Self-organization and Spatial Planning

The foundations, the challenge, the constraints and the consequences

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Draft

1. Does self-organization matter to planning?

Spatial Planning and self-organization: A perhaps somewhat unexpected combination of these two themes, one being a collective manifestation of intent , the other representing a spontaneous ph Nevertheless this combination is recently getting serious attention by the planning community. There are a few empirical incentives such as the spontaneous but devastating global housing, mortgage and financial crisis which are a challenge since 2008 to critically assess traditional practices and to develop alternative strategies. The repeating failures of large planning projects are another trigger. These projects cannot be treated as isolated activities, as the planning community is confronted with a highly interconnected world which evolves through unprecedented non-linear chains of causes and effects. There is a growing awareness of a world beyond the planners control, evolving in various This abstract notion of our world developing non-linearly is an incentive to explore further emerging theories addressing complexity, non-linearity, adaptivity, co-evolution, transition and self-organization.

Notwithstanding the recent interest, the world in which planners operate in has always had self-organizing processes. These processes were around in the traditional, coordinative era of command-and-control policy making and in the controlled reality of technical and functional planning. Also in the communicative era of planning and policy making processes of self-organization are very much there. These processes were not seen, were taken for granted, never got much attention and therefore never became part of mainstream planning. They were just there and did not relate much to the planners language of control, regulation and rationality or the planner s drive to reach consensus and a shared responsibility.

Therefore the question is: Does self-organization matter in understanding spatial development processes and will it be in support of the planner to address a world which is progressing beyond our control?

Here we take the stand processes of self-organization do matter and are relevant to planning. We consider the understanding of these processes to be supportive to an understanding of a reality which evolves spontaneously and autonomously from humans intent, their purposeful actions and control and their desire for consensus. At this very moment these processes are hardly understood. In this contribution we aim for a better understanding of self-organization combining planning thought with reasoning within the various disciplines which too relate to self-organizing processes and with theoretical arguments such

as those from the complexity sciences. This is the route we are willing to take, exploring characteristics and mechanisms of self-organization and how these can be seen in relationship to the planners de theory and practice.

2. What if assumptions fail?

Quite some planners were showing interest in non-linear processes way before 2008 and the crash of the housing, mortgage and financial market. Nevertheless the crash of the various markets made non-linear processes very explicit and hard to ignore. The credit crisis proved to be a major challenge affecting our political and socio-economic systems fundamentally. A lack of critical assessments, feedbacks and mechanisms of corrections of regulatory governmental and economic systems came into the light. The systems that were there failed completely. With it the idea fell apart of humans being in control. No one at that time had a clue what caused the crisis, what route it would follow, and who or what would be affected. It meant a complete blank about how to adjust, structure and regulate the situation after the crash.

Control and regulation are to the planning discipline what certainty and predictability are to disciplines having a traditional, reductionist and neo-positivist orientation. This orientation is also very much influential within the planning discipline, despite the idea of control and regulation being heavily criticized. And it would be wrong to take these traditional approaches to planning and their technical rational as dated or outdated. But instead of being valid for any kind of situation we argue the traditional approaches are relevant under particular conditions: in stable situations where straightforwardness, stability and certainty reign.

Planning has emerged towards a level of understanding through which the world is seen as differentiated, with approaches and strategies which are not just generic but are situation specific too. And therefore there is more to planning than control and regulation. Alternative, interpretative approaches have been around now for two decades. The unexpected crash of the various markets is supportive to even more alternative and competing approaches, fuelling kinds of reasoning which refer to the idea of a world evolving along in a non-linear, spontaneous and autonomous way.

Planners interest in the non-linear connects with a world that is fluid, fuzzy, and in a continuous process of discontinuous change including those processed we could call self-organization. Self-organization as a mechanism is quickly becoming a popular issue. Is it that self-organization is seen as the cure to all the pain society is confronted with? Self-organization being synonymous to problem solvi and self-regulation ? Of course it isn t. Could it that be self-organization is felt to be an expression hope or promise, comparable to notions like self-made and self-supporting ? Again organization is also not to be mistaken for a political agenda, such as neo-liberalism and its emphasis on the individual taking opportunities by its self .

A danger of fastly appearing popular notions is these being easily claimed by a wider community not willing to invest much in understanding its deeper meaning. This wider community is likely to give meaning to these notions making reference to them with a common, traditional or intuïtive understanding. Remember how such a mechanism made sustainability meaningless. Compactness is anoth

notion, stressing the importance of dense and multifunctional space, and in the past being praised as a route to a sustainable urban future, nowadays having lost its meaning with everyone using it to its own desires. And its assumptions remain by and large unproven. While spatial quality goes back to Vitruvius and his quality concept of functionality (utilitas), sustainability (firmitas) and beauty (venustas) being complementary to each other, it is another notion relevant to planning having lost most of its specificities due to the overarching power of common language and the one-sided attention by experts on functionality. How than to consider the notion self-organization ?

3. A semantic exploration

Self-organization is obviously a combination of two words each having specific meanings by themselves, independently from the other. When seen jointly, self and organization do not necessarily have intrinsic fit or meaning together, or logically add up to an integrated or synthesized understanding. There is no common denominator giving a clear meaning to self-organization . Self could my own identity (being my-self and knowing my-self), as in self-reflexive, self-assuring and self-made. According to this line of reasoning self-organization would refer to the organization s own identity, for example a self-made organization. This would have been supportive to Rousseau s philosophy (1712-1778), emphasizing the authenticity or uniqueness being a quality of importance for a self , an entity or an organization. This reasoning of an authentic self considers the organization as such, independent from a context. Some do define self-organization in this way: a process through which the organisation of initiatives, including the rules and responsibilities related to them, enfolds without intervention of an authority (Huygen, Van Marissing en Boutellier, 2012). This however is not how self-organization is being understood as a non-linear phenomenon.

Self could represent how it is , in the sense of being . This sense of b requires an object-orientation which can only work with an observer being present. From t point of view the self is subject to experiencing the world around him by himself t thoughts and ideas. The self is in this respect an observer experiencing his env conscious of him self . Some define self-organization accordingly, for example as a kind of social entrepreneurship with specific characteristics: intrinsic motivation, coherence with the surroundings through connectivity and fine tuning, autonomy and creativity (Wmo Kenniscahier 18, http://www.verwey-jonker.nl/participatie/publicaties/zorg/condities_ voor_zelforganisatie). The observer is also conscious of himself in response to his environment, not as a given but through interpretation. This self-awareness in the sense of being relates to how we consider ourselves and as being organized.

Descartes was among the very first to reason what self-organization could stand for, arguing that universal laws of nature represent the ordered production of organization. And how right he was! Consider a reality not responding to the order dictated by the universal laws of nature, a reality not being perfect, orderly or ideal. It could be an argument to interfere, to re-install the order according to the universal laws. Purposeful adjustments are in such cases meant to create a well-functioning environment.

It would mean a proposed route to reaching an orderly, perfect, ultimate, utopian or ideal outcome. This concept in which reality is supposed to reclaim its original state might seem traditional and out-dated, but surprisingly it isn t as it is currently going through a revival. This revival strongly relates to one particular type of resilience, a notion which gets loads of attention these days. While the idea of adjustment is crucial to self-organization, which we will discus below, the emphasis on being is substantially in contrast with self-organization as a non-linear process.

Self-organization as a non-linear process relates most of all to becoming (Prigogine, 1980; De Roo, 2012; Hillier, 2012). Self could refer to a chain of events which does start somewhe triggering various connected entities, situations or systems, resulting in a sequence of moves, activities and changes, sometimes self-replicating, sometimes triggering ad random effects along the chain of events, and all this seemingly unorganized. In a process of becoming self could be considered as effortless , without any attempt , going smoothly or spontaneous .

The notion organization originates from the concept of organs (and the Greek word or Organs , organized and organization do come up easily when considering the meanings of se such self-organization could be seen as a pleonasm. Organs refer first of all to an environ is biological. An organ has a specific function as part of a wider structure, th considered a metaphor for a system which is well structured in a mutually responsive way with all its parts. Kant (1790) has been arguing such processes are both means and ends. Organs are able to behave as if these have a mind of their own. Organs are not just all essential parts to and connected with a wider whole. They do show to some extend the flexibility to expand with and to adjust to the way the wider whole is developing, and are able to absorb negative impacts to a threshold before giving up. Despite all this, organs are structured a-priori, and show no patterns which are the result of self-organization as a non-linear process.

The notions organized and organization are first of all social constructs. The notion organization stresses an environment which is institutionally structured to allow agents, as parts of the organization, to aim collectively for a collective result based on collective actions. Herbert (1963) considers an organization to be a whole of parts in relatedness, of things and events in a r spatial and temporal relationships , being organized on the basis of a certain structure to end (Herbert, 1963, p. 200). Organization relates therefore to institutionally pre-arranged collective intentions. And that is contradicting with what we consider self-organization to be.

The self in self-organization as a non-linear process is not so much referring to m it is or to being . It relates more to by itself and to spontaneous . The or organization is neither pre-arranged nor intentional. Instead it refers to a pattern being the consequence of an unintended collective result. Cilliers defines self-organization as a property of (complex syste which enables them to develop or change internal structure spontaneously and adapt in order to cope with, or manipulate, their environment (Cilliers, 1998, in McDonalds, 2009: p. 460). Therefore organization is not a process aiming a-priori for a particular goal from within as an organizatio do. Self-organization is above all emphasizing a situation without organization a-priori , without organization , without purposeful behaviour or without intent . Consequently se

to a seemingly non-existing collective of disordered parts being triggered to an effort or move through which patterns emerge as a *collective result*. Self-organization stands for a spontaneous result w seemingly looks organized: A pattern that is becoming visible, which is seen by agents as something to respond to, therefore becoming a trigger for further action, out of which consequences emerge.

An organization has a strong goal orientation, which can be represented by a spectrum of options: It could be the organization is meant to maintain or to be supportive to something outside the organization or is meant to reach a new state of affairs. And in all situations the organization is linked to an external environment. The organization is doing its actions purposefully, intentional, with an internal structure being well informed and being ready to comply with its intended function.

And this is precisely what makes an organization different from self-organization. While an organization is a purposeful entity reaching out to its environment, self-organization is to be seen as an autonomous process triggered by and responsive to its environment. Organizations are prepared for intentional actions. Processes of self-organization are able to enfold without intent if the right conditions are met, allowing structural change to happen. Social systems are organizationally and institutionally conditioned, which doesn t make it easy to recognize processes of self-organization in a environment.

Well known examples of self-organization are the spontaneous emergence of pattern in traffic flows (Kerner, 1998), pedestrian movement (Helbing et al. 2001), bird flocking (Hemelrijk & Hildenbrandt, 2012), school of fishes (Camazine, et al., 2003), and a lot more. To what extent all these spontaneous patterns do emerge without pre-informed behaviour is not always easy to say. Traffic flows and pedestrian movement do have in common culturally informed agents. Also self-organization in trail-tracking and wall-building by ant colonies is not entirely without intent and undetermined, as mechanisms of sustained information are responsible for a kind of swarm intelligence (Bonabeau et al., 1999). As a result mechanisms of swarm behaviour become visible which include positive and negative feedback in the multiple interactions among the individuals leading to an increase of behaviour modification. However in all these examples there is no clear strategy or programme which determines a predefined and organized outcome.

Self-organization represents a situation that is in a state of becoming while balancing through a context of discontinuous change. While self-organization suggests a situation to be without organization, this will not mean a social system is impassive to self-organizing processes. On the contrary, aside from social systems to be organized for the sake of the organization and the goals are set, we argue social systems could or should also be organized in such a way to have the system prepared and ready for change to happen spontaneously. In those cases the social system or the organization is willing to bend along with the dynamic changes of the environment it is part of. This is sometimes more forfilling than opposing these contextual changes, which is often done to assure a misplaced idea of being in control. To organize a system to be ready for change means we have to consider the conditions of a system to allow responding to processes of self-organizations.

The process of self-organization is spontaneously evolving, giving rise to new structures, patterns or organizations within a system or a network as a result of interactions between elements, parts, agents or actors which are not externally controlled, coordinated or regulated (Nicolis and Prigogine, 1977; Bonabeau et al., 1997; Bak, 1999; Heylighen, 2008). In that respect self-organization is a process creating spontaneous order. And the abstract knowledge about how this process of self-organization evolves could be seen as a theory of spontaneous order. We know initial and contextual conditions are important in these processes, as well as the presence of fluctuations, and the existence of positive and negative feedback loops. These characteristics have been identified within physical, chemical, biological, ecological and social systems. Scientifically self-organisation relates to natural selection and other evolutionary mechanisms (Kello et al., 2010, p.223).

4. What about the invisible hand?

Being organized is subjective to the observer. It is a criterion we lay upon the world we perceive. Observations made to evaluate a situation which is not anthropocentric (for example morphology, cell structures and flocks of birds and fish) bring into the picture parts which are connected with a seemingly well-structured whole. We assume such a structure is a consequence of universal laws, biological programmes or social conventions. The observer would consider these laws, programmes and conventions as intrinsic intent of the system which determines the system s behaviour and th with mechanisms to connect the parts being predefined and laid down in advance. Intent has metaphorical meaning when referring to non-human parts or to agents, with conscious action and purposeful behaviour being absent. These parts have no intent what so ever to step in line or to act according to any law or programme. From their perspective it just happens. Due to an understanding of universa biological programmes or social conventions the observer is nevertheless capable to understand this happening as part of a determined process of change. The understanding of determined change and the Newtonian reasoning supporting this understanding was for several ages so successful it often pushed observations to the side which did not fit well within the Newtonian frame of reference. Not all of these observations were ignored though

Adam Smith proposed already in 1776 the idea of the invisible hand being a self-organizing mechanism within economic systems. Krugman (1996) illustrates the economic consequence of self-organization, which is is something we observe and try to understand, not necessarily something we want (Krugman 1996: p. 5-6). Economics is about what individuals do, and individuals are self-interested. The societal impact of these individuals (the parts) might be disappointing and might even contribute to a crisis, such as the global credit crisis that came up in 2008. In response to an increasing interest in self-organization Krugman reminds us self-organization is not necessarily a process with a positive outcome. This made Hardin to propose his concept of the tragedy of the commons of a higher order to interfere and to set conditions in case individual actions add up to disastrous and destructive consequences for the group (the commons) as a whole.

In modern times the concept of self-organization has been re-introduced through the works of W. Ross Ashby (1947) in cybernetics. Self-organization has been touched upon implicitly in writings on cybernetics by McCulloch and Pitts (Portugali, 2011). Cybernetics has had a strong effect on systems thinking, and system thinking has had a major impact on planning theory. Despite this chain of interests, self-organization did not get much attention in planning theory if at all. Self-organization gained wider attention through the work of Prigogine and Nicolis (1977), introducing dissipative structures and systems.

Dissipative systems are boundary breaking, and adapt and self-organize through their interactions with their environment (Bor, 1990). Dissipative structures (and synonymous to self-organization) within an open system environment and their irreversible mechanisms allow energy, matter and added to these by Eigen (1971) information being exchanged between the system and its environment, triggering the system itself to change. Dissipative systems exist in situations which are out of equilibrium and are therefore not in a stable state. Instead these systems continuously transform, reposition themselves, seeking for best fits, and are gaining, absorbing and passing on energy, matter and information. Systems exist, stay alive and even progress while being out of equilibrium, in a flow (of multiple agents) through which interactions between systems and within systems result in persistent new patterns and transformative effects. Consequently dissipative systems evolve. And Prigogine made us aware of self-organization having a role in the emergence of these transformative patterns (Keller, 2009).

Prigogine s work opened up a wonderful world of non-linear relations, with surprising examples ranging from self-organized Bénard cells (also known as the Rayleigh Bénard convection: Getling, 1998; Koschmieder, 1993) to fractural structured cities (see simulations made by Batty, 2005; Torrens, 2012). Prigogine s work is supported by additional ideas from Hermann Haken (1977) and his theory of synergetics. Humberto Maturana and Fransisco Varela (1974) and their concept of autopoiesis made a susbstantial contribution as well. It contributed to proposals for self-organizing communities (Luhmann, 1984), infrastructure systems and urban networks (Batty and Longley, 1994). All these ideas and concepts are part of the wider notion of complexity and non-linearity, and contribute to or build on the notion of self-organization.

5. From the outside and from within

While Prigonine stresses external interactions, Haken s synergetics (a term he considers more or less synonymous to self-organization, Keller, 2009) explains interactions within the system (Haken, 1977). At system level energy, matter and information is being absorbed, used and transformed, and being passed on, resulting in both stable phases and dynamic phase transitions. Through processes of self-organization among subsystems the system will show an increase of pattern-formation, which we perceive as order .

Maturana and Varela explain how subsystems are capable of reproducing and maintaining themselves introducing their model of autopoiesis. According to Jantsch (1980) autopoietic self-organization would then be the self-maintenance and reproduction of systems, or the inward orientation of social systems that is about self-maintenance, identity forming and stabilization, and reproduction . The focus is on subsystems, which are considered to function more or less autonomously while being

structurally coupled with their contextual environment. Through this process of autopoietic s
organization the system is able to stabilize, to attain an existing structure, to differentiate itself from its environment and maintaining its identiyt in self-referentiality (Luhmann, 1995; Flood, 1999).

It is not that hard to imagine these external, internal and bottom up processes influencing each other and through which the system transforms. These transforming mechanisms are structurally coupling more or less autonomously functioning subsystems and their contextual environment. This gives us a conceptual understanding of our reality existing out of very many layers, with each layer interacting with a higher level, exchanging energy, matter and information, which is digested within the system and it subsequential parts.

Obviously changes in the subsystems, affecting the system as a whole, will have an effect on the system s interactions with higher levels of existence. Perhaps systems at the levels beyond the immediate context of the system within which the process of self-organization was initiated will be triggered. And so on. The idea of the various levels of scale interacting gets evidence across disciplines, and relates to scaling laws . These scaling laws are among the factors conditioning processes This means a system and the processes of self-organization by which the system can be affected, is on all scales sensitive to change. And the mechanisms of self-organization allow systems to progress and to seek best fits with their environment (Kello et al., 2010: 223-224).

The result is a highly connected world of systems which interact with various levels of scale. It is an open world in which structure and function, and in which content and process are not to be seen isolated from their environment. Instead content and process are highly dependent and determined by their context. The world as it is , fixed and stable, can no longer be. How to relate self-organization to all of this?

Self-organization (or dissipative structures, or synergetics) is the product of nonlinear dynamics and stable attractors. In other words, it is the production of stable patterns observed in nonequilibrium systems governed by nonlinear dynamics (Keller, 2009: 17). Self-organiztion is part of and contributes to an alternative, non-linear world view, with processes of emergence and co-evolution, and with adaptive behaviour as a response to external influences. Emergence is crucial in complex adaptive systems not only due to the fact that it links different levels, but also because this creates memory , as the st on a higher level will through feedback loops affect the self-organization of the low level components (McDonalds, 2009). While its contribution is limited to spontaneous pattern formation due to symmetry breaks, self-organization is fundamental in creating spontaneous order and discontinuous change (Kauffman, 1993). Self-organization is a spontaneous creation of some sort of order within a complex adaptive system environment (Heylighen, 2001). And discontinuous change is at the core of non-linearity. A non-linear world view results in a relational understanding of space and time, and all it stands for.

The consequence is we have to consider reality not just as generic or universal, but as situational and specific as well. Such a specific situation is allocated at a particular place on a particular moment in time. And if the conditions are met, at such a particular place on a particular moment in time a spontaneous change might occur, due to a process of self-organization. This view is fundamentally different from a

Cartesian, Newtonian, neo-positivist or modernist perspective. Instead of a one true wor an exciting world, full of options, possibility space and windows of opportunity.

6. The fundamental steps of self-organization

Self-organization is a process, and a rather special one. Self-organization is not intentional, it is autonomous and spontaneous. While being a representative of a non-linear world that is becoming , self-organization is producing new states of being. And that is why self-organization matters. Agents and actors being parts of a system do respond to these new states of being. These new states of being emerge as spontaneous patterns, which are visible everywhere, around us, as part of everyday life.

Self-organization can be understood if we are willing to consider our world not to be static, but to be in a continuous state of discontinuous change. Instead of linear development such a world will evolve non-linearly, including sudden changes, jumps and transformations. Such a non-linear world might be far more common than we re used to think it is. Such a non-linear world is also far more out of our co than we perhaps would like it to be. Within such a world the various parts, agents or actors behave more autonomously than we might have imagined as we re used to see our world highly func planned, full of rules and driven purposefully and intentionally. This might indeed seem to be the case, nevertheless we argue that if we re willing to see spontaneous developments we wil often, and we ll see it everywhere. We dare to state that the world and our developments depent on it. Each and everyone of us behave partially autonomous and without intent, nevertheless contributing to pattern formation ang by being attracted to patterns. Self-organization is an autonomous process, resulting in patterns we understand, we relate to, we have confidence in and act upon.

Self-organization is a spontaneous process, and therefore beyond our control. Despite these characteristics, it doesn t mean it s a process we cannot understand. To begin with, sel situation specific. Social scientists are very much aware of situation specific processes resulting in rather unique events. While rather familiar to the social sciences, the phenomenon of unique events attracted attention of some physicists as well. This forced them to follow an approach which might be somewhat unusual within physics, nevertheless with interesting result which also supports social scientists again, in their struggle coping with non-linear processes of self-organization. Instead of doing research confirming laws of physics the specificities being essential to make self-organization happen are taken into consideration.

In the following we will dig deep to identify the various conditions under which self-organization will take place. We will identify *a set of rules* which help explaining how processes of self-organization do contribute to change and transformative processes. We will see the process of self-organization can be understood as a process being built up out of four essential steps:

- The *first step* is the creation of a symmetry break, a mismatch in an existing situation.
- While this symmetry break is increasing it builds up energy, which eventually will lead to the *second step*: reaching criticality.

- *Step three* is what happens beyond this critical point. Various parts, agents and actors respond individually to the symmetry break or mismatch, all in an effort to reach i effort state or a best fit with its environment.

- While there is no agreement or a collective intent in responding to the symmetry break having reached its critical point, it results nevertheless in a spontaneous pattern formation. This pattern formation is the *fourth and final step* in the process of self-organization: an unintended but collective result.

And this pattern formation will function as an attractor for more agents and actors to becoming part of it or to respond to it, which makes the pattern formation a stepping stone towards developments to come.

And that is why self-organization matters. And consequently it is important to understand more of this process of self-organization, about how it functions, under which conditions, and to what kind of consequences this process might lead to. And relevant questions from a planner s perspective: a to make use of these spontaneous, self-organization processes? And are we able to influence such a process at all? So here we go

Self-organization as a non-linear process relates first of all to structural change, through which a (spatial) pattern emerges by itself . Some use the word spontaneous , some refer say coincidental , in all cases it is an undefined becoming (Boelens and De Roo, 2014) this change by itself is a change in a response to something undefined which has layers, in the context and/or in the past. While self-organization relates to an undefined becoming its cause is undefined as well. But probably the best way to pinpoint the undefined cause of self-organization is a symmetry break within an existing structure.

A symmetry break

Let s imagine first a non-systemic, isomorph environment. Its basic structure would be a collection of parts being positioned in a least effort state. Bak s piles of grain and BØnard s examples, which we will explore more in depth further on in support of our argument. One would expect an isomorphic environment to be in equilibrium. Nevertheless due to an undefined cause parts become dislocated, having been perturbed from their original location, building up tensions around a symmetry break or single-phase interface. This is the beginning of an increasing tension within the existing structure, which comes with high interfacial energy and relatively weak bonding. The break becomes structural, and the preferred spot for the onset of a slide and for the precipitation of a new pattern.

Any kind of self-organization is being initiated somehow, with a symmetry break being pushed beyond its critical point. It might be unclear what the trigger is to this symmetry break: An unknown, undefined, internal or external initiator. While self-organization is considered to be a bottom up approach the initiating factor for a symmetry break to occur (step 1 of self-organization) might very well be contextual. For example a contextual force more or less evenly spread throughout a contextual plain or field triggering not only one particular system but as well its immediate (and perhaps even its wider)

environment, resulting in a planar movement. Such a movement could trigger systems, subsystems and their environment all at once, resulting in a major shift in interdepencies and in shifting balance between structures and their functional meanings.

Vesterby (2008) makes reference of a collision situation : An external movement and initiating internal movement, which triggers the first stages of self-organization. The Bénard cells experiment shows a contextual change which could trigger parts or agents, having an effect throughout the system s or the agent s contextual environment: a plain field of changing cond (1993) calls this weak turbulence) flows through the system, with triggering effects.

Vesterby (2008) qualifies self-organization to be essentially exceptionally simple at it after which it could develop further going through many stages. He made a serious attempt identifying origins of self-organization . Seemingly taking a paradoxal reductionist, mechani approach analysing a situation with spontaneous change, Vesterby s analysis allows us to get a clear understanding of the very beginning of self-organization. At the very beginning the process of self-organization is rather deterministic. In this process it is essential what comes first and what will follow. Crucial in such a process are space, motion and substance, with substance representing not just form (matter, energy) but information as well (Eigen, 1971). In social environments agents respond in particular to information.

Space, motion and substance are essential for seemingly organized structures and patterns to emerge. Space (made explicit by Rayleigh s contextual conditions (Rc)) allows substance to ongoing motion. This substance in motion is constrained by structural criteria depending on the kind of substance. The motion in space contributes to substance s identity as it is anchor and direction. The continuing motion will result in self-referential interactions, which could result in a new status quo. As such it is getting self organized through spatial patterns be certain point on a time-space continuum. In other words: To any observer this self-organized process in space becomes a pattern formation at a particular moment and place, through which this pattern gets identity and congruent structures and functions.

As it might sound all quite abstract, it is nevertheless visible around us. For example tectonic plates moving along each other or pushing one-another up or down, create tensions and frictions which build up energy until the point criticality. This energy being released every so often usually results in hardly noticeable shakes. It can happen the earthquake has a magnitude which is beyond imagination. These shakes are all the result of a symmetry break reaching criticality, sometimes generating destructive powers. A collective of water drops getting beyond a critical point could be the beginning of a flow of water, progressing into a stream, which after some time could become a river which organises itself a route based on physical conditions. The initial stage of Lorenz story of the butt as a process of self-organizing: The butterfly flapping its wings which triggers at a particular moment a chain of air movements varying in pressure, catching up speed and differences in pressure, eventually building up a tremendous force which is being released with a destructive power after a period of time, whipping away anything that s in its way, including houses, villages, towns and mo origin being one bird taking off for whatever reason: The trigger could be internally (an itch) or externally

(the first bird signalling danger, or just being hungry). It does however trigger all others in his vicinity to jump high into the air. And all of them group together while flying away, becoming a flock of birds on the move. Panic for whatever reason starting somewhere within a crowd resulting in a fast move outward, with all individuals being very convinced in what to do without negotiating with or consulting each other.

While these examples are colouring nicely the message of what we understand with a symmetry break, they also represent a world far from Bak s non-systemic, isomorph environment. It means we have to be very conscious about the validity of Bak s findings in a world which is more diverse. examples have in common is the increase of a symmetry break reaching criticality after which a change, a response or an adjustment takes place: The first step in the process of self-organization is a symmetry break.

Reaching the critical point

We consider the occurrence of self-organizing events as a consequence of mismatches or symmetry breaks between the parts of a system. These mismatches or breaks do create tensions and struggle within the system: The structural setting of the parts of the system and their functionality through which these parts contribute to the system no longer have a least effort fit. Instead of linear adjustments these brea accumulate tensions or frictions, with a critical point standing in between order (nothing happens) and chaos (turbulence breaks lose). Any small behaviour at or beyond this critical state could trigger parts of the system, eventually affecting the system as a whole.

Bak and colleagues (1987) studied avalanches in grain piles. They wondered about these piles with numerous avalanches suddenly occurring due to grain being provisioned from above. Avalanches happen the moment a critical point (threshold) has been reached. One would guess a small change would lead to a small shift in the grain pile, while a major change would lead to a massive avalanche. Bak and colleagues found something entirely different. The grain on the pile reaching a critical state shows no correlation between cause and effect. The system self-organizes its internal structure independent of external causes (Portugali, 2000). There is no correlation between the change (a perturbation) and the condition which makes this change happen (details of a perturbation). Dropping another grain onto the pile may cause a massive slide, but it may as well be that hardly anything happens. The avalanches represent a self-organized response to change. In other words: The criticality is self-organized. Bak and colleagues were the first to discover a dynamic system displaying self-organized criticality (Bak, Tang and Wiesenfeld, 1987).

While these outcomes seem fundamental, we have to question them again as they have been deducted from Bak s experiments with grain and its non-systemic, isomorph environment. Again we have to think through the validity of Bak s findings the moment we copy the seemingly fundamental outcomes to a world which is diverse. The Grain Pile case Bak uses in his experiments presents a slightly more complicated situation than the three body problem Pioncaré raised in 1887. The three body problem is about three objects influencing each other (either colliding or attracting) of which we know precisely where they are positioned in space, how much they weigh and what their speed and directions are. While

all data is there it is impossible to describe their future path and positions, as the motion of the three bodies does not proceed according to rules which can be generalized in axioms. The moving bodies are the very beginning of a discussion which resulted in chaos theory. Bak s pile of g multiple body problem. A grain will collide with various other grains, all far from being perfectly round, and all uniquely settled within the pile. With Bak s analysis we shift as well from a Newtonian perspective of ideal situations and ideal science, to real situations and science which has an eye for situation specific conditions (which doesn t mean the result cannot be an ideal ty grains therefore all have multiple friction points, which keeps them in place but do also contribute to the frictions and the criticality. At some point this results in an avalanche of which it is unknown a-priori if it will be a minor one or a big one. The human world is more complicated than Bak s pile of grain multiple categories of agents, all floating around, all interacting, with mismatches everywhere, not building up to one clear moment of criticality. Instead there are plenty, resulting in various avalanches in adjusting behaviour of which it will not always be clear to what cause the a respond to. In the human world a clear cut avalanche or straight forward adjusti necessarily the only result to be expected from a symmetry break reaching its criticality.

Nevertheless criticality is essential in a process of self-organization (Bak, 1999). Self-organization takes place in a system having reached a particular threshold (the criticality of tension, struggle or symmetry break between the parts), after which processes of pattern result is a varying degree of change, from abrupt events (grain pile) to periods of varying turbulence (Bénard cells), affected by contextual conditions (R_c) and structural criteria.

Beyond the threshold: adjusting behaviour

Remarkably, reaching the critical point leads to a period of fundamental uncertainty. It is not possible to identify a-priori outcome of this period of uncertainty. It s a contribution to non-line sublime form. It s the invisible hand all over. It has been in the world of quantum physics that uncertai has been recognized as fundamental. Fundamental uncertainty is also an intrinsic part of self-organization. The context of the system being influenced by self-organization can be influential to the creation of a symmetry break and of reaching the threshold, what follows next in the process of self-organization takes place independently from contextual triggers. Therefore the spontaneous pattern formation (step 4, the end result of self-organization) is not considered to be contextually influenced: the rules s interactions among the system s components are executed using only local information to the global pattern (Camazine et al., 2003: 8).

In other words: With processes of self-organization and their unique and abrupt events we have to accept and to address fundamental uncertainty at the human scale as well. These processes of self-organization have been studied intensely by physicists, resulting in a number of appealing examples. Bak s grain pile is one of them. According to Bak (1999) the out-of-balance critical state will lead to a chain of non-linear, spontaneous events varying in magnitudes. These events are neither regular nor

periodic. These abrupt events could range from small to major adjustments without a linear relationship in the way these events are being triggered.

The study of so-called Bénard cells is another. Bénard (1901) did his famous experiments already in 1900. He investigated a fluid in a dish which he heated from below. The result is surprising. Instead of a vertical upward movement of heat transport also a horizontal layer of convection fluid appears. A rather regular pattern of hexagonal convection cells appears, due to a peculiar mix of buoyance and gravity forces. These cells have become a landmark in the study of nonlinear developments exhibiting self-organization and pattern-formation mechanisms. It is the granddaddy of canonical examples [ ] to study pattern formation and behaviour in spatially extended systems (Newell et al., 1993).

It was Rayleigh (1916) who showed us these convection cells occur only when a critical value R_c has been reached (Ma & Wang, 2007). This $_cR$, or Reynolds number , is a non-dimensional value which relates to contextual conditions (temperature difference, gravity) and structural criteria (viscose of the liquid, thermal diffusivity). It gives expression to fluid motion and heat transfer (Getling, 2008). After R_c has been reached a transforming period of turbulence results in the appearance convection cells. Koschmieder (1993) adds to this the differentiation between weak turbulence and turbulence . By weak turbulence we mean irregular, nonperiodic, time-dependent flow with slow variations with time and slow motions. By turbulent we mean rapidly and randomly varying flow at high Reynolds numbers [$R>R_c$: GdR] with very fast variations with time, relative to the vertical thermal relaxation time (Koschmieder, 1993: 116).

Beyond a critical point self-organization represents the moving of parts, agents or actors seeking balance in new meaningful linkages, adjusting structurally and functionally towards a new state of congruency, consequentially becoming manifest in emerging patterns. Bak (1999) warns us not being biased with a positive attitude towards self-organization (See as well Zhang & De Roo, 2016). All is connected, is the message delivered to us from the complexity sciences. Internal adjusting mechanisms or rearrangements among the parts, agents, or actors of a system could very well be initiated somehow by external interference (sometimes called global information). However this has no effect o formation as such, which is considered essential to the process of self-organization. Randomly related and seemingly chaotic interactions do bifurcate somehow, presenting us with a pattern. In the complexity theorists: a process of autonomous development and the spontaneous emergence of order out of chaos is called self-organisation (Prigogine and Stengers, 1984).

Spontaneous pattern formation

The essence of self-organization is a pattern which results from a spontaneous rearrangement due to a symmetry break. Self-organization means a (structured) change due to undefined responses which trigger adjusting mechanisms: In a non-systemic environment such as a pile of grain or a glass of water its cause is a structure break. In other words, self-organization is considered to be a systemic adjusting effect of structure breaks and structure-function mismatches which comes into effect having reached a threshold.

Self-organization in this respect means a spontaneous adjustment of a structure break, and a better linkage between structure and function, either temporarily or in a more sustained way.

In a systemic environment a mismatch between structure and function might as well be the cause of adjusting mechanisms. In a systemic environment structure and function might find a new balance, different from a past situation, through which both are able to co-evolve. If so, self-organization stands for more than being a self-replicating mechanism, self-similar, self-adjusting, self-repairing or being resilient. The merging of structure and function originates often at a lower, decentralized level through which the system as a whole is being affected. Self-organization represents a responsive situation, linking moving parts and emerging patterns with contextual change, which could result in some sort of new order, at a higher level.

The process of self-organization includes spontaneous pattern formation. The self in self organization refers to spontaneous and to formation, while organization becomes emergence of a pattern. In other words: out of an undefined cause and a non-lineair process a result comes forth which is visible, can be differentiated from placid and chaotic environments, can be given meaning to and gets identity in space and time. In a way spontaneous pattern formation is synonymous to self-organization.

The undefined cause of a symmetry break in a systemic environment could be structure related as well (as in Bak s pile of grain) but could be as well a mismatch between structure mismatch between functions. A systemic environment is in abstraction an environment of nodes being connected with each other through meaningful interactions. These connected nodes are not just structure. These can be seen as functional too. The consequence of this reasoning is quite fundamental: In case of a symmetry break caused by a structure-function or a function-function mismatch, the spontaneous adjustment that might follow could very well be functional without immediate structural consequences. In such a case spontaneous pattern formation will be a secondary outcome.

Systems do well if there is a match between structure and function. This is not a fixed match: For example a family house is a house for a family of a particular size depending on conditions and policy restrictions. A change in culture (due to an increase of migrants for example), in social conditions (children no longer leave their parents house at the age of twe married couple staying in the family home, perhaps due to shortage of houses for starters), and more, a mismatch between structure and function emerges. This mismatch is due to conditions under which structure and function operate, do relate and do have meaning. In other words structure and function, and the system as a whole are conditional, which has consequences for and could trigger self-organizing processes.

Central to self-organization is the (adjusting) response to symmetry breaks and the tensions, frictions and struggles that come with it, resulting into pattern formation. Self-organization could be entirely meaningless, coming and going without any sustainable effect, showing us sudden order a pattern in a chaotic environment. This order can fade away again, but it could as well be the start of a chain of events which affects parts, attracts agents, or matters to the observer, to those affected by it, and

to society as a whole. In that case self-organization will bring sustainable rearrangements among parts, agents or actors under tension. These rearrangements or adjustments would then be an accumulative constructive process, which connects coherently external and internal impulses.

Self-organization is responsible for situation specific, place dependent and unique events taking place. It is therefore a major contribution to uncertainty within social environments. Self-organization as a phenomenon needs in-depth understanding to be able to distinguish it from other processes taking place within the social environment. Identifying the various phases of a process of self-organization contributes to this understanding, and to allow us to identify commonalities and differences with processes of self-organization, not only in a physical environment but as well in a social environment. This brings us back again to spatial planning.

What about spatial planning?

It is widely recognised that the development of urban areas, understood in socio-economic and environmental terms, cannot be planned by government action in a linear way, fro action, to outcome as planned. Even where a government agency controls many of the resources for physical development and acts in an integrated and coordinated way, socio-economic and environmental activities make use of the physical fabric of urban areas in all kinds of ways that are often difficult to imagine in advance, let alone predict. What goes on in urban areas is just too dynamic, mazy (Geddes 1915/1968). Understanding mechanisms of self-organization may therefore support the planner in various ways.

This understanding may be about triggering, influencing, avoiding or even preventing processes of self-organization to happen within the daily environment for the good of society. But above all this understanding will make the planner aware it asks for another attitude than the planner is used to. There is the traditional attitude, in which the planner considers the world to be his creation assuming this to be a factual reality - with the planner being in control. And there is the contemporary position of the planner being responsible to reaching consensus among stakeholders and the construct of an agreed reality. In both cases the planner considers the world as it is , factual, agreed and likely appreciate the existence of non-linear processes of self-organization the world will no longer be , but has to be seen as becoming .

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