Postulates of urban resilient sustainability transitions: a cross-disciplinary approach

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Abstract

Significant steps have been made towards reaching the goal of sustainable development in urban areas in the last two decades, especially in industrialised countries. However, there is still a long way to go in cities to correct key problems regarding socio-economic inequalities, environmental degradation and overconsumption. Cities are facing old and emergent global challenges including demographic growth, ageing and climate change. In this paper we pose the question of whether cities will be able to respond to these challenges with the current management and planning practices. Based on current and future consumption demands of energy, food, space, etc. the aim of this paper is to bring to the fore the notion of "urban resilient sustainability" to answer to questions such as: what is the added value of the idea of urban resilience for urban sustainable development? Furthermore, given the current unsustainable urban trends, how can local transitions to resilient sustainability be stimulated? We attempt to provide some answers based on the fast growing, although highly scattered, conceptual and empirical literature on urban resilience and by paying special attention to the role of urban governance towards sustainability transitions which we argue require the fulfilment of a set of key necessary conditions.

Key words: cities, sustainability, transitions, resilience, governance

1. Introduction

Given the projected rate of urbanization, cities might be facing potentially irreversible impacts (EEA 2009) adding pressure to the flow of ecosystem services from natural systems (Bai et al. 2005). Within the worst scenarios, cities are predicted to significantly increase the global demand for food (50%), water (30%) and energy (73%) by 2030 (IEA 2008; UN 2009). Nevertheless, projections concerning possible futures are diverse and sometimes bring scepticism to the conclusions on research studies based on them. Evidences on global environmental state and the states of cities draw more than a real picture looking at 7billion people on the planet, 50% of them urban, 12% in slums (UN-Habitat 2011; UN 2011), a exponentially growing resource consumption (Krausmann et al. 2009) and average temperature increase (IPCC 2011).

Recognising this pressure and under a business as usual scenario, cities potential irreversible patterns might be recognized when acknowledging projections on global environmental trends especially regarding the scenarios of fossil fuels scarcity (Newman et al. 2009), the potential risk of human settlements due to climatic factors (IPCC 2007), and the degrading urban environmental quality (UN-Habitat 2011).

Following this path, our human urban world will collapse if no measures to correct these trends are implemented regarding models of land-use planning, consumption and management of assets. Although, it should be recognised the past work towards the achievement of sustainable development in cities over the past twenty years in line with a number of the Millennium Development Goals, according to the *Common statement by the UN System Chief Executives Board for Coordination (CEB) on the Outcome of the United Nations Conference on Sustainable Development (Rio+20)* "it is of grave concern, however, that these positive trends have been accompanied by increasing disparities and inequalities, persistent gender inequality, social inequity, a growing deterioration of the environment, and recurrent economic, financial, energy

and food crises". It is evident that we need to stimulate a renewed system-wide effort since we have a long way to correct disparity, inequalities, environmental quality and social inequities.

In this regard, there are many ways in which research can support cities in the transition to more sustainable models leading back our urban patterns, such as with the provision of new operational tools to support long-term decision making (Prasad et al. 2009). Certainly, new frameworks which allow to analyse the complexity of the interdependencies within ecological, social and economical systems across scales and in time are needed in order to forecast unintended effects (Holling 2001; Kinzig et al. 2006).

Under the hypothesis that the process towards urban sustainability consist on a combination of encompassing transitions as a response to natural resources scarcity and climate change (Kemp et al. 2011), this paper shows how the theory of resilience is a promising framework to conceptualize and develop tools to plan and manage urban sustainability transitions, as it provides a long-term perspective and is based on the three key concepts of learning, adaptation and transformation (Walker et al. 2004b; Folke et al. 2010).

2. Resilience, sustainability and transitions in the urban context

Here forth, we define city (or urban area) as the social community network comprised by citizens, associations and organizations, companies, governance institutions and service providers plus the network of natural and built infrastructural elements and the flows of energy, matter and information derived from their interdependencies. As the challenges and targets regarding sustainability in cities are context-dependant, in this paper we would like to address the problematic in ordinary medium size cities where capacity for intervention could be limited (e.g. due to rigid governance structures, resources dependency, social disarrange, strong historically unsustainable patterns, geographic and spatial restrictions) and a change in technological, social and economic patterns is needed to jointly face resource scarcity constraints, population demands and climate change.

In the recent literature, the resilience of socio-ecological systems is defined as the system's capacity to absorb disturbance and self-organize while undergoing change and still retaining essentially the same function, structure, identity, and feedbacks (Walker et al. 2004b). This involves processes of learning and adapting in order to create opportunities of transformation to more desirable states in view of potential shifts. In this context urban resilience is an attribute of urban systems that require the adaptive management in the face of uncertainty and surprise (Resilience Alliance 2007) and the capacity to take positive opportunities that change may bring about (Berkes et al. 1998; Barnett 2001) while reducing the vulnerability to such changes (Folke et al. 2002b; Folke et al. 2002a; Resilience Alliance 2007).

Coupled human-ecological systems, such as cities, are complex (Holling 2001; Berkes et al. 2003; Liu et al. 2007b) and as a result, modelling such systems and using that information to govern and manage them is a complex undertaking. Moreover, one may see cities as inherently unsustainable (UNU/IAS 2003; Bermejo 2008) because the impacts they cause on the environment are not only negative to the ecosystems but to the life path of cities too (Fischer-Kowalski 2011). Certainly, negative impacts over environment are producing serious consequences for human livelihoods, vulnerability, and security (UN-Habitat 2011). This line of thought suggests that a resilient city would imply it being an insatiable resource consuming machine and might question the need for a resilience theory applied to the urban systems. However, the resilience theory acknowledges that there might be resilient undesirable states and unintended transitions to those states should be avoided. Cities follow the non-equilibrium view of resilience (Pickett et al. 2004) which is the ability to adapt and adjust to changing internal or external processes. This view of resilience is not only possible but imperative when calling for urban sustainability transition as it allows the dynamism an evolution angle that urban planning and design requires.

Currently, the risks related to unplanned population growth, climate change and resource scarcity have become significant for most cities and its impacts already experienced for many

others (Bai et al. 2005; UN-Habitat 2011). Due to the growing concentration of people in cities, they are largely the most exposed systems. Cities are the very paradox of sustainability since, as hubs of development, many of them are located in the most vulnerable areas to natural disasters (estuaries, coastlines ...) and at the same time, concentrate the mayor impacts on the environment due to the unintended consequences over the environment that the human activity creates. In truth, cities are the key to the promotion of global sustainability (UNU/IAS 2003; Ahern 2011; Romero-Lankao et al. 2011).

The static view of urban sustainable has phased out as sustainable urban development policies establish rigid targets and do not contemplate the possibility of surprises or external factors unbalancing the parameters of the system, nor promote research to cope with them. The search for sustainability in cities needs social innovation and transformation (Lee 2006) involving policy making which acknowledges the non-equilibrium view of cities (Pickett et al. 2004; Ahern 2011) through adaptive management. Urban sustainability thus derives from enhancing urban resilience. As Holling (2001) pointed out in a broader context, “sustainability is the capacity to create, test, and maintain adaptive capability, whereas development is the process of creating, testing, and maintaining opportunity”. It follows that ‘sustainable development’ ought to be understood as the development which fosters adaptive capabilities and creates opportunities to maintain prosperous (desirable) social, economic, and ecological systems (Holling 2001; Folke et al. 2002b; Folke et al. 2002a). We take this idea to expand the notion of “Urban Resilient Sustainability (URS henceforth)” understood as the long-term urban sustainability which guarantees the provision of ecosystem services and satisfies needs for the future generations (Leichenko 2011).

If we take a sustainable state as the desirable one, the idea of URS implies supporting cities to face, resist, adapt to changes as an opportunity of transition to a more sustainable state.

URS should be stimulated by ways of urban governance which explores the consequences and acknowledges risks and surprises thus departing from a static and deterministic idea of urban sustainability.

Despite the growing attraction of resilience thinking to policy making mainly by the concept of learning by doing (Evans 2011), policy towards URS ought to focus on promoting knowledge, diversity, flexibility, innovation, robustness, etc. so that once the added value of urban resilience approach is demonstrated, the probability of getting resources to (self) organize the system and make it sustainable would be higher (Ostrom 2009).

This section has argued how resilience thinking can provide cities of a vision about their desirable transition pathways. That is, as above-mentioned, such transformations should promote self-knowledge, adaptation and innovation in order to guarantee economic wealth, quality of life and environmental quality. However, at this point, resilience theory does not provide cities with a framework on how to identify and govern transitions.

In this regard, this paper also acknowledges that socio-technical transitions research and the Multi-Level Perspective (MLP) (Geels 2004; Geels 2010, 2011b) can be used to understand and further approach this need. As argued by Hodson and Marvin (2010), the adaptation of this approach to cities is an unexplored research line which, although seen as promising, needs of empirical studies, requires tools to manage uncertainty in future envisioning and also calls for an identification of capacity requisites to mobilise the resources needed to promote transitions.

The benefit of a multidisciplinary approach to urban transitions is obvious, which initially departs from the integration of different economic, social and ecological goals within sustainable policies. As such, this paper focuses on sustainability and resilience on one hand, and the integration of these with the socio-technical transitions theory in order to provide the insights of the role of governance and society and production and consumption drivers in innovation and technology, and the need to address particular contexts, such as those in cities, from a multi-scale approach.

In this paper we attempt to provide some answers based on the fast growing, although highly scattered, conceptual and empirical literature on urban resilience and by paying special attention to the role of urban governance towards sustainability transitions which we argue require the fulfilment of a set of key necessary conditions. In this line, this paper is structured in three sections. The first section uses an analytical method (resilience of what to what) to analyse so far the cross-disciplinary contributions to the emergent urban resilience framework and, based on the results, it identifies key aspects which can be applicable in cities' management and planning. The second section uses this information to build a rationale framework to plan urban transitions to resilient sustainability engaging also the existing literature regarding socio-technical transitions principles and its use in urban contexts. Finally the last section sets out the key conclusions of the paper.

3. Providing a shared approach: urban resilience of what to what

There exists a rather abstract understanding of the concept of urban resilience. According to the Resilience Alliance (2007), urban resilience focuses on how much and which kinds of disturbances urban areas can absorb without shifting to alternative less desirable regimes. Among other assumptions it is key to realize that cities are highly dependent, open systems which means that the resilience of cities is contingent on the resilience of other places in accordance to the 'systems of cities' idea of Ernstson et al (2010) and that a flexible efficiency in the use of resources is beneficial if rigidity of the system is avoided (Carpenter et al. 2008). This approach understands urban resilience as the balance of urban and ecological functions (Alberti et al. 2004) following the MEA (Millennium Ecosystem Assessment) approach (MEA 2005; TEEB 2008), by stressing the role of metabolic flows in sustaining urban functions human well-being and quality of life. It also stresses the importance of governance networks and "the ability of society to learn, adapt and reorganise to meet urban challenges and the social dynamics of people […] and their relationship with the built environment which defines the physical patterns of urban form" (Resilience Alliance 2007).

There have been multiple applications of the ecological resilience theory to urban areas although each of them tend to vary depending on the space and time boundaries for the resilience phenomena being analysed (Pendall et al. 2010). It is thus important to understand the "resilience of what to what" (as suggested by Carpenter et al. 2001).

The following table shows a list of the recommended references from the wide extent of literature reviewed. The table analyses each contribution following a scheme of *resilience of what to what*.

Table 1 Key contributions to urban resilience thinking

RESILIENCE *OF* WHAT in cities?	**RESILIENCE *TO* WHAT in cities?**				
	Unpredictable shifts		**Gradual changes (slow variables):**		
	Natural and Man-made disasters	Socio-Economic Crisis	Climate change	Resource scarcity	**GENERAL** (no specific disturbance)
Built infrastructure	(Coaffee 2008) (Bertolini 2007) (Campanella 2006)			(Coaffee 2008)	(Coaffee 2008)
Urban Ecosystems				(Alberti et al. 2004)	(Alberti et al. 2004) (Colding 2007) (Elmqvist et al. 2003)
Communities/society	(Cutter et al. 2008) (Rose 2011) (Wallace et al. 2007) (Wallace et al. 2008)	(Allenby et al. 2005) (Rose 2011)		(Muller 2007)	
Urban Planning			(Wardekker et al. 2009)		(Pickett et al. 2004) (Garcia et al. 2011)
Governance	(Wallace et al. 2008)		(Ayers 2009) (Tanner et al. 2009)	(Newman et al. 2009)	(Evans 2011)
SYSTEMIC approach			(Newman et al. 2009) (Leichenko 2011)	(Newman et al. 2009)	(Ernstson et al. 2010)

Note: There are many other contributions but only the key ones as from the perspective of the authors have been included. Furthermore, only case studies or approaches focused to problem solving in cities have been included in this table. There is still literature which methods, although focused on resilience at upper scales, could be also used and/or adapted to the urban scale.

3.1 Resilience of what in cities

From the literature review, we find five areas covered by the contributions of resilience *of what* in cities. These areas can be seen as inter-related networks inside the city. These are:

1 - Community, which encompasses the analysis of the resilience of society and citizens to shifts in the services being provided to the city. The literature covers a wide range of aspects when analysing this so-called social resilience understood as the ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change (see Adger 2000). Social fabric related issues such as education, social cohesion, participation, health, and quality of life are tackled.

2- Governance/Institutional structures, which deals with the analysis of the resilience of the urban governance system to changes which affect the way of management and distribution of services within the city. Research on resilience of the governance systems is directed to the study of concepts such as capacity self-organization, adaptive capacity and learning (see Lebel et al. 2006) which provide the abilities to manage and support the overall resilience of the city.

3- Urban ecosystems, which deals with the analysis of resilience of urban ecosystems when facing disturbances which generate poor environmental quality, resources scarcity, loose of biodiversity which affect ecosystem services in cities (see Alberti et al. 2004).

4- Urban Planning encompasses the analysis of the resilience of current city planning models to disturbances due to economic, environmental or social factors. This area of research deals with the study of planning instruments, design strategies, responsible stakeholders, planning drivers and different agents' interests and also, historical models of planning which influence in current trends. There are different complementary approaches to this area of analysis, but commonly, it could be understood as the resilience of urban planning and design to meet in combination sustainability and security standards (see Coaffee 2008).

5- Built infrastructure deals with the analysis of specific resilience of private and public buildings and infrastructures related to transport, water, energy and waste. This area is the most related with the concept of engineering resilience which is understood as the measure of the rate at which a system approaches steady state following a perturbation, also measured as the inverse of return time (see Holling 1986). It deals with resistance and recovering issues.

These five co-nested areas can be analysed in isolation or combination. However, resilience would be ideally achieved from a holistic approach having in mind sustainability goals which call for the integration of economy, society and environmental needs and additionally, taking into account that resilience is sensitive to the choice of scale and to the resilience of adjacent systems, as previously argued.

3.2 Resilience to what in cities

The resilience of a city, as any other socio-ecological system, is influenced by the states, interactions and dynamics of key variables at scales above and below the scale of interest (Kinzig et al. 2006; Walker et al. 2006), theory developed by the concept of *panarchy* within the theory of resilience (see Gunderson et al. 2002; Holling et al. 2002). These key variables not only operate at different scales in space (at smaller or larger scales) but also in time (at slower or faster rates). Managers tend to focus just on fast variables and overlooked the slow dynamics of key parameters (Walker et al. 2006). Controlling both types of variables is fundamental to manage resilience of socio-ecological systems, such as cities.

On one hand we have evidence that, urbanization has a key role in climate change and carbon emissions which derive in a direct relation to global environmental change (Romero-Lankao et al. 2011; UN-Habitat 2011). At the same time, urbanization and resource extraction derived from economic development threatens the provision of ecosystem services and the quality of life in cities. Supporting 50% of the world wide population, cities need to guarantee security and wellbeing. Both are influenced by slow and fast variables related to global environmental change such as resources availability, climate and environmental quality. Their state, synergies and dynamics derive in urban gradual changes which affect the resilience of the system, leading to likely undesirable transformations. Variables related to other macro-systems such as economic markets (Pendall et al. 2010; Simmie et al. 2010) or technology (Allenby et al. 2005) can affect urban resilience too. Natural and man-made disasters (such as floods, epidemics, hurricanes, wars... etc.) are a product of the combination of global environmental change, population growth and the availability, quality and use of economic and technological resources.

During the last decade, many contributions to the study of urban resilience provide useful conceptual and practical inputs to the analysis of USR since seminal works by Holling (2001) and Alberti (2004). From these incipient works, the metaphor of resilience has been applied in cities to enhance their capacities to adapt climate change gradual impacts, to recover from natural and man-made disasters, to accommodate population changing demands, to respond to resource scarcity and finally, to buffer economic crisis.

3.3 Emerging knowledge areas

So far, we found multiple and isolated combinations of approaches which are mainly conceptual. While this enriches the study of the fundamentals of urban resilience, there exists a lack of a basic shared approach, including a widely accepted definition of urban resilience. More empirical and analytical work at urban scale is needed. The existing studies are mainly related to disaster-risk reduction (e.g. Wallace et al. 2007) and resilience to climate change (e.g. Eakin et al. 2009; Lomas et al. 2009). It is also evident that most of the focus on resilience has been performed at upper governance levels and less emphasis has been put on the role of urban networks, social behaviours and local institutional structures.

It is interesting to note that research on urban resilience is paying little attention to the consequences of demographic changes especially in the urban planning area where the study of the impacts of infrastructure provision and land-occupation policies on sustainable use of resources is of great importance to urban sustainability. It is been noted that this analysis will be of especial interest due to the role of population displacements induced by climate change and future research will have to put emphasis on this unexplored domain (de Sherbinin et al. 2011; Romero Lankao et al. 2011).

A clear conclusion which is inferred from this review is that cities lack an understanding of the causes and sources of the different levels of emissions, vulnerabilities and adaptive capacities in cities (Romero-Lankao et al. 2011) which make effortful and sometimes impossible the definition efficient measures. This likely derives in maladaptations and undesirable transitions. URS research agenda should pay in fact more attention to the provision of operative tools in the science-policy interface to confer knowledge to the decisions to be made in cities. This relates mainly to the study of cross-scales interactions (in space and time), the interdependencies of ecosystems and urban demands, patterns of societal metabolism and scenarios development.

So far, the quantitative measurement of URS has not been sufficiently. The sets of indicators are the most common and easy to use tool that local decision-makers have utilized so far as sustainable development in urban areas regards. Local Agenda 21 is a good example of these management habits. Additionally, the precedents on environmental monitoring actions implemented within processes such as SEA (Strategic Environmental Assessment of Plans and Programs) and EIA (Environmental Impact Assessment of Projects), have set governance behaviours which constitute an excellent platform to include other areas to develop diagnosis. In a context of urban resilience fostering, here is to say that such diagnosis or follow up should respond to some key questions: (i) Does the urban action/measure/project/plan/programme

contribute to resilient sustainability? (ii) Will the proposed strategies be resilient to climatic, economic or social shifts at long term?

However, resilience thinking is not only a philosophy to be implemented during the diagnosis or follow up stages of actions or strategies. On one hand, other urban planning and management phases are pertinent to be approached from a resilience perspective: scope, screening, definition of actions, stakeholders' participation, and assignation of responsibilities among others. Secondly, urban monitoring indicators are commonly used for benchmarking. However, why cities should perform a resilient sustainability benchmarking?

In a context of more social commitment, the public sector is following the path of the private practises in order to increase transparency in how they are expending taxpayers' money (EEA 2001). Benchmarking is used both to know how cities are doing and also to build up a process of best practises interchanging in order to learn from what other cities are doing. The new grand challenges that cities are facing, require an active process of data recording, storing, analysing and benchmarking. Resilience is all about learning from the past and from the existing experiences in order to avoid undesirable transitions.

Based on recent inspiring papers (Walker et al. 2004b; Van der Veen et al. 2005; Resilience Alliance 2007; Ernstson et al. 2010; Ahern 2011; Leichenko 2011) and the well explored theory of socio-ecological resilience (for instance Holling 1973, 2001; Walker et al. 2004b; Kinzig et al. 2006; Folke et al. 2010), we conclude that URS measurement must focus on processes such as adaptation, learning and transformation and monitor parameters such as diversity (bio, social and economical), flexibility, adaptive governance, capacity for learning, capacity for response and redundancy. URS indicators should monitor the long-term guarantee of sustainability. Future research should focus on the role of these processes in the urban arena, taking into account that the challenge of resilience measurement takes form at multiple-scales and requires further efforts on operationalisation to provide urban resilience approach of added-value to policy-makers, planners, companies and private land promoters. Notwithstanding, citizens need to know how well cities are doing to face threats such as climate change, peak oil etc.

However, indicators are just parameters which provide us with indicative and comparative information about our advances, and, as argued by Dawson (2011) they should be used alongside other type of information which enriches the evidence or taking well-informed decisions, such as the outputs of models, scenarios, experiments etc

Regarding the dynamics in cities, from the resilience point of view, the capacity to transform at smaller scales is a window for opportunity and innovation (Folke et al. 2010). Innovation and creativity are mentioned in recent literature as key to support the resilience of cities (see Ernstson et al. 2010; Ahern 2011) and specially, the idea of strengthen cities as hubs of a new culture of innovation is highlighted (Ernstson et al. 2010; Ahern 2011; Evans 2011). There is a need to define this new culture of innovation. Should it be approached from urban economies perspective where confrontation between redundancy and specialization exists? Contrary, in climate change adaptation research, some authors call for new urban governance techniques (Anguelovski et al. 2011; Evans 2011) through innovative ways of approaching planning towards urban sustainability. Certainly, resilient sustainability needs an evolution of planning culture which acknowledges science evidence (Evans 2011), precautionary principles (Haigh 1993; Iverson et al. 2011) and limits of the ecosystem service provision (Alberti et al. 2004; Pickett et al. 2004) through instruments, models, procedures…etc.

In regard to this last idea of the existence of limits in cities development, according to the EEA (2009) cities are on the threshold of potentially irreversible change due to the strong social demand on ecological services. Pickett (2004) suggests that, in the case of cities, there may be parallel social, economic, engineering, and aesthetic realms, crucial for the city functioning. The study of urban resilience thresholds falls short from empirical studies and experiences (solely in its area García et al. 2011 study city size thresholds) and a database compiling empirical experiences of thresholds analysis in cities would be beneficial for city management and

planning (this has been inspired from the experiences in ecosystem management, see Walker et al. 2004a).

Reversing urban current patterns towards sustainability, which ought to be long-term resilient, is a challenge for urban policy. Together with the study of thresholds for change, research on urban transition planning and management structures and habits towards sustainability is essential and progress beyond the state of the art needs to be realised.

Parallel to this, research on the dependency of cities' resilience on the resilience of adjacent systems (Resilience Alliance 2007; Ernstson et al. 2010) needs to be performed (see research gap G in Table 2) in order to define adequate measure to coordinate actions among cities within the same system. Taking again the thresholds issue, it is in fact the crossing of one of them, the event which produces a cascade effect that ultimately leads to the breaching of one or more additional thresholds. According to Kinzig (2006), managers focused too strongly on one domain or one scale will not see the interdependencies among scales and the likelihood that a new, resilient, and possibly less desirable system will emerge.

Eventually, the understanding of the cities' aptitudes (which capacities cities should have) and attitudes (how cities should behave) and their implications for resilient sustainability transitions is barely explored. As a solely initiative, Pelling and Manuel-Navarrete (2011) tentatively analyse how the adaptive cycle of the resilience theory explains the rigidity trap in urban governance structures and address study case transitions (also called transformations) from this perspective.

In this regard, we find that efforts to maximise and optimise cities aptitudes by urban planning research, technology development, urban metabolism knowledge acquisition, etc. need to be realised. On the other hand we need to deal with the attitude: the factors which determine resilience on the social & political and legal & financial domains (White 2005; ICLEI 2011) of resilience building.

4. Planning and governing city transitions towards resilient sustainability

Based on previous research, and acknowledging the huge contribution that the resilience theory can provide to cities management and governance, in this paper we suggest that, given the current unsustainable patterns of cities, the need to plan transitions towards urban resilient sustainability is evident, as argued in previous sections.

Here, we aim to provide an overall and holistic clear understanding of what a city transition towards resilient sustainability involves, which is a first step to progress beyond the state of the art as regards Urban Transition Planning and Management towards URS, and assuming that the fulfilment of a set of key necessary conditions will be required. The outcome could be understood also as a conceptual framework of URS research which describes the postulates for its consecution through transitions based on learning and adaptation, in line with resilience philosophy.

As argued by Kemp and van Lente (2011), sustainability transitions, as having socio-technical nature, involve two major challenges: long-term change of technologies and infrastructures and secondly, the change of consumers' options which is needed to support the change of the first one.

To these two challenges, approached within the MLP (Multi-level perspective) as described by Geels and Kemp (2007) and further explained by Geels (2011b), we have identified two extra Transition planning needs which respond to the URS Research Agenda resulted from the analysis of the literature (see Table 2). These are: (3) the operationalization of urban knowledge and (4) the development of a legal and financial framework which links different scales and regulates the transition, promoting investments and incentives. Not surprisingly, these have been also identified by socio-technical transitions and MLP scholars (see Hodson et al. 2010; Smith et al. 2010), as future research needs in sustainable transitions management

As argued by Geels (2011b), “since transitions are a complex and multi-faceted research topic, researchers are likely to disagree about how best to investigate them”. Although the literature on the linkages of MLP, sustainability and resilience is recent, there are growing papers which address the need of a common approach of these applied to the urban context. Certainly, the MLP and the socio-ecological resilience theory provide good frameworks for the development of an adapted framework for transition planning and governing towards resilient sustainability at urban scale.

Summarising, in previous sections, we have described how the resilience theory has been adapted to the urban, and the added-value which the resilience thinking can potentially provide to the already implemented urban sustainable policies. We have highlighted also the research needs that should to be addressed in order to respond to multiple:

Regarding urban long-term politics, cities benefit from resilience theory by learning political and management habits on how to formulate policies, strategies, plans, management processes which are flexible enough to drive cities development to sustainability. Furthermore, knowledge from past experiences, scientific resources and data sets need to be stored, classified, analysed and interpreted in order to prepare cities for surprise, using the results to forecast outcomes of planned strategies or identify potential consequences of current trends/patterns.

In the recent book of Cities and Low Carbon Transitions (Bulkeley et al. 2011), Geels (2011a) describes that the role of cities in technological transitions comes in three ways: (1) as city governments and agencies being important actors regarding specific sustainable interventions related to for example, transport, water and waste management etc. (2) cities as the location of the experimentation of low carbon innovations and (3) limited role compared to market dynamics and other actors. He argues then than, as technology regards, successful transitions exclusively focused on cities can not be guaranteed.

In line with these challenges, this paper indentifies 4 postulates (see Figure 1) in order to promote transition processes towards URS. These postulates, which aim to establish a renovated URS Research Agenda, summarise the research needs identified from the literature.

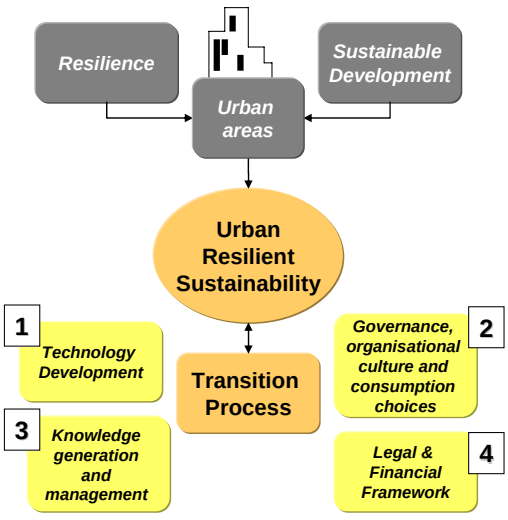

Fig. 1. Conceptual Framework of URS Research.

According to this framework, a transition towards resilient sustainability seeded in a city should take into account 4 aspects: (1) technology, (2) governance, organisational culture and consumption choices (3) knowledge generation and management and (4) legal and financial framework.

Acknowledging the key role of communities towards social transitions (Smith 2011) and the relevance of a cascading top-down strategy to support urban transitions (Geels 2011a), this framework should orient future research within URS. In this context, urban transition processes must also encompass adaptations and mitigation of impacts and are defined by a set of actions and a management structure in which experimenting, learning, timing, governance and financing are of key influence.

The following sub-sections briefly expand Figure 1.

4.1 Technology and infrastructure management and planning

Historically, critical infrastructures of energy, water, waste and transport have been fundamental in supporting urban transitions (Hodson et al. 2010). The role of technology in urban transitions to resilient sustainability is essential to support the construction and use of resilient and efficient infrastructures, transport means and services, looking to energy and matter flows, their generation sources, processes of production, uses and interdependencies among the elements of the technological network. Although, so far they have been seen as challenging engineering and administrative issues, new pressures such as urban growth, climate change and resources scarcity, require the need of reconfiguration of these networks (Hodson et al. 2010). Governing and planning for sustainable transitions of infrastructures systems and technologies involved is essential in order to support society's change. Research on governance of sustainable transitions of some sectors is currently emerging (see Blokhuis et al. 2011; Farrelly et al. 2011; van de Meene et al. 2011).

Technology and infrastructures network is tightly linked to society's consumption demand and also, to legal and financial framework in place. In fact, technology neither can nor should be prioritized as the main guiding principle for a transition (Azar et al. 2011). As argued by Kemp (1994) a change in technology induces fundamental changes in production, organization and the way in which people live their lives. Which adds more complexity to the urban systems functioning and to its understanding (Liu et al. 2007b).

Thinking of regional and national socio-technical transitions, both Jacobsson (2011) and Azar (2011) argue that in some cases where there is a high self-knowedge, technology-specific policies are necessary (although as climate change regards, at higher levels, technology-neutral policies are recommended). This seems to be the case of cities too, where self-knowledge and historical data could bring robust and well-informed decisions about technology development investments in urban areas. In fact, cities are in a far better position to weigh the individual costs and benefits of using different technologies for highly specific purposes, as exposed by Kemp (1994).

We suggest that research on planning and managing urban technology and infrastructure systems transitions should then, focus on the following issues:

- Development of operational decision making tools to map scenarios of technology and infrastructure use based on projection of consumption options, social behaviour, lifestyle, market drivers, socio-economic drivers, land use change, availability of resources and ecosystem services use.
- Selection of energy and matter technology: through technology specific policies and plans together with financial incentives for stakeholders and consumers
- Networks of infrastructures of generation, production, treatment, distribution and disposal towards circular economies along the life-cycle of energy and matter use flows (see industrial ecology principles and the principles of urban metabolism assessment approach Wolman 1965; Frosch 1992; Ayres 1994; Newman 1999; Kennedy et al. 2007; Allenby 2009) and supported by governance and management processes and institutional architecture.
- Exploring and maximizing benefits of the cross-sectorial interdependencies (among energy and matter use in buildings, food consumption, transportation, cultural and tourism services, industry etc.) towards the integration of infrastructures planning within the urban land-use planning and design.

4.2 Governance, organisational culture and consumption choices

According to Barbier (2011), the New Institutional Economics (*NIE*) define institutions as "all the mechanisms and structures for ordering the behaviour and ensuring the cooperation of individuals within society". Based on this, he argues that as societies develop, they become more complex, and consequently their institutions are more difficult to change. This institutional inertia is then one of the challenges which urban resilient sustainability practices must face when planning for transitions.

Certainly, technological change is unlikely to happen as long as this situation is maintained, as argued by Barbier (2011). As stated by Meadowcroft (2011), "politics is a constant companion of socio-technical transitions, [..] [as] it influences the general economic climate, regulation, technology use, and it can protect or discourage innovation in certain niches".

Civil society is also a crucial driver for sustainability transitions as its actions are driven by maximum utility choices. Individuals, as causal agents, influence also the urban inertia towards unsustainable consumption patterns. According to Geels (2010) "sustainability transitions will be full of debates about the relative importance of various environmental problems, which entail deep-seated values and beliefs". Unfortunately, alternatives and material preferences are assumed and fixed by market drivers which establish patterns of growing consumption (Mishan 1967; Schumacher 1973; Fournier 2008) and information about the consequences of choices is supposed to be readily available to individuals. However, the consequences of individual actions are not assumed by society and are often attributed to bad governance and management practices. This is the case for example of urban land-use planning and design which practices and patterns are mainly a result of private actors' investments and consumer options. The demand of urban infrastructures services is highly influenced by these economical, social and lifestyle vested interest (Alberti et al. 2004; Liu et al. 2007a).

Therefore, stakeholders and private actors entail the third social driver of URS transition, as their objective is to maximise profit from their activities. There is an evident need of engaging business to reorient their innovation and economic activities (Geels 2010; Evans 2011) influencing the economic frame conditions and consumer practices (Geels 2010).

In the current urban context, private actors do not have motivation and incentives to address sustainability problems (Geels 2010), debate which is additionally discussed within the degrowth movement (Fournier 2008) arguing that current sustainable policies only sustain the unsustainable (Blühdorn 2007). Certainly, "the politics of sustainability transitions requires a redefinition of societal interests" (Meadowcroft 2011).

Thus, it is necessary to analyse vested interests in cities since, although a transition is claimed to be driven when there is a exhaustion of opportunities and at the same time opening of new ones (Fischer-Kowalski 2011), there could happen large lobbying efforts to avoid transitions to more sustainable habits which are not so good for certain markets. This could be the case of transitions to new forms of energy where lobbying could take place to prevent society from changing lifestyle energetic habits (Kemp 1994) or to preserve institutional inertia (Barbier 2011).

Transitions should be accompanied by people's changes of values and beliefs, and society must acknowledge the consequences of individual decisions in costs and benefits for health, competitiveness, environmental quality and global environmental change. In decision-making, new 'sustainability' criteria have to be internalised and for this theory, criteria and methods to meet the desires of people and sustainability transitions goals need to be revised (Geels et al. 2007; Kemp et al. 2011). Following this discussion, Whiteman (2011) stresses the need to analyse how corporate activity affects urban systems, since, according to him, the key role of business in strengthening resilience in cities has not been analysed so far. Whiteman concludes that, based on the case study of Rotterdam city, further research is needed to better understand

the conditions that encourage effective bridging activity by companies aiming to facilitate stronger actors networks and to more tightly couple information flows.

Last of all, community led initiatives are a key ingredient for successful transitions at city level (Smith 2011). So far, the work realised by *Transitions Towns* movement which philosophy can be found in the *Transitions Handbook* (Hopkins 2008) is a key part on this discourse and growing initiatives all around the world are emerging which, in our opinion, will stimulate top-down strategies to support them.

4.3 Knowledge generation and management

Due to the complexity of socio-ecological and economical systems and the interactions derived by them (Holling 2001, Ostrom 2009), decision-makers often need to define policies which meet multiple objectives (social, economic and environmental) while balancing science information with socio-economic and policy evidences. It is then when scientists need to realize that the consistency with the end-use is essential (Fisher 2009). Indeed, information provided to policy-makers needs to be addressed to the characteristics of the strategy, plan or instruments which is being defined for. Such instruments are defined by factors of time, strategic or detailed level of the planned actions, implementation requirements, resources etc. which will in turn, drive scientific information needs.

The underlying feeling is that at urban scale, cities have the resources (indicators, modelling tools, knowledge… etc) to approach these issues but don't know how to synthesize this knowledge and use it to inform and orient decisions to make sustainable interventions.

There are different stages in a decision-making process, which are generally driven by the following decision needs: (1) Define the situation, (2) Generate alternatives (3) Information gathering (4) Selection of desirable alternative (5) definition of actions and, (6) monitoring.

As data and knowledge regards, we could summarize this knowledge management needs in three aims: (1) Diagnosis (2) Screening and (3) Assessment or monitoring. In each of them, different operational tools could be used.

Thus, in regard to diagnosis, according to Fischer-Kowalski (2011) "a regime can be characterized by the socio-metabolic profile of the society involved, and the associated modifications in natural systems that occur either as an unintended consequence (such as resource exhaustion or pollution) or as intentional change induced by society (such as land cover change)". Clearly, in order to balance human activities and ecological services in cities, local decision-makers need to get info about the real demand of infrastructures to plan provision of services at long term. As well, resilience of existing infrastructures should not be compromised. From a broader perspective, these analyses should also consider changes in social lifestyle which might lead to an underuse or overuse of infrastructures.

Screening is a key stage in planning for transitions. As highlighted in section 2, cities still lack of operative tools applied to the urban context which address the need of model transitions and build maps of alternatives actions (Hodson et al. 2010), but there are some recent studies which should be analysed for further replication in real practise (see e.g. Gusdorf et al. 2008). It is fact unclear how to address this challenge since as argued by Dawson (2011) it would be naïve to pre-define sustainable transitions when uncertainties and surprises need to be addressed through flexible strategies. Because of this, he proposes the "scenario neutral strategy" approach (see example for urban heat island effect in Dawson 2011, p. 182-183) where a set of interventions are drawn depending on the level of operation in cities which importantly, are not tied to a specific time-scale or climate change scenario.

Assessment of potential alternatives and implementing monitoring processes alongside the implementation of the transition plan would well support governance and prevent undesirable surprises allowing forecasting and reorientation of transition politics or the establishment of abatement/mitigation measures of negative indirect impacts. This kind of practises would allow

the resilience thinking crucial processes of learning and adaptation through evaluation. Because of this, urban monitoring should be performed looking at long term, multiscale, and cross-sectorial (Dawson 2011)

Lastly, as discussed in the previous section, urban benchmarking is world-wide used to compare urban patterns and extract the best practises from other cities' past experience. Indicator sets are the most common tool to realize this and progress beyond the state of the art regarding urban resilient sustainability assessment should be made.

The following table 2 shows some examples of operative tools to support urban resilient sustainability transitions, which have been mentioned along the review of the literature or identify as key knowledge management tools to help decision making in transition planning and governance processes.

Table 2. Operative tools to support urban transitions in generating knowledge to informed decision making.

Some examples of operative tools to support urban resilient sustainability transitions
– **Diagnosis**
Cities experimentation platforms
Urban metabolism analysis tools
Interdependencies (scale and time) modelling tools
Urban Raw Data recording and storage platform
…
– **Screening: Transition modelling and planning**
Scenario modelling tools (+ analysis of key parameters which drive urban system)
Transition mapping and modelling tools (related to planning, governance, markets, behaviours etc)
Transition planning methodologies: process, timing, screenings, scoping… etc.
Economic valuation of costs and benefits of adaptation/transitioning/mitigation
Flexible Urban Planning methodologies/models
Science-informed decision making support tools
Governance Procedures and best practises (compendium of win-win-win situations)
Behavioural Change Analysis Tools
…
– **Assessment and monitoring**
Assessment of costs and benefits of alternatives
Social Resilience assessment tools
Urban Resilient Sustainability benchmarking tools
Early Emergency Systems
…

4.4 Legal and financial framework

Smith at al. (2010) argue that as long as policies engaging with socio-technical change, through market interventions, R&D funding and provision of platforms for strategic niche management remain an external factor of influence, the application of such policies would continue to be obscure

Timing implications and procedures of the introduction of new legislation must be studied. As described in earlier sections, recent studies show that unplanned regulations can derive in unexpected outcomes, such as other products price increase or land development far or close to the city centre (see example of inequalities created by quick or slow introduction of transport taxes in Gusdorf et al. 2008).

On the other hand, financial incentives or regulations which motivate sustainable principles implementation by private actors or civil society seem to be a good option. For example carbon pricing policy instruments allow a range of different solutions, which might be used to meet different objectives such as incentivising motivation of stakeholders, providing flexibility to transitions and improving environmental quality and human health.

In any case, as technology regards, financing its development might be hard to plan for a government. Companies might see returns too far if the market is not prepared now to receive

such new businesses. Although the promotion of new technologies should be part of the local agenda, technology development investment should be part of upper scale regional and national plans and strategies. Financing technology development and its use by civil society (for example by providing economic support for its installation in buildings) should be promoted not only at local scale, since resources might not be enough, but also from the upper levels and also from a cross-sectorial approach, given that synergetic impacts of technologies could be problematic (Meadowcroft 2011). In the selection of technologies, attention should be paid in early market niches, available knowledge that may be used, institutional support, and the role of expectations (Kemp 1994).

As earlier mentioned, this paper aims to address the specific problematic of medium-size ordinary cities where capacity for intervention could be limited. For these reason financing to support the actions to be taken within the transition plan, and financing the development of the plan itself, will be crucial.

5. Conclusions and further research

From the review of the literature which cover a wide range of disciplines, we suggest that resilient cities are those which stimulate social cohesion, culture and innovation through diversity, which are flexible and open to opportunities, which identify niches of success and invest on them, which understand ecosystems and ecological networks and are grateful for the services they receive from them, which anticipate to conflicts and learn from errors understanding that competitiveness needs innovation, and innovation & creativity need experimentation. Resilient cities are those where citizens, stakeholders and politicians pursue different aims under the same mean and outcome, and therefore participate and constructively criticize in order to build a better future.

This paper has posed two questions: given the current state of the art in the adaptation of the resilience theory to the urban context, what is the added value of the urban resilience approach for sustainability? And, based on the evidence that current city patterns are not sustainable, how do we stimulate local transitions to resilient sustainability?

Certainly, sustainability policies at urban scale are not enough to tackle with current challenges mainly because they lack of a long term view. Resilience provides a framework (with empirical experience in managed natural systems) where capacities for learning, adaptation and transformation are strengthened to have a long-term view which sustainable policies lack. Still, we see that a dual sustainability & resilience policy approach might still not be enough given that current city patterns are now unsustainable. Thus, it becomes evident the need of deliberately lead urban transitions to more desirable states and/or avoid undesirable transitions at city scale. We propose socio-technical transitions research experience to build urban practices to govern and manage urban transitions to resilient sustainability, following recent suggestions on the field (Hodson et al. 2010). Still, empirical studies based on successful experiences would be needed.

The main contribution of this paper encompasses a conceptual framework for the emerging school of URS thinking. This conceptual framework methodizes the knowledge generated so far under a common aim, which is to contribute to society providing ways to achieve more sustainable urban environments outlining the necessary conditions which are needed to push cities towards a more resilient sustainability

The conceptual framework of URS developed in this paper tries to provide an umbrella of urban practises towards more competitive cities in times of climate change, resource scarcity and socio-economic changes.

Cities need in fact to stimulate their capacities to develop strategies towards building resilient sustainability regimes bringing transformations, adaptations, together with mitigation of the impacts on our social, ecological, institutional and infrastructure services provision.

The experience in the application of the study of socio-technical transitions has been proposed as a key to support the planning of such strategies and governing the process of transitions. Nevertheless, according to Smith (2010), the evolution of this theory in the context of innovation studies and sustainable development still raises some challenging analytical and practical issues such as niche dynamics, unlocking regimes, spatial aspects of transitions, methods to map transitions, politics of transitions, and the interlinkage with dynamics of governance.

For sustainability transitions however criteria need to change dramatically, else transitions run the risk of not being sustainable due to rebound effects and other impacts (Kemp et al. 2011). This hypothesis, applied to the urban context and supported by (1) resilience criteria in terms of the need of transition processes based on learning and adaptation, and (2) sustainability criteria, given the existence of wide experience in benchmarking, opens a promising future of applied research, innovation and experimenting in cities. Nevertheless, there is an evident need of empirical work needs at city scale to support this cross-disciplinary approach.

This paper has argued the need of city governments to lead urban transition to resilient sustainability by the fulfilment of a set of key necessary four conditions regarding: (1) Technologies and infrastructures development, (2) Social stimuli, regarding consumers' options, flexible institutional structure and stakeholders' commitment to support socio-technical changes and guarantee sustainable development, (3) the operationalization of urban knowledge to support decision making and scenario development, and (4) the development of a legal and financial framework which links different scales and regulates the transition promoting investments and incentives.

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