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Stimulating urban transition and transformation to achieve sustainable and resilient cities

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ABSTRACT

Political decision-makers need to consider the various challenges and opportunities that climate change can bring, and they must take decisions under high uncertainty to achieve resilient cities. Here, we synthesise the push and pull approaches reported in the literature and employed in practice to achieve sustainable and resilient cities.

First, we present a literature review which identified the major research fields on transition theories, frameworks and methods that underpin this concept. We analyse the conditions for change, identify enablers or triggers for change at governance level for transitioning a city towards sustainability and resilience. We discuss the theories, frameworks and methods which can be used to address the urban climate change challenge at city level.

Second, we present an empirical approach based on stakeholder participation that we conducted to detect the conditions for change. We report on the design and implementation of stakeholder exercises that helped us detecting the conditions for changes.

Third, we combine the information obtained from these stakeholder exercises with that extracted from the literature in order to provide a fuller picture on how stimulate the transition and transformation to achieve sustainable and resilient cities. Based on our literature review and empirical approach, we formulate an integrated conceptual model for transition that enables the design of adaptation (and mitigation) strategies that consider the triggers of change. Uniquely we identified 8 triggers of change, including authority and political leadership, learning from disasters, co-responsibility, increased public-private interface, social participation and the living lab approach to innovation. The proposed model can be applied to the whole city or to a certain sector of the city (e.g. energy). We demonstrate that triggers of change help to overcome planning and implementation barriers and move the socio-ecological and socio-technical systems of any city towards those of a resilient city.

1. Introduction

More than half of the world's population lives in cities and faces the challenges of climate change [1–3] and urban development. This situation necessitates a change in present governance in order to acquire the capacity to generate long-term, flexible and sustainable policy instruments to address problems. However, such change should involve the coordination of pre-existing authorities, organised interests and knowledge [4]. Heidrich et al. [5] investigated the relationship between climate change strategies at urban level and EU and national climate policies. Of the 200 cities surveyed, they found that only 56 cities (23%) had adaptation strategies. This highlights the need to strengthen the capacity of local authorities and develop tools and resources that enable them to plan and respond to their specific climate change problems.

Generally speaking climate change has two areas mitigation i.e. to reduce the causes of climate change via for example renewable or sustainable energy systems, and climate change adaptation i.e. to reduce the negative impacts that climate change may bring for example energy, heat island, flooding or vulnerability [6]. Besides, the policy response should integrate both areas [7]. A clear example of this is the new merged Covenant of Mayors for Climate and Energy which integrates mitigation and adaptation issues to achieve the EU energy and climate targets [8].

Therefore, the cities challenge lies on designing workable

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governance instruments to support low carbon energy transition [9] and stimulate urban transition and transformation to achieve sustainable and resilient cities [10,11]. Energy consumption model and greenhouse gases reduction is highly dependent on the urban characteristics (e.g. urban form) [12,13]. In turn, cities should take action to both reduce the greenhouse gas emissions and adapt the system to reduce the negative impacts of climate change [12].

A few studies have focused on urban energy resilience [14] this paper would like to highlight the importance of transitioning the whole city but also discusses specific sectors like energy at the same time as they both have common planning and design criteria (e.g. land use, urban geometry and morphology, governance, socio-demographic aspects). Therefore, it is hoped that the review and the transition model presented here can help in the adaptation and mitigation to climate change of the whole city, that is applicable in various sectors like energy, water and transport.

Several approaches (e.g. incremental, transformative or reformist adaptation) and conceptual models (e.g. Adaptation Action Cycles, Transition Handbook) to study climate change mitigation and adaptation have been presented to determine how to transition towards sustainable urban development can achieve more resilient and sustainable cities [10,15,16]. Two research communities have emerged that address the transition and transformation of the cities: climate adaptation and transition communities. The climate adaptation community addresses problems related to climate change, which has improved the analysis and quantification of climate change impacts (consequences of climate hazards), developed vulnerability assessment methods, provided strategies for adaptation and identified opportunities but also barriers to adaptation [10,17]. Meanwhile, there is another community - the transition community - that has been focused on the transition of urban governance tools to achieve e.g. sustainability, low carbon energy systems and resilience [14,18,19]. In this latter community, sustainable transitions have entered the academic debate [20–22] about the governance, methods and tools necessary to help cities attain sustainable living, cleaner energy and resilience.

Effective governance of transitions requires the capacity to deal with complexity and uncertainty, manage big data and conduct in-depth analysis. It must also involve a broad range of stakeholders in these processes. In this respect, several scientific communities have addressed the governance of urban transition. In one hand, the transition community has developed the transition management (TM) approach [15,23–27], a governance model focused on society and technology. Urban transition management is a variation of transition management which focuses on city-specific challenges and employs the same principles as transition management [28]. Meanwhile, in the other hand, the climate adaptation community has proposed the adaptive governance approach, which consists of creating adaptability and transformability in socio-ecological systems. Although initially formulated as an adaptive management approach [4,25,29–31], it differs in considering broader social contexts [30]. Whereas adaptive management focuses on the interaction between social and natural dynamics [32–36], adaptive governance is a broader concept adopted by the climate adaptation community that uses adaptation to increase the resilience of socio-ecological systems [34].

Despite their different approaches, both these scientific communities (transition and climate adaptation communities) address the urban system with the same aim: to increase resilience and sustainability and prepare for the global challenges ahead, i.e. cleaner energy or flood protection as responses to the threats and opportunities of climate change [11]. Resilience provides the capacity to absorb disturbances while maintaining function [32], endowing the system with the capacity to reorganise itself after a disturbance [37], and to adapt and learn [25,38,39]. Sustainability is a multidimensional systemic concept that embraces the environment, society and the economy and adopts a long-term vision for energy generation and consumption [38,40,41].

Therefore, specific governance models are required to enhance resilience and sustainability in this uncertain world. Wise et al. [31] have argued that the analytical focus in climate adaptation science is changing from a problem-orientated (provide evidence-based advice for decision-makers) to a decision-orientated approach (which aims emphasising the need for robust decision making under deep uncertainty). This change has been prompted by the need to assist decision-makers in adaptation planning, in which policy options must be assessed and implemented within highly uncertain, dynamic and complex socio-ecological systems. Moreover, city systems require dynamic adaptive plans rather than static robust plans.

Last but not least, in order to develop effective governance for transitioning, the barriers and drivers must be considered. In this context, barriers are “social factors and conditions [that] hamper our ability to adapt proactively to future environmental changes” [42]. Elsewhere, barriers have been defined as “obstacles that can be overcome with concerted effort, creative management, change of thinking, prioritisation, and related shifts in resources, land uses, institutions” [43], or with sufficient political will, social support, resources and effort [17,44]

There is a danger that using the terms “barriers” and “drivers” in the context of climate change policies may suggest a clear-cut causality between human activities, processes and patterns impacting on adaptation efforts [17]. We acknowledge that neither barriers nor drivers imply monocausality, i.e. no one specific driver or barrier causes or prevents a specific impact or behaviour.

The aim of this paper is to synthesise the push and pull approaches described or employed to achieve resilient cities. To this end, we established the following objectives:

- Collect published peer-reviewed and grey literature
- Review and analyse push and pull approaches
- Categorise methodological differences between these approaches
- Design and conduct empirical exercises to identify the city conditions for change
- Advance the understanding and applicability of the different approaches by providing a theoretical/conceptual framework
- Discuss the findings in terms of resilience, adaptation and energy

We identified major research fields in transitioning, detecting the theories, frameworks, approaches, methods and tools to determine which can be used to address the urban climate change challenges.

The literature that analyses barriers and drivers also explores the reasons for the limited transfer of assessments, agendas and plans to transition, as well as examining how barriers are transformed into enablers. Therefore, both scientific communities (transition and climate adaptation) identify the conditions for change in order to determine those necessary to promote transition to achieve sustainable and resilient cities. In addition, we designed an empirical approach to detect the conditions for changes and combined this information with that reported in the literature.

The information obtained from our literature review and empirical approach enabled us to define an integrated conceptual framework for transition. The purpose of this framework is to serve as a basis for developing a systems-based approach that considers trade-offs and synergies and interlink ages between social and environmental issues, combining top-down and bottom-up approaches.

2. Materials and methods

We conducted a systematic literature review to summarise the two main communities’ approaches to the subject of transition by performing a keyword search using search engines Google Scholar, Science Direct and Web of Science (WOS). WOS and Science Direct were selected as they are the most powerful, up-to-date, comprehensive and widely used search engines available for the analysis of

interdisciplinary, peer-reviewed literature. Google Scholar was selected as it includes most peer-reviewed online journals published by Europe and America's largest academic publishers, as well as academic books and other non-peer-reviewed journals.

In total, we found 105 papers, book sections, conference papers and reports which contained the words “transition” and “adaptation”. Some 65 of the papers and documents included the word “transition”, while 89 of the studies included the word “adaptation”. Thus, some of the papers and documents addressed both adaptation and transition. Our review of the transition and climate adaptation literature served to describe the transition concepts defined by the two respective scientific communities and identify their best methods and tools for pushing cities towards resilience.

Based on our findings we designed and implemented an empirical approach based on exercises aimed at encouraging diverse stakeholders to work together in the framework of transition and adaptation to climate change [45] in order to detect the conditions for changes (enablers or triggers for change). We complemented the information obtained with that extracted from the literature in order to provide additional data. Our approach consisted of a stakeholder dialogue (SD) exercises held on the 11th of May 2015 in Copenhagen, which brought together more than 20 participants from different European countries (see Supplementary Material, Appendix A, Table 1). Participants included city representatives and regional stakeholders, researchers and consultants from the private sector. The topic addressed was “Detecting triggers of change for transition in cities” [46].

Before holding the SD exercises, a desktop study was carried out to generate city typologies for use during the SD exercises (encompassing European climate change regions and vulnerability characterisation: Mediterranean and southeast Europe) (see Supplementary Material, Appendix A for more information). Participants were asked to detect and describe vulnerabilities and after these have been identified for a particular city typology, the next step consisted of converting the previous hotspots/challenges of the impact chain into positive statements (combining elements inspired in the different generic visions). Then, these were transformed into a vision.

Another desktop study was carried out in order to pre-identify generic visions for the cities based on a literature review [47–51] (Supplementary Material, Appendix B). These were presented during the SD as a baseline from which to identify the factors that would enable the vision to be achieved. The backasting technique was followed [52]. Each participant was asked to add triggers of change in a brown paper. The importance of the pre-identified transition factors were then evaluated (highly, medium and low importance). The output of the SD exercise was a list of triggers of change. This information was compared and positioned with the wider literature that we have found in order to add richer information to the wider research communities of resilience, sustainability and energy systems to the detected triggers of change.

3. Results

3.1. Systems theory

Systems theory has been applied by the two main communities addressing transition studies in the urban context. The transition community analyses socio-technical systems, while the climate change adaptation community mainly focuses on socio-ecological systems. We analyse each of these approaches below.

Through its analysis of socio-technical systems, the transition community examines how societal and technical systems co-evolve over time [53,54], focusing on transitions, which are defined as non-linear long-term processes (lasting between 25 and 50 years) [18,55–57]. The bases of transition are the structural changes in society's or a subsystem of society's operability. Governance to establish transition is called **transition management** or transition governance [25,26,53,58].

Transition management (TM) is based on governance, complex systems and practical experiment [15,23,58]. Four different types of governance activity (also called “spheres”) are identified in TM: strategy (the transition arena), tactics (the transition agenda), operations (experiments), and reflection (monitoring and evaluation). The TM approach has already been applied empirically at national and sectoral level (e.g. energy, water, transport and construction). In the last few years energy transition gained attention and has been extensively studied [59].

Furthermore, TM should be seen as a reflective governance approach primarily aimed at analysing, implementing and facilitating sustainability transitions. In addition, TM takes into account the complexity of the system and uncertainty [23]. TM has prompted increasing research interest in sustainability transitions [18,22]. Last but not least, the literature includes the concept of urban transition management, a variation of the TM approach which employs TM principles and guidelines but focuses on city-specific challenges [28].

In analysing the socio-ecological system, the climate adaptation community explores social and ecological systems and their interactions, and also considers the concept of resilience. This approach has given rise to the concept of adaptive governance, which is aimed at anticipating long-term change, responding to immediate shocks and recovering from such events. Hence, it focuses on the capacity to maintain system functions under changing conditions [25]. The changes in socio-ecological systems are described through a series of distinct phases, which comprise the adaptive cycle [15,32]. These changes can be the result of natural responses (involving organisms or species) or socio-economic or institutional responses (involving individual or collective, private or public agents, among others) [33,60].

Thus, adaptive governance is an approach aimed at improving the adaptability and transformability of socio-ecological systems. This concept arises from the combination of two areas [29]: natural resource management, which is studied in line with ecological systems theory (advocated by Buzz Holling and the Resilience Alliance) [37], and self-governing institutions, which is led by Elinor Ostrom [61].

Meanwhile, the concept of adaptive management [32–36] is based on a systems perspective (interaction between social and natural

Table 1
The triggers of change proposed in the SD are summarised in the table, including the importance and the number of votes representing the number of times participants made reference to a trigger or used certain words to certain trigger.

Triggers of change	Importance	Number of votes
Education and awareness: availability, accessibility and ability to use data	High	7
The regulatory framework, including codes, accountability, pricing, taxation, penalties and incentives	High	5
Learning from disasters, learning from narrative research	High	4
Informed, inclusive and adaptive multi-level governance	High	3
Authority and political leadership for disruptive innovations and change	Low	2
Integrated and adaptive planning and management	Medium	6
Co-responsibility, increased public-private interface, social participation	Medium	4

dynamics) and forges a link between ecological, social and economic systems. It can be divided into two phases: the planning phase (or set-up), which addresses essential elements, and an iterative phase, when these elements are linked together in a sequential decision process.

Adaptive management is considered more analytical and substantial than transition management (the latter has a strong process orientation with a focus on sustainability) [62].

3.2. The socio-technical approaches and processes

3.2.1. A snapshot of socio-technical and socio-ecological system approaches

The socio-technical approach incorporates a process of successive stages and activities. These can be summarised as: (i) a pre-development stage, where experimentation occurs at the individual level (the system dynamics do not change visibly); (ii) a take-off stage, where innovation emerges, thus prompting structural change and destabilisation of the existing regime; (iii) an acceleration stage, where cumulative socio-cultural, economic, ecological and institutional changes are implemented, leading to structural transformation; and (iv) a stabilisation stage, where the system attains a new dynamic state of equilibrium. Multi-level governance is crucial to this perspective [15,25,58,63].

The TM approach includes several successive steps [48,58]: 1) analysing a system; 2) envisioning; 3) exploring pathways; 4) experimenting; 5) assessing; and 6) transferring.

The socio-ecological approach also incorporates a process of successive stages and activities, but these are different from those of the socio-technological one. These four stages are: i) growth or exploitation (r); ii) conservation (K); iii) collapse or release (omega); and iv) reorganisation (alpha) [64]. The arrows shown in Fig. 1 represent speed of flow in the cycle. Short, closely spaced arrows indicate slow change whereas long arrows indicate rapid change between stages.

Four steps have been defined by Park et al. [15] to describe adaptation in socio-ecological systems, known as the adaptation action cycle, and have also been mentioned by other authors such as [43]. These steps have similarities with the steps proposed in TM: 1) problem structuring and establishing the adaptation arena; 2) developing the adaptation agenda, vision and pathway; 3) implementing adaptation actions; and 4) evaluating, monitoring and learning.

3.2.2. From incremental adaptation to transition

Three types of adaptation have been defined in the climate adaptation community: adjustment or incremental adaptation, transformative adaptation and reformist adaptation or transition [31].

Adjustment [incremental] adaptation views climate impacts as the major source of vulnerability [10,65,66], and focuses more on the effects of climate change rather than on the social causes of vulnerability.

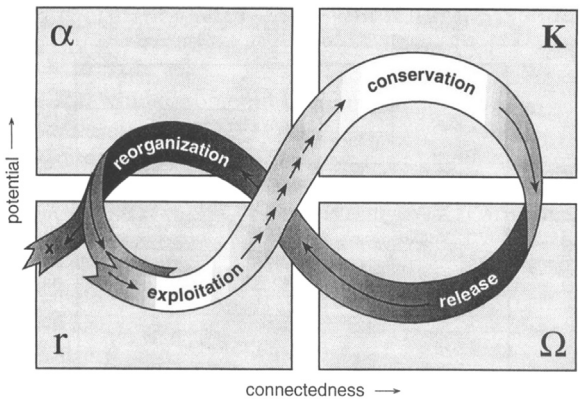

Fig. 1. Representation of the four ecosystem functions (r, K, Qf, a) [32]. From Panarchy edited by Lance H. Gunderson and C.S. Holling. Copyright © 2002 Island Press. Reproduced by permission of Island Press, Washington, DC.

In this case, the aim of adaptation is to adjust the system to the future new conditions through climate risk management, attempting to "return" society to a desirable equilibrium state. To do so, the system's integrity must be maintained [15]. In summary, adaptation solutions stem from risk management.

Transformative adaptation is defined within resilience theory. Transformation can be considered a process which results in a change in the biophysical, social or economic dimensions of a system from one form, function or location to another (the change can be reversible). In transformative adaptation, it is very important to understand the causal structure of vulnerability, as this will form the basis of adaptation planning. The proposed solutions are related to a "political regime shift" which changes the existing system altogether [15,65–67].

Reformist adaptation [transition] falls between the adjustment and transformative adaptation approaches. Research on this type of adaptation focuses on the social and political dimensions of vulnerability, and the aim of reformist adaptation is to reduce social vulnerability. In this case, the proposed adaptation focuses on altering rules and decision-making processes within the limits of the existing system, without significantly altering the norms and principles that governed such rules [33,65,66].

3.3. Conditions for change

The participants from the SD identified the triggers of change that would enable the vision to be achieved. Participants particularly discussed political drivers for the transition starting from the vision.

Table 1 summarizes the triggers of change proposed in the SD, including the importance and the number of times participants made reference to a trigger or used certain words to certain trigger.

Below, we include additional information to the triggers of change detected in the SD in light of the literature reviewed.

3.3.1. Authority and political leadership for disruptive innovations and change

This represents a long-term commitment [68]. It constitutes a common barrier and can be critical in the initial stage of the adaptation process [69]. Regardless of political affiliations, a leader with motivation, a clear vision and the capacity to guide is required to initiate the process. The most important part of leadership is trust, and consequently, a leader must have excellent communication, facilitation and inspirational skills and capacities together with high standards of integrity [43]. As an example, many communities in British Columbia have demonstrated leadership on climate change (Shaw et al., 2014).

3.3.2. The regulatory framework, including codes, accountability, pricing, taxation, penalties and incentives

Accountability, legality and procedural feasibility are frequent barriers throughout the stages of the managing phase (i.e. implementing options and sub-processes). The existing policies, regulations, laws, programmes and mandates are necessary instruments to implement the adaptation option [43,70].

3.3.3. Learning from disasters, learning from narrative research

Society learns from past experiences, and therefore people look at new problems and situations (which can be climate change effects) from the perspective of knowledge gained in the past. Past experiences represent part of personal development, in which the values, beliefs and norms thus formed also contribute to perceptions, interpretations and responses to new situations [43]. A narrative approach is of great importance in this learning context. Combined with participatory learning, it helps generate a better understanding not only of disasters but also of the socio-ecological system. Narrative research provides additional inputs to adaptive governance in the form of data on local knowledge [71].

Table 2
Description of the transition concepts defined in two scientific communities (transition and climate adaptation).

	Transition	Climate adaptation
SYSTEM	Socio-technical *(society and technical system co-evolve)*	Socio-ecological *(resilience)*
GOVERNANCE	Transition management (governance)	Adaptive management (governance)
STAGES	Pre-development, take-off, acceleration, stabilisation	Reorganisation, growth, conservation and collapse *(adaptive cycle)*
STEPS	Analyse a system, envisioning, exploring pathways, experimenting, assessing, transferring	Structure the problem and establish the adaptation arena; create a vision, define an agenda and develop a pathway; implement the pathway; evaluate, monitor and learn
APPROACH	1. Socio-technical transition theory	1. Adjustment [incremental] adaptation 2. Transformative adaptation 3. Reformist [transition] adaptation
METHODS/TOOLS	1. Multi-level perspective (*niche-innovation, regimes and landscape*) 2. Backcasting 3. Urban transition labs (*living lab*) 4. Transition pathway (*multi-level interaction*)	1. Adaptive policy making (APM) (design dynamic, robust plans) 2. Adaptation pathway (AP) (focus on decision-making processes) 3. Dynamic adaptive policy pathways (combination of APM and AP)

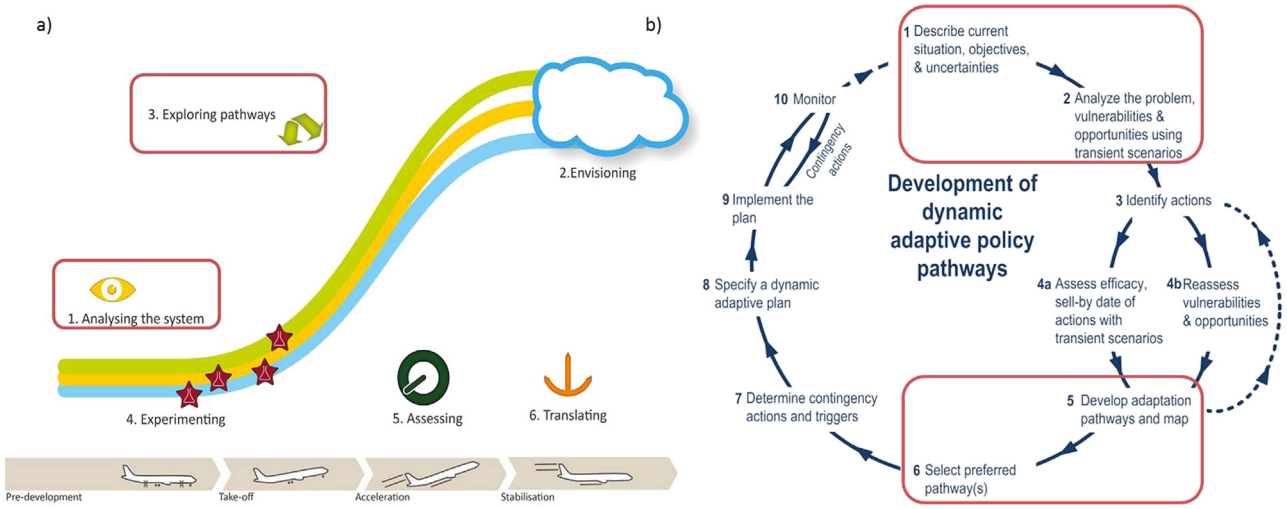

Fig. 2. The similarities in the steps covered by both approaches in red, a) the transition community's approach to sustainable development [58] and b) the dynamic adaptive policy pathways approach of the climate adaptation community [81]. Reprinted from Nevens and Haasnoot.

3.3.4. Education and awareness: availability, accessibility and ability to use data

These frequently represent barriers in the understanding and planning phases of the adaptation process (i.e. collecting information and assessing options and sub-processes). Good, effective communication is essential to improve understanding of climate change issues and therefore increase awareness. It also has the added effect of engaging stakeholders, decision-makers and society. Information barriers are related to who delivers it, how it is communicated and who receives it. Insufficient information presented unclearly and infrequently creates a huge barrier [43,70]. In a study by [72], stakeholders and scientists participated in collaborative scenario-building. The process helped participants to develop a common understanding of the risks and impacts of climate change in a specific region and provides a good example of how shared understanding can help overcome this barrier.

3.3.5. Co-responsibility, increased public-private interface, social participation [68,70]

These constitute frequent barriers throughout the managing phase (implementing options and sub-processes) [43]. Behavioural barriers are particularly critical as regards local action. However, with the appropriate facilitation, some forces can create policy changes and can also alter the behaviour of societal sectors. Such forces include societal pressure, financial and market stimuli, voluntary agreements and coercion. The key to addressing present inertia is to create opportunities for collaboration between municipal stakeholders or decision-makers and climate change experts. This highlights the need to consider a broader range of actors and institutions through a participatory process [70,73]. In addition, an uncoordinated effort between public and private sectors can be a barrier for identifying the most suitable opportunities to overcome climate related problems and success in the transition [59]

3.3.6. Living lab approach to innovation

The lack of availability of technology as a social tool and to increase the adaptive capacity of cities can be a common barrier [74]. However, successful pilot experiments involving living labs could be scaled up and replicated in other places. Living labs have the capacity to support transition towards sustainable urban transformation [75], while also going beyond the urban context. In 2014, the University of British Columbia approved a 20 year sustainability strategy, which covered a wide spectrum of university activities and entailed a renewed focus on university operations and infrastructure through the lens of a living lab [76].

3.3.7. Informed, inclusive and adaptive multi-level governance

The implementation of adaptation options can be influenced by governance and social context. On the one hand, municipalities are not sufficiently empowered to implement some adaptation options or the entire adaptation strategy, and therefore these actions must be implemented at a higher level of government or specific legislation must be created [73]. On the other hand, adaptation options can exert an effect on the actor's perception and therefore this can considered a barrier [43].

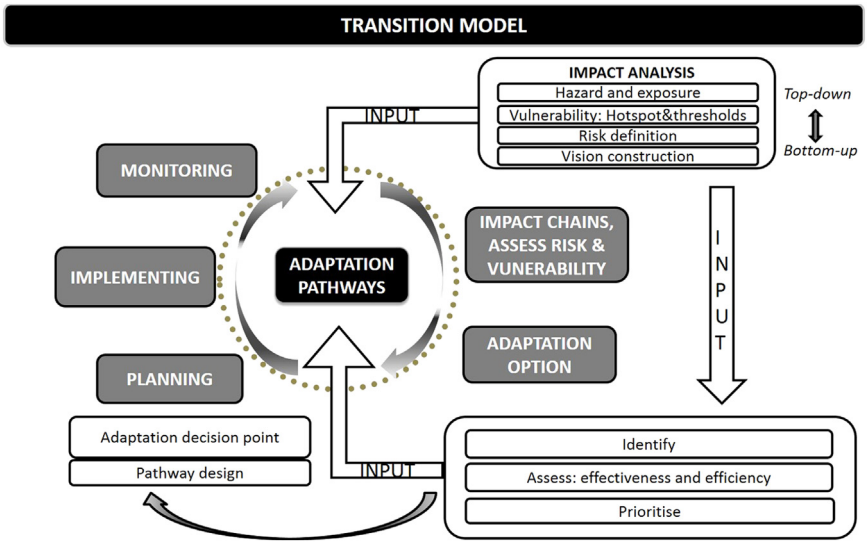

Fig. 3. Proposed transition model.

3.3.8. Integrated and adaptive planning and management [68]

Successful adaptation appears to depend on the degree of consistency with other programmes designed to address non-climatic problems. Therefore, misaligned adaptation plans are unlikely to be implemented successfully. The key issue is to avoid dependence on personalities or politics, which can ultimately render the plan fragile [73]. A sustainability approach may provide a level of integration with existing policies, plans and priorities [20,77]. Moreover, the existence of a monitoring plan is a frequent barrier in the managing phase (monitoring outcomes and environment sub-processes). To guarantee effective implementation of the adaptation plan, a monitoring and evaluation system must be defined. Some of the barriers linked to this step include lack of data, methods and expertise [43]. Cities such as Surrey, Vancouver and Victoria provide examples of monitoring and evaluation systems [68].

3.4. Synthesis of the approaches for transition

There are several approaches related to transition in the literature, some of which have emerged from the transition community and others from the adaptation community. These communities define approaches using specific concepts, methods and tools.

The results we obtained from our synthesis of the approaches in both communities (transition and climate adaptation) are summarised in Table 2. Both communities provide methods and tools that can be useful for city transitions.

[78] compared the socio-ecological and socio-technical systems, and found that while social-ecological system recognised technology as a key component influencing resilience, the dynamic of this component was rarely detailed. In contrast, the socio-technical system considered technology dynamics in detail. Nevertheless, both systems consider the same elements, differing only in the elements highlighted. In addition, the two approaches overlap in other ways related to actor intervention and functions (e.g. the same actor articulates pressure, the condition for change, in niche-regimes while at the same time coordinating resources for adaptation) [79].

The core issue when moving a city towards a sustainable and resilient stage is the adaptation approach selected: incremental, transformative or transition. The latter represents an intermediate option between the other two opposing options [15]. Proactive preparation for the future will require adaptations that continually alternate between incremental and transformative actions [15], to ensure effective transition.

Regarding top-down and bottom-up approaches, the literature suggests a combination of both as the best option. Incremental adaptations tend to be top-down whereas transformative adaptations can exhibit both approaches. However, the involvement of a wide spectrum of stakeholders and close collaboration with researchers is highly important to successful adaptation [80]. Lastly, the debate is focused on governance (transition management or adaptive governance) and the methods and tools selected to help cities attain sustainability and resilience.

4. Discussion

During the SD exercise, the stakeholders detected the need for a long-term vision as a crucial issue. In turn, this long-term vision would need to be complemented by short-term plans for the cities. The key to achieving this would be to add long-term commitments to the short-term vision guiding the cities towards the defined long-term vision transitioning in terms of both mitigation e.g. energy and adaptation e.g. flooding. In addition, cities should establish partnerships with different actors and initiatives across the different sectors with a long-term perspective [20,74,81–83].

Transition is a very broad concept, rendering it difficult to define precise triggers of change. As we saw in the SD, cities do not have a single transition factor. What cities need to do is to push towards a resilient and staged adaptation considering all the phases and sub-processes involved (understanding, planning and managing). It is of crucial importance to consider the obstacles that cities face regarding adaptation. Although awareness in general (institutional, societal, etc.) has increased in recent years, leading to a better understanding of the effects of climate change, several institutional obstacles to adaptation remain, of a structural, regulatory, contextual and cultural nature [73]. [43] have defined potential barriers in each phase of the adaptation process (which are very much in line with those identified by [73]. The triggers of change should be aligned with the obstacles detected for each phase of the adaptation process in order to facilitate effective and efficient actions and move the socio-ecological and socio-technical systems towards an adapted and resilient stage.

In our SD, the exercises allowed us to collect the stakeholders' first impressions and opinions regarding the usefulness of these concepts. Their responses led us to conclude that while models and science can explain part of the reality of climate drivers and impacts, this information must be verified and validated with stakeholders. In our study, the stakeholders considered the development of an impact chain

to be a positive exercise, and felt that it was crucial to create a vision that was aligned with both local governance and climate issues. They also noted the importance of facilitating the implementation of adaptation actions and the need to push the adaptation process. Last but not least, we also concluded that for triggers of change to be accurately identified, enablers and barriers should be clearly defined.

Our literature review enabled us to define an integrated conceptual framework for transition which adopts aspects from both communities. Some of the steps are not common to both approaches, but must be taken into account due to their importance: envisioning and detection of the triggers of change (Fig. 2).

This model analyses how change can take place and which measures can support the changes. Moreover, the present approach not only captures "top-down" drivers of change but also provides the "bottom-up" local context. The framework enables the design of adaptation strategies and consists of (Fig. 3):

- A system map, in which the impacts on the urban system are analysed, the key problems are detected and normative scenarios are created — also called desirable futures, visions or future visions. In this phase, science meets policy in order to build a vision aligned with local knowledge and governance;
- Selecting adaptation options, where the pre-identified adaptation options that act against the detected problems are characterised, assessed and prioritised. This phase must be conducted using the methods and tools proposed by experts and contrasted with local stakeholders (selection of prioritisation method, selection of criteria, weighting and scoring);
- Planning and implementing, where the adaptation pathway approach is used to define "how", "when" and "by whom", identify the triggers of change for the transition identified and define the monitoring. The pathway approach has emerged in both communities, and represents a solid approach to delineate city transitions.

The transition model is aligned with the Urban Adaptation Support Tool [84], linked to the Mayors Adapt initiative, which provides step-by-step guidance for the adaptation planning and implementation cycles.

The innovative core element of the model is the adaptation pathway approach. The aim of the adaptation pathway approach is to define an iterative and adaptive governance process with the capacity to sequence and implement groups of actions [85]. The pathway provides a flexible and iterative approach for decision-makers (it considers adaptation options to implement in the near future and leaves the possibility of scaling up these options in the future) ([86]. It combines the concepts of timing and effectiveness, where timing refers to when an adaptation option must be activated and the duration of its effectiveness, and effectiveness refers to the extent to which the specific adaptation option reduces the climate change impact. Moreover, the pathway considers the interdependency between these two concepts [81].

The presented transition model aims gaining urban resilience and it is scalable. It can be applied to city or sector level (e.g. energy). Nevertheless, this paper highlights the importance of transitioning the whole city integrating different sectors (e.g. energy, water, transport, etc.) at the same time as they all have common planning and design criteria. The transition model allows the city to change (e.g. in form or function) and achieve a sustainable and resilient cities vision (including energy resilience which should be aligned with the urban resilience).

5. Conclusions

The aim of transition management is to guide the transformation of socio-political landscapes and socio-technical practices together with "the structural character of society" from one equilibrium to another [27]. This governance model focuses mainly on society and technology. However, in practice, there have been limited opportunities to validate TM. Meanwhile, adaptive governance is the process of creating capacity to adapt and transform socio-ecological systems [29]. Adaptive management focuses mainly on the interaction between social and natural dynamics, but also on adaptation through learning which increases the resilience of socio-ecological systems. It is considered more analytical and substantial than transition management (which exhibits a strong process orientation with a focus on sustainability) [34].

Regarding the methods used in studies of socio-ecological systems, some approaches such as adaptive policymaking, adaptation pathways and dynamic adaptive policy pathways produce dynamic, robust plans. The latter has been developed by selecting the best aspects of the other two approaches.

From the literature review, we conclude that both communities have developed useful methods to improve present governance models of the whole city (but also useful for specific sectors like energy or risk management). Selecting the best methods from each (e.g. backcasting techniques, pathway methodology, etc.) and considering different components from each system (e.g. technical system, society, resilience etc.) improves our understanding of the system's response to climate change. Moreover, selecting the best experience from both governance types (TM and adaptive management) helps advance the present governance model.

Lastly, we would like to highlight the importance of triggers of change in this framework that is applicable to both mitigation and adaptation efforts. Triggers of change make it possible to overcome barriers, ensure the success of the action implemented and help move the socio-ecological and socio-technical systems towards a resilient and adapted stage. However, even in transition it is difficult to define precise triggers of change. However the 8 identified triggers should be considered by stakeholders in order to succeed in transition governance and achieve sustainable cities that can reduce the cause of climate change by providing low carbon energy systems and live with the consequences of climate change such as flooding or heatwaves.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.rser.2018.06.003.

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