements of space, along with humans, as stable, lifeless objects; it segmented the socio-spatial problems in independent units of work (i.e. closed systems thinking and sectoral specialization), and resulted in blueprints (McAdams, 2008; Timmermans, 2012). This technical perspective on planning may seem capable to tackle certain straightforward problems (e.g. building a road, power line or canal, etc.) but quickly raised doubts about its effectiveness to the many planning issues that are actually (at least to a degree) complex.

Nevertheless, when following the reasoning of De Roo (2007), which connects the successive shifts in planning theory to the gradual understanding of complexity's needs, one can certainly acknowledge the progress that has been made in addressing the complex reality. According to De Roo's reasoning, the latest crisis in planning resulted in the 'communicative turn' (Healey, 1992; Innes, 1995), which, bringing new theorists into planning theory (e.g. Habermas, Foucault, Dewey), attempted to respond to a number of stimuli, the 'postmodern critiques of scientific rationalism' included (Harris, 2002: 24). The communicative rationale underlying planning forms such as communicative planning (Forester, 1989), collaborative planning (Healey, 1997) and consensus building (Innes, 1996), is based on the assertion that the interaction among social agents is central to understanding and conducting planning (Innes and Booher, 2014). In contrast to the technical rationale, the focus here is on values rather than on facts: 'the "facts" themselves are socially constructed' and changing along with the participants' re-considerations of 'positions, interests and even values in the course of dialogue' (Innes and Booher, 2014: 4). Thus, uncertainty becomes the starting point of planning since each agent is considered to be a 'black box' leading planners to seek certainty through interpersonal communication (De Roo, 2012).

Scholars, who investigate the integration of complexity's insights into planning, acknowledge the potential of the communicative rationale and its relative forms of planning, first and foremost because they respect the fact that every 'discussant' is an agent and, thus, actually a planner, able to act and influence the evolution of the whole system (Batty and Marshall, 2012; Boonstra and Boelens, 2011; Byrne, 1998, 2003; De Roo, 2010). For instance, Innes and Booher (2010) reflect (mainly) on the social complexity of today's planning issues and discuss the need for 'collaborative rationality' as an alternative to the traditional linear planning model. However, we would like to go beyond such a direct and absolute causality between complexity and the communicative rationale (as did also Allen, 1997; De Roo, 2007; Zellner and Campbell, 2015).

In a recent publication, Zellner and Campbell (2015) called planners to further develop their quantitative and computational skills in addition to negotiation and communication as they perceive complexity sciences to be an 'extension and technologically-assisted enhancement of communicative action' (p. 472).[9] From this perspective, the focus is on using simulations for deeper understanding of the complex problem, of the interventions' cross-scale effects, and of the proposed solutions' robustness to support collective decisions and promote the negotiations. Expect from the 'embodiment of present knowledge' the simulations constitute also 'stimuli for learning' setting the planner more free in a virtual learning-by-doing adaptive process (Allen, 2001; Walker et al., 2013). Although we consider Zellner and Campbell (2015) to raise an important point on the complexity sciences' function within planning, we still miss some reflection on the broader 'organizational recipes' (Allen, 2001) that will embody such tools and will finally construct planning approaches capable to co-shape complexity as we previously argued for. Hence, instead of seeing complexity sciences as a mere 'extension' and an additional 'tool' of current (communicative) planning approaches, we aim to move a step further and discuss how they enhance the analytical and normative aspects of planning. Thus, taking into account research supporting that planning is currently undergoing a crisis and needs to pursue an additional trajectory[10] (Alfasi and Portugali, 2007; De Roo, 2012; Eraydin, 2013; Schoenwandt, 2012), we attempt to put forward aspects of a possible 'complexity turn' and of a subsequent new adaptive rationale (De Roo, 2007).

The adaptive rationale

De Roo (2007, 2012) describes the evolution of planning theory through the evolution of systems thinking and, more specifically, he attributes each planning rationale to the different classes of systems as identified by Kauffman (1993). According to De Roo's (2007, 2012) argumentation, the technical and communicative rationales could be perceived as the two ends of the planning rationales' evolution: the first end refers to the so-called closed systems, high degree of certainty and an object-oriented perspective based on facts; the second end refers to very complex or chaotic systems, high degree of uncertainty and an inter-subjective perspective based on values. Following our analysis in this article and further elaborating on De Roo (2007, 2012) and Boelens and De Roo (2014), a rationale aiming to address complex planning problems (i.e. complex adaptive systems that are characterized both by uncertainty and certain known behavioural patterns) should probably be positioned in a dynamic space in between these two ends,

nourishing from both of them. As implied by the dynamic space, this non-linear or adaptive rationale (De Roo, 2007) calls adaptive planning to co-evolve with the spatial processes as an integral element in their dynamics. In this regard, the adaptability in the adaptive rationale formulates a both responsive and proactive integrated strategy constructed by a number of individual spatiotemporal planning solutions that aim to address specific situations and are especially concerned with the circumstances with which the object of planning might co-evolve (Boelens and De Roo, 2014).

Such a description of the adaptive rationale should not be misunderstood as an attempt to unify the technical and communicative planning rationales, satisfy the different proponents, and, subsequently, establish the adaptive rationale as a meta-rationale in planning theory. Instead, it should be regarded as an opportunity to bring up new debates, as well as to give more room to some already existing but somehow hidden discussions in planning when considering its future evolution. In this respect, the following important issue comes up: considering the position attributed to the adaptive rationale within planning theory, a main characteristic of the adaptive rationale could be the revision of the role of the planner and of his or her (scientific) knowledge in the planning process. More specifically, the adaptive rationale we argue for brings the discussion on the approach to science within planning, a discussion that had been crowded out by the communicative turn, to the forefront, and calls for facts and values in a dialectic relationship.

In fact, while the communicative generation in planning has been mostly engaged with the 'short-term success of public deliberations' (i.e. procedural fairness, inclusion and convergence towards consensus), the substantive success of the same planning processes has not been always ensured by a fair collective process alone (Innes and Booher, 2014; Zellner and Campbell, 2015: 460). Thus, the adaptive rationale could assist especially with substantive issues for which the 'discursive problem-solving skills' do not seem sufficient such as scalability, multiple forms of knowledge, highly technical information, cumulative impacts and unintended consequences (Zellner and Campbell, 2015). This also means that the planner's role is upgraded and from a mere facilitator and mediator, as often seen from a communicative perspective, he or she is acting (also) as a scientist (not an expert) capable to navigate amid uncertainties (Zandvoort et al., 2018) and work deliberatively within imperfections (Funtowicz, 2006) to produce and/or manage changes (De Roo, 2012).

Adaptive planning and post-normal science for sustainability

Considering the characteristics we have attributed to the adaptive rationale, we argue here that adaptive planning can fruitfully be based on the post-normal approaches to science (Funtowicz and Ravetz, 1993). The post-normal science concept has been developed in contrast to Kuhn's (1962) 'normal science', underpinned by positivist philosophy, where 'uncertainties are managed automatically, values are unspoken, and foundational problems unheard of', as well as alternatively to the nihilistic response of post-modernity (Funtowicz and Ravetz, 1993: 740). It refers to issue-driven knowledge production marked by high decision stakes and extreme epistemological and ethical uncertainties, where the priority is to achieve quality in relation to outcome rather than a single truth (Frame and Brown, 2008; Funtowicz and Ravetz, 1993). As Funtowicz and Ravetz

(1993) mention, post-normal science should be seen as a societal problem-solving strategy that partly draws on normal science, which however is no longer sufficient. Such an acknowledgement does not seek to undermine the importance of scientific research but to enrich it with the engagement of non-scientists and their own bodies of relevant legitimated facts and perceptions informed by diverse values and normative standpoints (Frame and Brown, 2008).

In this article, we have in fact followed a post-normal understanding of complexity sciences to explore their contribution to planning and it is this post-normal approach that builds the characteristics of adaptive planning. As mentioned earlier, the adaptive rationale to planning integrates the technical 'facts' with the communicative 'values' and calls them in a dialectic relationship within its epistemology. The reference to the 'dialectic relationship' is important since it implies an equal and issue-driven relationship between the two that will need to guide each other for the building of planning mechanisms, which, despite their inefficiencies, will be the most effective possible. In other words, there will be cases when the facts will dominate over the values and will guide or 'frame' the adaptive planning's content and process (e.g. when exact ecological tipping points have been identified), and cases when the high level of uncertainty, along the high decision stakes, will determine value commitments as 'hard' inputs, decisive for the setting of adaptive planning (e.g. when mitigating the effects of a possible sea-level rise) (Funtowicz and Ravetz, 1993).

Along with facts and values, the post-normal approach to complexity sciences includes ethics as well. As mentioned earlier in this article, the 'neutrality' of complexity sciences' concepts is not any more relevant as these expand the scope of their concerns. Thus, the aforementioned 'how can such a CAS be (deliberately) led towards a well-adapted state?' is immediately complemented by subsequent inquiries concerning 'how to define a well-adapted state' and 'for whom will this be a well-adaptive state', which are inquiries of strong ethical dimensions and will determine aspects of the adaptive planning. Considering that the complexity sciences and adaptive planning are expected to assist especially with planning issues related to the various unsustainabilities brought by the Anthropocene, we can agree that today there is enough evidence to suggest the need of planning approaches that will focus on the welfare of new stakeholders and new forms of equity among future generations, other species and entities, and the planetary environment in a global scale. In other words, there is enough evidence to suggest the need for planning approaches that will focus on normative sustainability. Thus, adaptive planning seems to demand an inherent normative sustainability stance within its epistemology, nourished by post-normal science and recently emerged, broadly controversial yet highly influential concepts related to the era of the Anthropocene such as the 'planetary boundaries', in order to be effective.

Conclusion

In this article, we integrated aspects of the complexity-planning relationship dispersedly found in the literature in order to build up our argument on evidence and characteristics of a systematic 'complexity turn' in planning. We conceptualized this complexity turn through the adaptive rationale; an additional normative and analytical trajectory in

planning theory that has yet to be defined. To contribute to the definition of the adaptive rationale and its operationalization, we argued for an adaptive planning with inherent normative sustainability stance within its epistemology, based on the post-normal approaches to science. Such a perspective on adaptive planning seems suitable for tackling the current complex, situation-specific as well as global, planning problems. The discussed adaptive planning approaches imply a (complex) planning system capable to be tuned with the complex planning issues – a task planning theory up to recently overlooked for not considering it a real scientific question[11]. Perceiving the use of space in some respects as a common-pool resource, the engagement of planning theory with the abundant literature of adaptive governance focused on natural resource management (i.e. governance system requiring structure of nested institutions and institutional diversity at the local, regional and state levels, connected by formal and informal social networks) seems both necessary and inevitable.

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Notes

1. We acknowledge that in specialized language the 'city' has been proven difficult to define. At this point of the article, the 'city' refers to the common imageries created when the term is used in everyday language (e.g. densely inhabited territorial entity) and will be re-defined later through a complex adaptive systems (CAS) perspective.
2. The accessibility space is being formed by the numerous constraints that restrict societal development. The total range of theoretical future development trajectories of a system is being restricted to a potentially accessible set of alternative states due to usually robust factors such as the laws of nature and the role of evolution (Bossel, 1999).
3. Adaptation in the context of human dimensions of global change usually refers to a process, action or outcome in a system (household, community, group, sector, region, country) in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity. (Smit and Wandel, 2006: 282). According to the degree of adjustment or change required from the original system there can be many levels of urban adaptation and thus there is also the possibility of transformation as a deep adaptation or else a 'substantial adaptation' (Smit and Wandel, 2006: 288).
4. We perceive spatial planning as a hybrid of social sciences, natural sciences and engineering. When using the 'spatial sciences' term we refer to Geography, Urban Studies, Environmental Planning, Architectural Engineering, Geospatial Engineering and so on but it is spatial planning that we have mainly in mind.
5. Approaches of complexity in the social sciences can be found even before the 1990s. However, both Urry (2005) and Castellani (2014) agree that the actual, more evident and robust social research on complexity took place in the late 1990s.
6. See the analogy Portugali (2012) draws between 'the two cultures of science' and 'the two cultures of cities'.
7. An analysis of these achievements is beyond the scope of this article; see Portugali (2012: 48).
8. It is important to note that we acknowledge that planning has generally worked in a complexity

frame (Byrne, 2003; McAdams, 2008). However, in this article, we argue for a more conscious application of complexity's insights in planning.

9. Zellner and Campbell (2015) are explicit both about the importance of complex systems reasoning over the optimization of software or modelling codes and about the differences of their proposal from the previous (false) quest for comprehensive urban modelling.
10. Supporting that there should not be the expectation to articulate a singular stance towards theories and methods in planning (Zellner and Campbell, 2015), the 'additional trajectory' does not aim to replace the known so far planning trajectories but to add in planning's toolkit in order to better address certain complex issues.
11. Portugali (2011a) is an exception, having engaged with the question of a planning system not based on certainties and predictability, introducing the concept of the 'self-planned city' and the process of 'planning hermeneutics', which is an actual adaptive planning system.

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Helene Haniotou is presently an Associate Professor at the Department of Urban and Regional Planning, School of Architecture, NTUA. She has started her career as an architect and urban designer in Athens, in 1983, and won several first prizes in national competitions. Between 1989 and 1992, she has worked at the European commission as a consultant at DG 11 (Environment and civil protection). In 1996, she obtained her Doctorate in Geography at the University of Strasbourg and started working as a researcher then Maître-assistant associé at the School of Architecture (Ecole Nationale Supérieure d'Architecture de Strasbourg) and the Faculty of Geography and Regional Planning in Strasbourg. Since 2009, she is working with the NTUA (Assistant Professor, then, since 2015, Associate Professor) and since 2013 she is the director of the laboratory of Urban Design, supervising diploma dissertations and projects as well as PhDs.

Constanza Parra, Assistant Professor at the University of Leuven, is an environmental social scientist with inter and transdisciplinary interests in the ways societies relate to the natural environment and deal with contemporary sustainability challenges. Since 2014, she has worked at the Division of Geopgraphy, Department of Earth and Environmental Sciences at the University of Leuven. Before moving to Belgium, she was a Rosalind Franklin Fellow at the University of Groningen, The Netherlands, and an AFR/Marie Curie postdoctoral fellow at the University of Luxembourg. Her research focuses on social sustainability, social innovation, nature-culture nexus, environmental justice and governance of socio-ecological systems. Ongoing projects cover themes such as protected areas and biodiversity conservation, disasters, ecotourism, food, land grabbing and the rebuilding of the commons.