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Peri-cene Framework

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framework: with tools for analysis
and synthesis of the research

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1 Summary

The Peri-cene project has the challenge of working with a multiplicity of causes, effects and responses. Peri-urban development, climate risk and vulnerability, and adaptive governance and pathways, are complex, contingent and often controversial.

To provide a theoretical structure and practical tools for a wide range of knowledge, we have developed the *Peri-cene Framework*, and its applications through various templates and tools. This provides a practical structure for exploring and mapping not only tangible problems but those of 'deeper complexity'.

This combined Peri-cene Framework is a combination of two main 'Models':

- The '**Causal Model**' follows a mainly functional frame of cause and effect, in direct problems and responses, between four main factors in the peri-urban climate/environment challenge.
- The '**Synergistic Model**' addresses wider systems with deeper complexity and potential for transformation via collective intelligence, with strategic level problems and responses.

Each Model has a role and purpose. The *Causal Model* is a practical place to start to gather data and explore the tangible peri-urban-climate-environment interactions. The *Synergistic Model* is actually more realistic for real-world problems of 'deeper complexity', but more challenging for research and knowledge management, and more suited to a creative process of collaborative (co)-design and dialogue.

The *Causal Model* contains four main themes, or clusters of tangible causes-effects:

- a) peri-urban development and urban / metropolitan / regional spatial systems
- b) climate change physical hazards and risks
- c) climate vulnerability and sensitivity
- d) governance and adaptive capacity

The *Synergistic Model* then builds on the functional version, in three main dimensions

- '**Wider**' communities of stakeholders
- '**Deeper**' layers of value and logic, i.e. social, economic, ecological, political, cultural etc.
- '**Further**' scope of upstream causes and downstream effects

The role of each model is illustrated by a typical example, from peri-urban Manchester, where there is increasing severity of fluvial flooding:

- The *Causal Model* would assess the flood levels and risk of return: and then look at how to build up the local flood defences;
- The *Synergistic model* would include for indirect / strategic factors in the problem, such as the ownership of land upstream: and then explore the indirect / strategic opportunities for response, such as new forms of land stewardship and governance.

In this way the typical '*adaptive pathways*' would generally combine responses from both models:

- Direct / tangible / functional responses, such as building flood defences
- Strategic / systemic responses, such as new forms of land stewardship.

Generally such adaptive pathways will emerge through a process of participative dialogue and co-creation with stakeholders. To help guide this, we use the *Synergistic Toolkit*, a (pre-existing) four part cycle of analysis and synthesis.

To apply both models, the project developed a '20-question' template, for the online reporting, interview structures and spatial mapping layers (a full template is shown in the Annex).

This report begins with an outline of the overall Framework and its two models, with and some theoretical background. It then explores the application of the Framework to each work package of the Peri-cene project:

- (WP1) Overall theoretical and operational framework for peri-urban / climate-environment interactions and adaptive pathways
- (WP2) applications of the framework for spatial analysis and visualization
- (WP3) applications of the framework for international comparisons and online templates
- (WP4) applications of the framework for case study knowledge management and consultations
- (WP5) applications of the framework for exploring governance and adaptive pathways
- (WP6) applications of the framework for the online material and communications.

The Annex contains further details and working templates for fieldwork activities.

2 Introduction

2.1.1 Scope & structure of this report

This report is an outline of the Peri-cene Framework, an analytic and practical toolkit for managing knowledge on peri-urban / climate-environment interactions. Generally the project addresses a complex set of causes, effects and responses, in a wide variety of locations around the world. Peri-urban development, climate risk and vulnerability, and adaptive governance and pathways, are each complex and often controversial.

To manage this large body of information and analysis we have developed the Peri-cene Framework, and its applications through various templates and methods. This provides a practical structure for exploring and mapping a complex set of problems and opportunities.

This report describes the result, both for theoretical-conceptual analysis, and for practical information management. It provides the foundation for the other deliverables in the project.

This report includes:

- Introduction to the scope and background
- Outline of the Framework, as a combination of the 'Basic' model and 'Synergistic model'
- Further notes on the 'Basic' model and 'Synergistic model'
- Applications of the framework through the various project work packages, as above:
 - (WP1) Overall theoretical and operational framework for peri-urban / climate-environment interactions and adaptive pathways
 - (WP2) applications of the framework for spatial analysis and visualization
 - (WP3) applications of the framework for international comparisons and online templates
 - (WP4) applications of the framework for case study knowledge management and consultations
 - (WP5) applications of the framework for exploring governance and adaptive pathways
 - - (WP6) applications of the framework for the online material and communications.
- Annex with further details and working templates.

2.1.2 Overview of the Peri-cene project

Peri-cene explores the links between peri-urbanisation and climate risk / resilience, at scales from global to local. The overall aim is:

To explore the interactions between peri-urbanisation and climate risk, at local and global levels, in order to co-design adaptive pathways towards more sustainable and resilient forms of peri-urbanisation.

With this aim the PERI-CENE works to five specific objectives, (as per the WP structure):

- 1) a framework and typology for (a) peri-urbanization impacts / effects on climate change risk: and (b) climate risk impacts / effects on peri-urban areas, in the frames of risk, vulnerability and resilience;
- 2) a global assessment of peri-urban / climate-environment conditions and trends;
- 3) a comparative and interactive study of peri-urbanisation in the Policy Lab of 20 partner city-regions around the world;
- 4) in-depth case studies, in India and the UK, which explore the deeper dynamics and potential opportunities for peri-urban climate risk interactions;
- 5) a set of adaptive pathways and tools for strategic policy intelligence, for practical solutions which are scalable and transferable.

The project addresses some practical questions, at the appropriate level:

- What are the effects of peri-urbanisation on climate risk?
- What are the effects of climate risk on peri-urban areas?
- How are these interactions shown in different developmental types, urban-regional types, and climatic-biome types around the world?
- What forms of governance can best mitigate the impacts, and steer towards more sustainable and resilient forms of peri-urbanisation?

3 Peri-cene framework: outline

3.1 Overview & background

This framework consists of two 'models' or components:

- The '**Causal Model**' has a simple 4-part structure. It follows a linear systems concept of functional cause and effect, between four main factors: peri-urban, climate risk, vulnerability, and governance. This has limits, but is a practical way to gather data and start to explore the interactions of the peri-urban / climate-environment.
- The '**Synergistic model**' is more realistic for systems of 'deeper complexity' (i.e. where social, technical, economic, environmental, political or cultural layers all interact), and where direct causes and effects are uncertain. However it can be more challenging to gather data for this kind of model, and it involves not only analysis but a creative synthesis. So this synergistic model includes both a conceptual structure, and also a dynamic process for collaborative (co)-design of adaptive / synergistic pathways. (see section 5 below).

Each of these is based on previous research, as in D1-1:

The '**Causal model**' draws on studies on both peri-urbanization and climate risk. The first is mainly the work of the EU project PLUREL (Ravetz et al 2013; Piorr et al 2013), and follow-on urban foresight studies (REGIO 2011: Ravetz 2015). For the second issue of climate risk, this builds firstly on the work of the EU project RESIN, with methods based on the IPCC (2014), and applied to the proposed framework by Connelly et al (2017).

The '**Synergistic model**' builds on the work of Ravetz (2000, 2015, 2020), and also on a wide range of literature on systems thinking, complexity, cybernetics and transitions (Cohen 2012: Cornell 2009: Ackoff 1973, Meadows 2009 etc).

Both the Causal and the Synergistic Models are used to explore and define 'adaptive pathways', which are scaleable and transferable, as the goal of the Peri-cene. For this there is a long literature, (e.g. Smit & Wandel 2006): they are here defined as 'a pathway of intentional change with *deeper* synergies between multiple domains, with *wider* synergies between actors' (Ravetz 2020).

Overall this Framework draws on a wide range of literature, as reviewed in D1-1. In summary some key themes include:

- Complexity and emergence (Waltner-Toews et al 2009)
- Institutional analysis and design for the commons (Ostrom 2004)
- Collaborative planning and governance (Healey 2007)
- Adaptive governance for climate adaptation (Revi et al 2014)

3.2 'Causal Model' outline

There is huge diversity of cause-effect chains and interactions between peri-urbanization and climate risk, vulnerability and adaptation around the world. Each of these can be structured (up to a point) with the 'climate risk / vulnerability framework' (IPCC 2014: Connelly et al 2018).

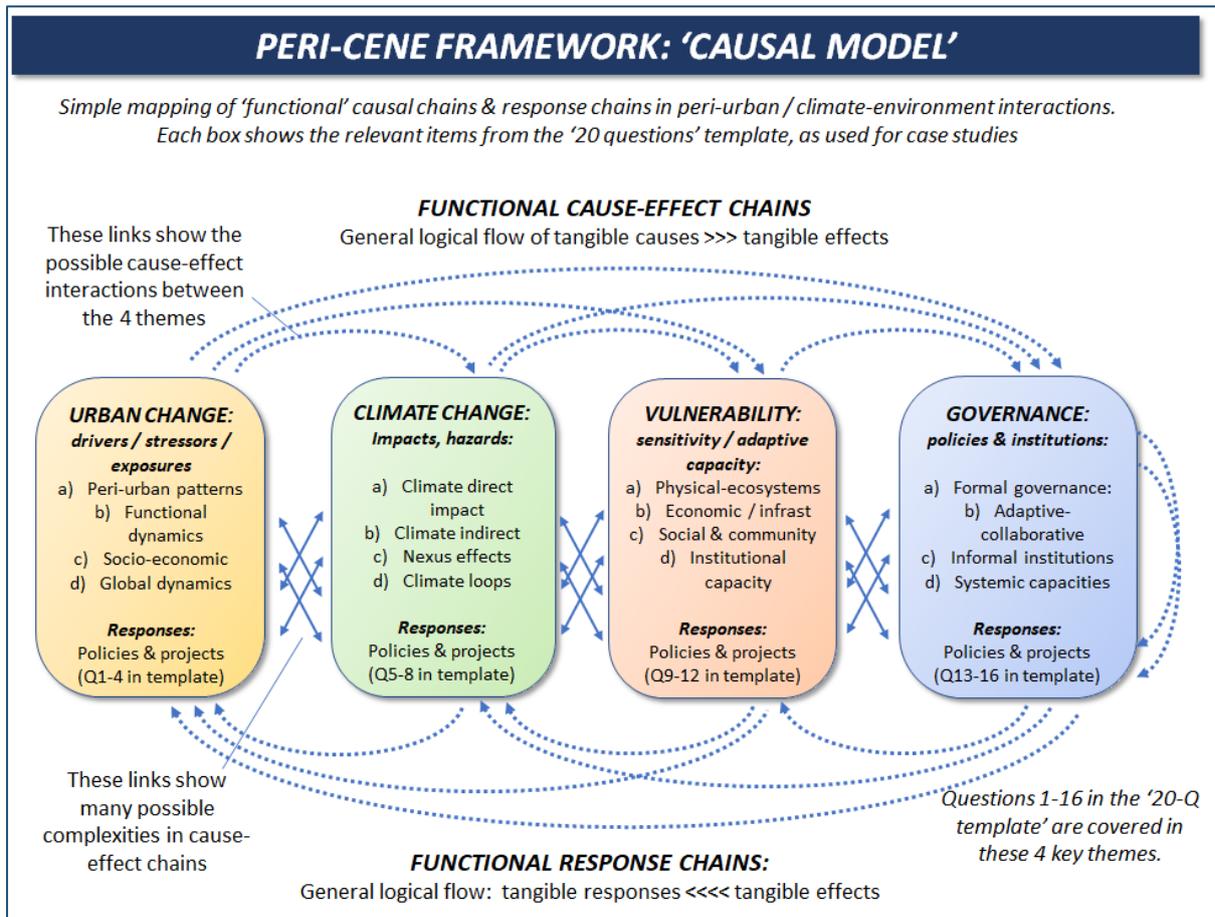
This model was developed for the RESIN project by Connelly et al (2018), as an interpretation of the IPCC 2014 concept model, and then updated here for the larger scope of the Peri-cene project.

This provides a structure for exploring and mapping a very complex set of problems and opportunities. This 'Peri-urban-climate' model is composed of four main themes:

- **SPATIAL CHANGE: drivers / stressors / exposures:** this includes spatial peri-urban types & patterns of urban expansion: spatial peri-urban functional dynamics of techno-economic change: other social and cultural drivers of change: global inter-dependencies:
- **CLIMATE CHANGE: direct / indirect hazards:** this covers direct climate change in temperature, precipitation etc, together with the direct effects of wildfire, heat, drought, flood, coastal sea level rise and storm surges, etc. Indirect impacts then include the multiple and inter-connected hazards of food, energy, land, water, ecosystems, buildings and human health.
- **VULNERABILITY: sensitivity / adaptive capacity:** this theme includes a wide range of capacities in physical and biological capacity: landuse, farming and forestry: social deprivation, health, housing, social cohesion etc: technology / critical infrastructure vulnerability: economic / business / livelihood vulnerability:
- **GOVERNANCE and institutions:** Formal policy & governance, both spatial / economic and other: adaptive institutions, networks, collaborations, partnerships: Informal factors both positive (social innovation etc) and negative (corruption, elite capture etc): Systemic qualities of resilience, adaptive capacity, collective intelligence.

A summary version is shown in Figure 1:

Figure 1: Peri-cene Framework: 'Causal Model'



This shows in the upper part, a variety of functional cause-effect chains or 'impact chains'. There is a general logical flow from urban / climate causes, to effects, to governance conditions: however there are many causal links & inter-connections between the themes (e.g. between urban change and vulnerability). The lower boxes show the tangible and functional responses to such problems, both in governance and policy, and in social, technical, economic, environmental or cultural change. Again this is a huge simplification of a complex reality.

(Example: in the uplands areas north of Manchester there are growing peri-urban settlements in the river valleys, which suffer increasingly severe levels of flood risk due to climate change. This combines with the vulnerability of the landscape due to long term decline of farming and forestry, and the flood events then affect the most vulnerable and least abled populations. The emergencies and long term impacts are exacerbated by the fragmentation and under-funding of local government, and privatization of many public services. In response, the 'Causal Model' focuses on the functional level, of building flood walls and retention basins).

Each of the 4 main themes in this Causal Model is identified in a template with 4 questions per theme. As and where the case studies use this Causal Model, the results can be shown in questions 1-16 of the '20-questions' template. Various applications of the template to the different Work Packages are shown in Section 5 and the Annex.

3.3 'Synergistic model' outline

The above functional model is a practical starting point, but it has limits in understanding or managing with dynamic systems of '**deeper complexity**': this can be defined (as in D1-1), as combined layers of social, technical, economic, political, cultural logic and value, which are irreducible and intractable (Ravetz 2020:265). To understand and manage systems of deeper complexity, and their potential for transformation, we use a *Synergistic Model*. This then extends from the Causal Model, in three main dimensions:

- '**Deeper**' layers of value and logic, i.e. social, economic, ecological, political, cultural etc;
- '**Wider**' communities of stakeholders and communities of interest
- '**Further**' scope of upstream causes and downstream effects.

This extended scope of transformation calls for collaborative (co)-learning and co-creation, as the components of a '*collective peri-urban intelligence*'. Again this will be based on deeper layers of value and logic, with wider communities of stakeholders.

Such transformations can be enabled by '**adaptive pathways**': combinations of governance and policy, with social, technical, economic, ecological, and/or cultural change. Such pathways typically include tangible cause-effect-response chains as in the Causal Model, and the more systemic cause-effect-response chains, as in the Synergistic Model.

Understanding and managing such transformations depends on collaborative processes of mutual dialogue and learning. Here the Peri-cene uses a pre-existing process model, the '**synergistic toolkit**', to help structure this collaborative process (Ravetz 2015; Ravetz et al 2020). The Synergistic Toolkit works in a four stage cycle, summarized as '4-s':

- Systems mapping for problems and challenges;
- Scenario mapping for future possibilities;
- Synergy mapping for ideas, visions, opportunities;
- Strategy mapping for practical road-maps, plans and programs.

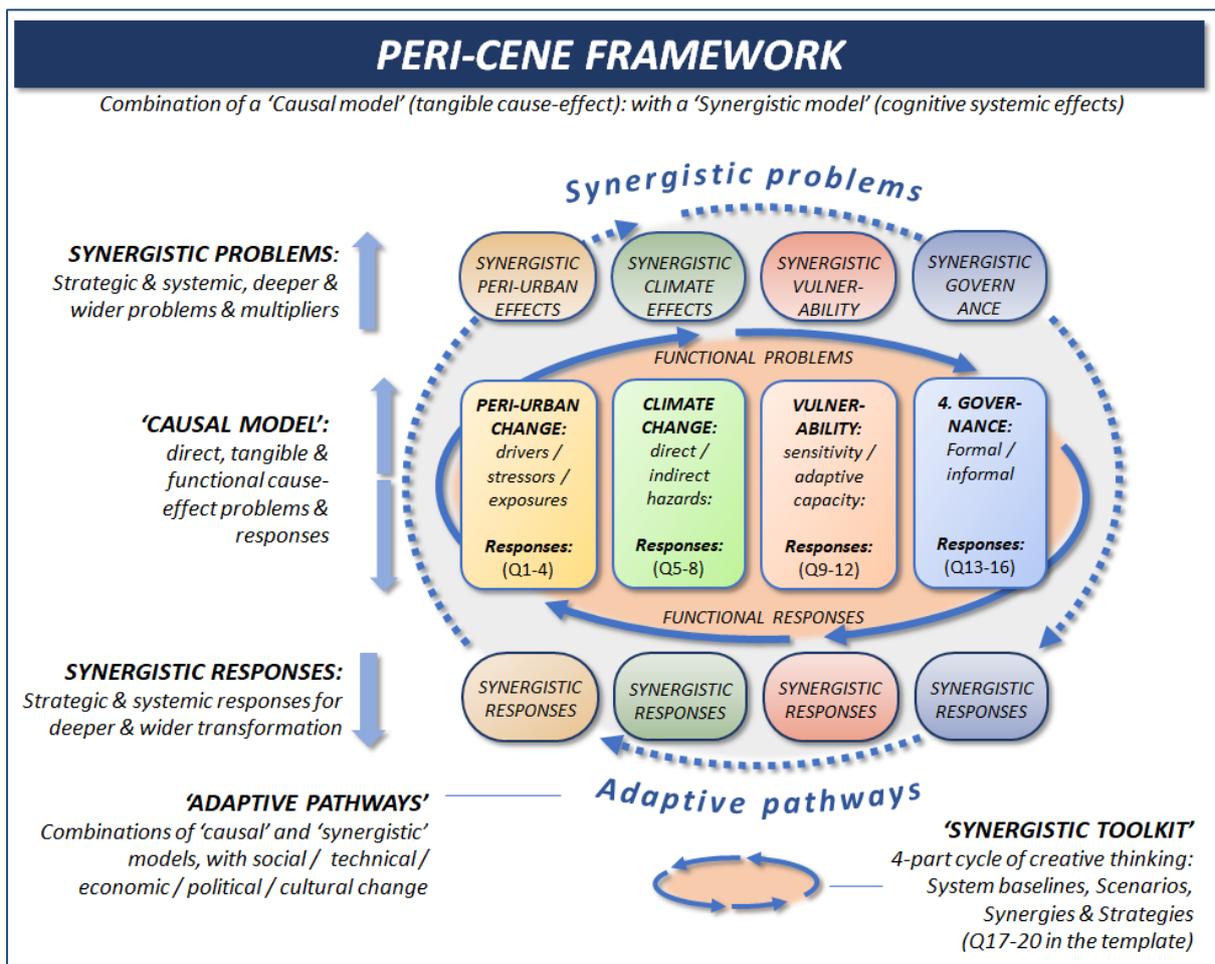
As and where the case studies apply this toolkit, the results can be shown in questions 17-20 of the '20-questions' online template.

Again this is illustrated by example:

(Example: in the peri-urban uplands north of Manchester, the tangible problem of town centre flooding can be traced to more systemic factors, such as the pattern of upstream land ownership, or the fragmentation of local government. In response, the Synergistic Model helps to define more systemic 'adaptive pathways', such as new forms of community land stewardship, and/ or neighbourhood governance. To develop these opportunities calls for collaborative (co)-learning and co-creation, involving residents, businesses, public services, engineers, social workers, local government and others. (details in Peri-cene D4-1b).

In Figure 2 the full Peri-cene framework is shown: this combines the tangible and functional Causal Model, with the more extended and transformational Synergistic Model.

Figure 2: Peri-cene Framework: 'Causal combined with Synergistic Models'



4 Peri-cene framework: theory & practice

This section provides further notes on theory and practice of the Framework and its 2 models: (see literature review in D1-1 for the theoretical background).

4.1 Peri-cene 'Causal Model': notes & applications

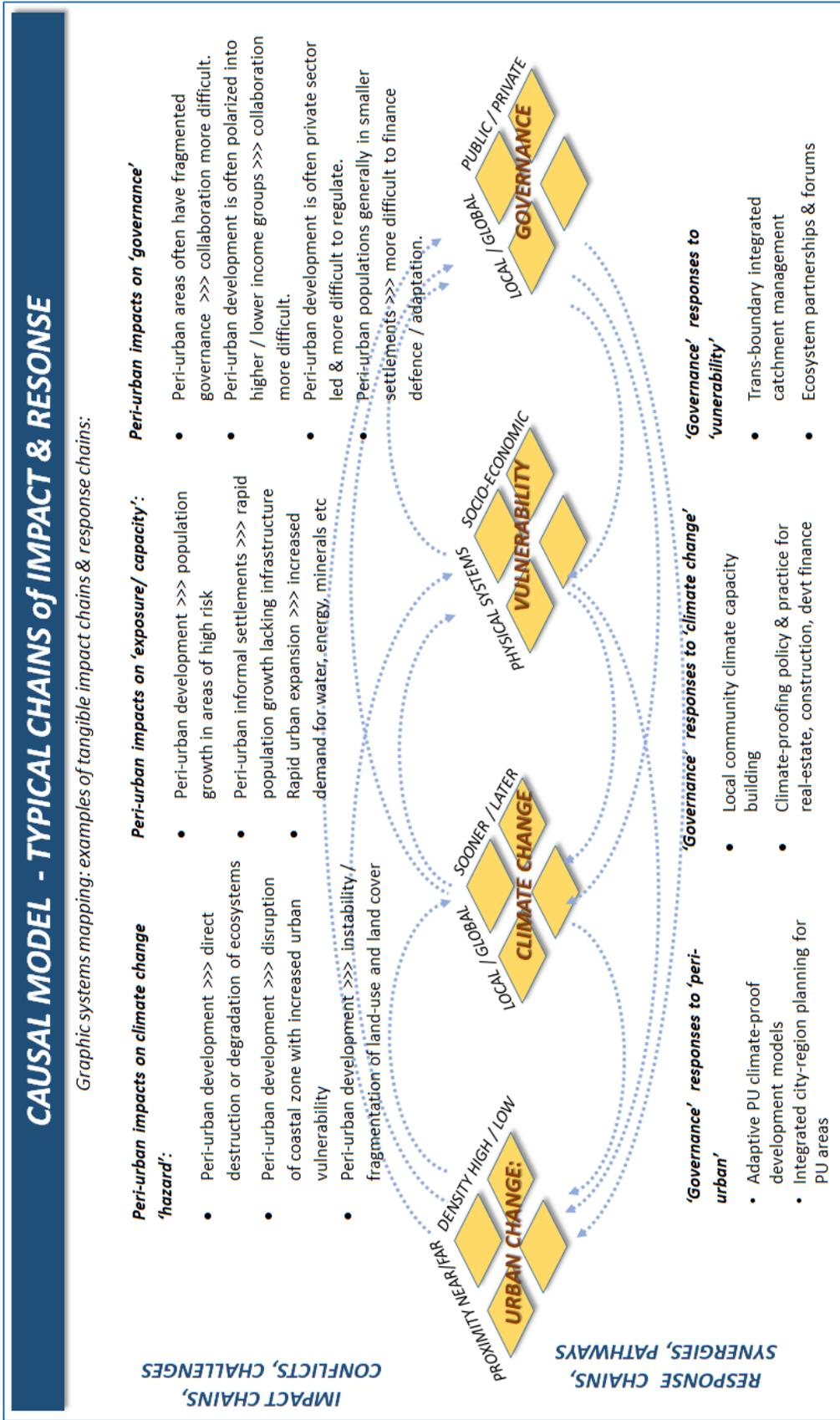
The Peri-cene Causal Model adapts the IPCC's (2014) climate risk conceptual framework, to include for the theme of peri-urban expansion and change. This framework considers climate risk to be a function of (climate) hazard, exposure to that hazard, and vulnerability to that hazard. Vulnerability is further divided into two components: sensitivity and adaptive capacity. (The IPCC definitions are provided in D1-1). The climate risk framework, which specifically separates out exposure, has been demonstrated to be particularly useful in terms of spatial planning and in helping practitioners to think through the potential ways that they can adapt to climate risks and increase resilience (Connelly et al. 2018). The Peri-cene case studies, with a focus on adaptive pathways and collaborative governance approaches, connect to the 'adaptive capacity' dimension of the climate risk framework.

The Peri-cene Causal Model further develops the climate risk framework, by outlining factors that are particularly relevant in peri-urban areas. Here, climate change hazards interact with receptors (e.g. people, infrastructure, landscapes) which become exposed to the hazard (e.g. flooding). Spatial changes influenced by drivers and stressors related to changing peri-urban types, patterns and dynamics, increase or reduce exposure of receptors to climate hazards (e.g. by increasing or decreasing impermeable surface cover). Vulnerability factors exacerbate or attenuate overall levels of climate risk. Actions can also be put into place through governance arrangements (e.g. formal government and regulation, informal networks, adaptive-collaborative partnerships and other institutional collaborations), to build adaptive capacity to influence each of the climate risk components. Whilst the model shows a logical flow between each element of climate risk, it is important to emphasise that such models can be too simplistic and reductive. The arrows between each component in Figure 1 are intended to emphasise that there are multiple interconnections between the elements of the model.

4.1.1 Mapping typical cause-effect chains

This 4-part Causal Model can be used to map the typical causal chains, which link the peri-urban development with climate change risk and adaptation. Such linkages can be identified in a number of ways, structured as "peri-urban development impacts on hazard, exposure, vulnerability / capacity, or governance": (based on the IPCC risk framework, as above). Each of these can (in principle) be traced on a variation on the Causal Model diagram in Figure 3. The aim here is not to replace more detailed and complex causal chains or systems diagrams, but to provide a common basis for summary and comparison between case studies, or between different cause-effect-chains in the same case study.

Figure 3 : Causal Model: typical chains of cause-effect-response



This is the summary of the above typical cause-effect chains, (as summarized in *Figure 3*). Note these are typical or generic causal chains, representing a wide range of situations around the world, distilled from a wide range of literature, which is summarized in D1-1. Each chain links between two or more of the 4 themes of the Causal Model.

A more analytic matrix to structure this information is shown below in section 5.

Peri-urban impacts on climate change 'hazard':

- Peri-urban development >>> direct destruction or degradation of ecosystems (forests, water bodies, soils, mangroves etc) which would otherwise protect urban areas from climate-related events or stresses.
- Peri-urban development >>> disruption of coastal zone with increased urban vulnerability to sea-level rise, salination and other problems
- Peri-urban development >>> leads to instability and fragmentation of land-use and land cover, with loss of ecosystems services

Peri-urban impacts on 'exposure':

- Peri-urban development >>> population growth in areas of high risk (fire, flood, landslides, cyclones, coastal zone etc)
- Peri-urban informal settlements >>> rapid population growth lacking infrastructure or defences, often with displaced communities and vulnerable livelihoods
- Rapid urban expansion >>> increased demand for water, energy, minerals, waste disposal & other urban resources >>> increased scale and potential vulnerability.

Peri-urban impacts on 'adaptive capacity':

- Peri-urban development >>> increased dependency on critical but vulnerable infrastructure (i.e. car dependency)
- Peri-urban development of enclaves >>> high social vulnerability (e.g. seniors, low income resettlement)
- Peri-urban development >>> lowers the overall population density so that building defence or adaptive capacity is more difficult (e.g. isolated dwellings in fire risk zones).
- Peri-urban economic development >>> displacement, disruption or bypassing of lower income rural livelihoods and communities >>> increases social & ecological vulnerability.

Peri-urban impacts on 'governance'

- Peri-urban areas generally have fragmented governance in political units which do not fit with ecological zones >>> collaborative governance is more difficult.
- Peri-urban development is often more polarized into higher / lower income enclaves >>> collaborative governance is more difficult.
- Peri-urban development is generally private sector led and more difficult to regulate or coordinate.
- Peri-urban populations are generally in smaller settlements and/or lower density >>> more difficult to finance defence / adaptation.

4.1.2 Causal Model: common typologies

Clearly there are many kinds of peri-urban expansion, many types of vulnerability or governance, and so on. Each of the four main themes of the Causal Model can be shown as a matrix of possible variations, or a set of common types, shown in outline in Figure 3. For each theme two main axes have been identified, which provides the simplest possible mapping of the typical range for each theme (with further details are in the Annex). The typologies include:

- **Peri-urban:** Proximity to urban (near / far): Density of population: (low / high)
- **Climate change:** Spatial scale (local-direct / external-indirect): Time horizon (shorter / longer term)
- **Vulnerability:** Physical ecosystems & infrastructure: (organized / fragmented): Socio-economic: (organized / fragmented)
- **Governance:** Scale: (local & internal / global & external): Structures (public-social values / private-techno-economic values)

These are visualized with examples in the Policy Lab documentation, D3-1.

4.1.3 20-questions template:

Each of the 4 main themes in this Causal model is identified in a template, both online and in tables. Each theme is summarized in 4 questions, and with a further 4 questions on the Synergistic model, there is a total of '20 questions'. The full template is shown in the Annex with a worked example. There are various applications of this basic template, in each of the Work Packages, as detailed in the next section:

- Information management with online access
- Comparison of case studies, or of areas within one case study
- Linking text with maps or indicators or other data
- Interview structure and sample questions for case studies

4.2 Synergistic model – notes & applications

This section provides further notes on the theory and practical applications of this model: (for more see the practical guidance on www.manchester.ac.uk/synergistics and Ravetz 2015 and 2020)

4.2.1 Context

Clearly the peri-urban is hugely complex: climate change risk and adaptation is also complex, as are the countless interactions between. The Peri-cene project is not intended to analyse every possible interaction in cities around the world, but instead, it aims to provide an overview, the 'forest for the trees', and a comparison between multiple cases. It also provides an opportunity to compare the inter-connections and dialogue between different case studies, with different framings of problems and opportunities.

The Synergistic methods of mapping and design provide a conceptual foundation and practical toolkit for understanding and managing systems of 'deeper complexity' (Ravetz 2020). These are defined as multiple arrays of complex emergent systems, as per the 'STEEPC' menu (social, technical, economic, environmental, political, cultural etc), which cannot be reduced to one analytic theory or concept (Waltner-Toews et al 2009).

Then we need to look at the dynamics of this whole system (i.e. its ability to respond to pressures and challenges) and to design opportunities and problems via 'adaptive pathways'. For example 'Resilience' is a topical system condition, very relevant to the Peri-cene, but critical questions can be asked – resilience to what, for whom, where and when? (White & O'Hare 2016). For the UN Sendai Framework, resilience is defined as: "*The ability of a system, community or society exposed to hazards to resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.*" (UNSDR 2011) But if the '*community or society*' here is based on inequality and exploitation, this 'functional' or 'bounce-back' frame of resilience would simply return to the same gaps in power and wealth. For instance, high income home-owners in a peri-urban flood risk zone, with more resources and influence, would aim to channel the floodwaters downstream to other lower value areas: in this way risk / resilience is not only a functional 'engineering question' but a socio-political question (Beilin & Wilkinson 2015).

This example highlights the challenge for the Peri-cene. The analysis might frame the risk / resilience as an engineering question, with maps and quantitative data, but missing any bigger real-world picture (as in the *causal model*). Or it can frame the risk/resilience as a socio-political question, where knowledge is typically uncertain and contested, and where forward pathways depend on participatory dialogue and co-creation (as in the *synergistic model*). The Peri-cene Framework recognizes that both approaches are valid and necessary, within the limits of time and resources.

4.2.2 Framing problems and responses

The Synergistic general approach extends the frame of the chains of causes-effects- responses: as above, a typical flood risk situation is both an issue of water levels and flood walls, and also a bigger picture with human systems of governance, investment, information and skills, cultural learning and so on.

The Peri-cene Synergistic Model helps to explore and map this kind of bigger picture, by systematically looking '*wider, deeper and further*' than the Causal Model. This includes:

- '**Wider**' synergies between the **actors** of the system, (stakeholders, organizations, institutions, etc): this would work with '*actor mappings*', of the inter-connections and power structures of the stakeholders around the table.
- '**Deeper**' synergies between different value systems: social, technical, economic, ecological, political, cultural etc. (as in 'STEEPC'). This is also about different kinds of logic and knowledge – 'know-what, know-how, know-who' etc.
- '**Further**' synergies between the '**factors**' of the system: upstream causes, (literally up-river in the case of flooding), and downstream effects (downriver which gets the impact of our actions). The Causal Model above is structured as a '**factor mapping**' of the tangible part of the problem. To extend from the Causal

Model, questions can be asked on the root causes of peri-urban expansion, and the causes of those causes: and then similar questions on the extended downstream effects.

The synergistic general approach then provides a structure, both theoretical and practical, for different levels of cognitive systems (Ravetz et al 2020):

- **Functional** and **'Evolutionary'** systems are framed by tangible causes and effects, with responses mobilized by competition and innovation. These are described in the Peri-cene Causal Model;
- **Co-evolutionary** systems are those described in the Peri-cene Synergistic Model. These are based on a wider / deeper / further scope of systems transformation. This can be explored by collaborative (co)-learning, thinking, co-creation and co-production between all stakeholders. Each of these are components in an emerging *'collective peri-urban intelligence'*, i.e. the capacity of all stakeholders to learn, think, co-create and co-produce, in response to the peri-urban / climate challenges.

(For example: the Kachipedu project in peri-urban Chennai works with local unemployed and disaffected youth, to restore the local water bodies and their ecosystems. This is an engineering task of managing vegetation and water (an 'eco-technology pathway'). It is also a human task of mobilizing young people, typically alienated and entangled with gangs, and re-connecting them with their community (a 'socio-cultural pathway'). The Peri-cene Causal Model identifies the water engineering: while the Synergistic Model explores the more human side of the transformation. Overall this combined approach demonstrates an 'adaptive pathway', which helps build resilience to drought, flood and future climate change, together with combined social, economic, political and cultural co-benefits (details in Peri-cene D4-1a).

4.2.3 Adaptive pathways

The so-called 'adaptive pathway' is the key concept / insight of the Peri-cene Framework. This overlaps with the concept of 'transition pathways', and its context in transition theory and management. (See the literature review D1-1 for background and citations). Synergistic thinking then offers a way to integrate the two concepts, otherwise titled the 'synergistic pathways'. In the Peri-cene framework, such 'pathways' can be reported in summary form, at the final stage (#20) in the '20-question template'.

- An **adaptive pathway** is a general approach to decision making under deep uncertainty, with multiple time steps, multiple stakeholders, multiple values and frames, and multiple conflicts (Haasnoot et al 2019)
- Also defined as 'structured approach for designing climate adaptation policies based on the concepts of Adaptation Pathways, Adaptive Policy Making, and Real Options Analysis. Such an approach results in incorporation of flexibility that allows change over time in response to how the future unfolds, what is learned about the system, and changes in societal preferences.' (Buurman & Babovic 2016).
- For climate change, *'adaptation pathways'* is a planning approach addressing the uncertainty and challenges of climate change decision-making. It enables consideration of multiple possible futures, and allows analysis/exploration of the robustness and flexibility of various options across those multiple futures. (SW Australia Climate Change 2018:
http://www.swclimatechange.com.au/cb_pages/adaptation_pathways.php

In parallel the '**transition pathway**' concept has emerged as a useful way to understand systemic change and evolution, particularly for technology / infrastructure systems such as energy or transport, and the climate mitigation agenda. Some key concepts are also relevant to the Peri-cene:

- Multi-level perspective, which looks for 'niches, regimes and landscapes' at different levels of systems, sub-systems and super-systems (Schot & Geels 2005)
- 'Transformative innovation', which compares conventional R&D, systems of innovation and transformative change (Schot & Steinmueller 2018)
- 'Sustainability transitions pathways', which highlight and address the challenges of governance, participation, conflicting worldviews and objectives (Turnheim et al 2015; Ravetz 1999).

For the Peri-cene, the '**synergistic pathways**' approach is proposed. This can help to integrate the above, respond to the complexity of both peri-urban and climate systems, and provide a practical mapping of ways forward (Ravetz 2020; Ravetz, Neuvonen & Mantysalo 2020). This approach extends the above concepts, 'wider - further - deeper':

- 'Wider' synergies between extended communities of stakeholders
- 'Further' synergies of upstream & downstream in impact chains, value chains, policy chains
- 'Deeper' synergies between domains (social, economic, technical, ecological, cultural etc).

Overall, a *synergistic pathway* is a journey of mutual learning and collaboration with all involved: it aims to turn potential synergies, towards practical reality. This is not only a technical but creative and learning process, which calls for design thinking and similar methods. And most important, the multiple system change level or 'modes' work side by side:

- *Mode-I* functional or clever pathways focus more on technical issues and analysis: for instance, the Low-Carb City could do technical pathways with energy or economic modelling.
- *Mode-II* smart pathways are more about transition by evolution, innovation, incentives and competition. Some pathway projects build on the technical by exploring which policies or social changes could make the models more realistic and workable.
- *Mode-III* 'wise' or *synergistic pathways* explore the potential transformation via collective intelligence. The Peri-cene *synergistic pathways* look *deeper* and *wider*, at the integration of policies, technologies, markets, social networks and cultural waves.

IN simple terms, these *synergistic pathways* can be defined by the synergies or value-added between two or more domains. For example the pathways in the example below include the combinations of socio-economic 'livelihood', and ecological-political 'stewardship'. The logic here is quite practical: as problems tend to appear between domains (economic versus environmental limits, or political versus social goals), we look for pathways or opportunities in those same overlaps, to generate shared value between social, economic, political and so on.

There is a strong linkage / overlap between adaptive pathways and adaptive governance, with different definitions on the framing, which can be discussed:

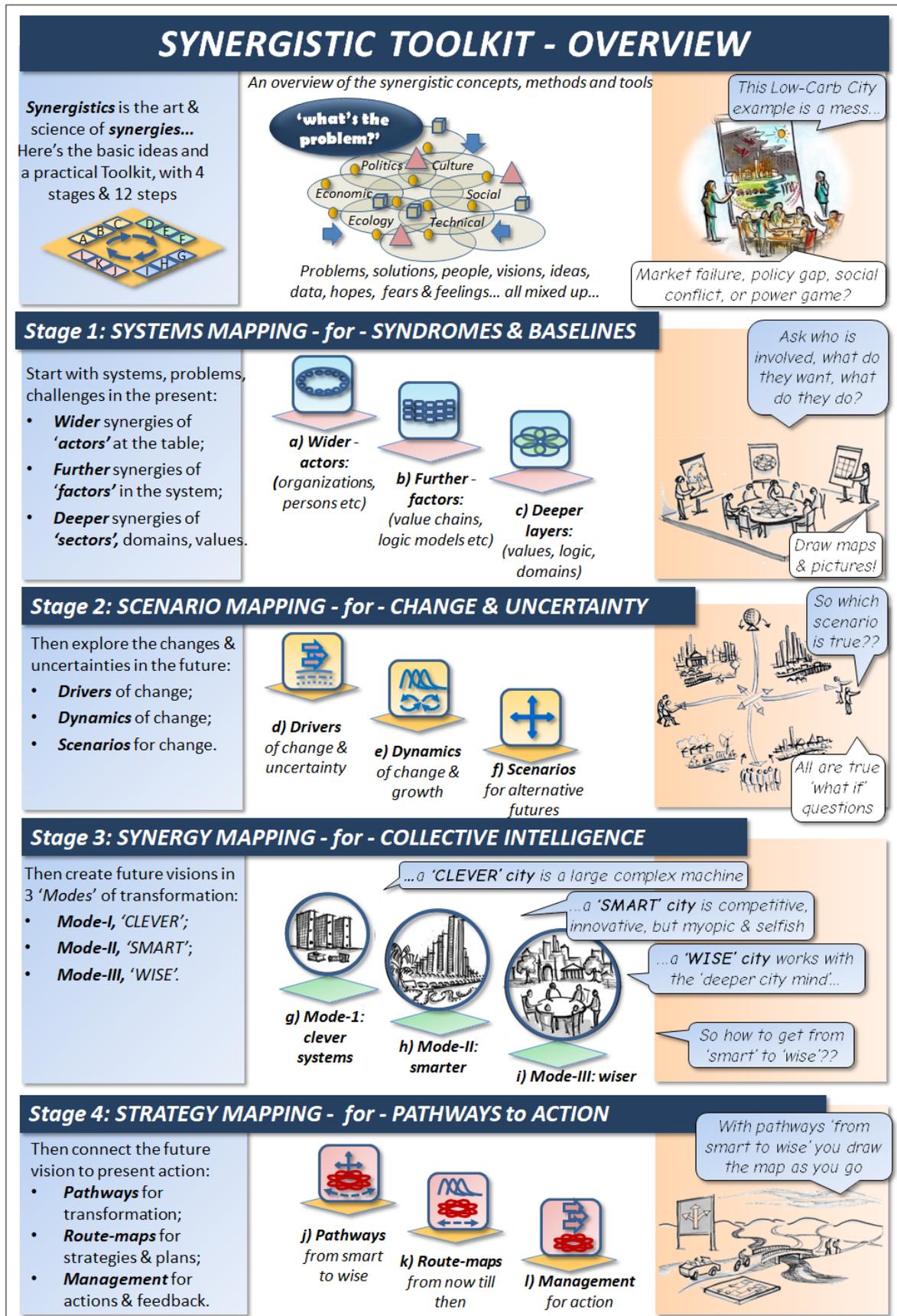
- adaptive pathways include adaptive governance along with adaptive technology change, social change etc, which may be autonomous or exogenous;
- adaptive governance is the overall intentional and strategic coordination of adaptive pathways, which include technology change, social change etc.

4.2.4 Synergistic toolkit

Exploring the potential for such co-evolution and transformation is a process of mutual learning and deliberation between all stakeholders. To help structure and guide this process, the Peri-cene uses a pre-existing Synergistic Toolkit (Ravetz 2020) The Synergistic Toolkit helps to explore and enable 'collective intelligence' and its application for adaptive pathways, which depend on collaboration between many organizations, institutions, supply chains or value-chains, business / enterprise models, networks or communities.

To explore the potential for collective intelligence, involves a dynamic process of creative thinking, and collaborative co-design / co-production. For this the Synergistic Toolkit provides a flexible set of techniques, with 4 stages, each with visual systems mapping format. Each of these stages is reported in the questions 17-20 of the Peri-cene '20-questions' template. Figure xxx shows the

Figure 4: Synergistic toolkit - overview



- a) **System mapping:** the baseline syndromes, issues or challenges on the table: includes the 'wider-deeper-further' boundaries above. The Peri-cene explores the problem of peri-urbanization and its interaction with climate change.
- b) **Scenario mapping:** the drivers of change & alternative futures. The Peri-cene looks at future trends and projections for peri-urban and climate change, and then at alternative scenarios. (see next section for the scenario structure).
- c) **Synergy mapping:** design of opportunities, synergies, innovations: includes the transformation from functional to 'co-evolutionary' in the scheme above. The Peri-cene second phase uses techniques of synergy mapping, to explore the vision and potential for adaptive pathways.
- d) **Strategy mapping:** design of practical plans, road-maps, policies & projects, (this can use mainstream methods). The Peri-cene final stage aims to focus the visions and opportunities into practical 'adaptive pathways', which are comparable, transferable and scaleable.

Visual thinking is at the centre of the synergistic methods and tools (Ravetz 2013). The Synergistic Toolkit Guide (online) provides a series of visual templates and typical questions for debate, for each of the 4 stages above. These visual templates provide a practical structure for building and visualizing complex information, i.e. concept maps / systems maps / *deeper-mind* maps (these are different to *mind-maps*, as they focus on problems of deeper complexity).

5 Applications of the framework

This section charts out the proposed application of the Framework in each of the Peri-cene work packages: spatial analysis, international comparison, local case studies and governance / pathways.

5.1 WP1: further notes on the framework

This summary table takes the diagram mapping of impact chains and response chains (Figure 3), and puts into a more systematic matrix of interactions.

Table xxx: Causal model: generic interaction matrix

<i>FROM...</i>	<i>TO... Peri-urban change</i>	<i>Climate change</i>	<i>Vulnerability / capacity</i>	<i>Governance</i>
<i>Peri-urban change</i>	Internal peri-urban interactions	Effect of peri-urban on climate impact	Effect of peri-urban on vulnerability	Effect of peri-urban on governance
<i>Climate change</i>	Effect of climate change on peri-urban	Internal climate change interactions	Effect of climate change on vulnerability	Effect of climate change on governance
<i>Vulnerability / capacity</i>	Effect of vulnerability issues on peri-urban	Effect of vulnerability issues on	Internal vulnerability interactions	Effect of vulnerability issues on
<i>Governance & pathways</i>	Effect of governance on peri-urban	Effect of governance on climate change	Effect of governance on vulnerability	Internal governance interactions

5.2 WP2: spatial analysis

The most common and available spatial mapping themes for the '20 questions' template, are summarized here. A more complete listing is shown in the Annex.

Table xxx: summary of spatial mapping layers for the 20 questions template

THEMES	BASELINE DATA	HISTORIC / CHANGE / PROJECTIONS
URBAN MAPPING:		
Population density	Polygon / 1km /250m?	1975, 1990, 2005 Change 1990/2015
Proximity / gravity field	Polygon / iso-contours	
Built up density	30m landsat	Change 1990/2015
Land use & land cover:	Global 250m	<i>Change 1990/2015?</i>
Standard 'basemap' combined overlay	Density / gravity contours / landsat	
CLIMATE MAPPING		
Flood event / risk	Local data	<i>Future projection??</i>
Sea level surge / rise	Global 250m	Future projection 2050/80
Water systems	Local data	
Wildfires / landslide etc	<i>Global 250m?</i>	
VULNERABILITY		
Poverty / deprivation	Local polygons	
Critical infrastructure	Global data?	
Forests / GI	Local data?	
Topography / slope	Global data?	
GOVERNANCE		
Admin boundaries	Local data	
Green belt / protected	Local data	
(Strategic spatial plans??)	Local data?	

5.3 WP3: international comparison

For the international comparison in the Policy Lab of WP3, each case study will be assembled with a full 20 question template: but the comparison between different cities may be more practical with just the summary 'overview' rows. (note there are questions on how far one large city-region can be generalized, or whether to keep the diversity of zones and locations).

The online version enables the building of custom tables for such summaries, between cities or peri-urban types, or climatic types. An example could be as follows (using the online colour coding of themes):

Table xxx: international summary comparison (example)

	CHENNAI	MANCHESTER	MELBOURNE
Spatial framework: (drivers / exposure)	Rapid urbanization of edge & near rural Peri-urbanization of further rural Rural-urban migration, mainly unplanned	(N&E) river valley development (S&W) urban edge development, some large extensions	Surplus of interior land, extensive road network, most population on S&E coastal strip.
Climate-environment (causes / hazards):	Growing water demand, reducing resources Local food shrinking	(N&E) impacts on vulnerable landscape (S&W) impacts on farming	Each state is mainly self-sufficient Fossil fuel legacy
Social-economic drivers / sensitivities ('STEEP')	National modernization & global value chains socio-eco transition to middle income digital / infrastructure transition	(N&E) post-industrial economy in transition (S&W) farming in flux: commuter in migration: extreme wealth enclaves	Decline / selling off farming economy Complex agri-debt structure Social aversion to dense urban
Adaptive – collaborative governance	Growth in education, digital, open democracy	(N&E) fragmented & shrinking governance (S&W) pressures of affluence & polarized society	Strong state under shrinkage & polarization
Synergistic model:	Some seeds emerging	(N&E) new synergistic enterprises / networks	New modes of civil society

5.4 WP4: local case studies

5.4.1 Local case studies template

A further application of the template is to represent some of the diversity of local examples in each city. Again this uses the 'overview' rows in each of the main themes. Further details can be as text, images, charts or maps, which can be linked to the main template, as popups. The example is the IET from the Manchester case:

Table xxx: summary table for local initiatives (example)

	SCOPE & TOPICS	EXAMPLE: SOUTH PENNINES
LOCAL CASE STUDIES		
		"INCREDIBLE EDIBLE" EXAMPLE
PERI-URBAN	<ul style="list-style-type: none"> <i>Spatial patterns, urban form & design, settlement types</i> 	Under-used land, small settlements, former industrial towns, steep valley sides, barren uplands.
<i>MAPS / INDICATORS</i>		
CLIMATE HAZARD / RISK	<ul style="list-style-type: none"> <i>Flood, storm, drought, heat, fire, sea level, etc:</i> 	Pluvial / SW flooding: upland fires: decline of local farming
<i>MAPS / INDICATORS</i>		
VULNERABILITY / CAPACITY	<ul style="list-style-type: none"> <i>exclusion, inequality, social change : infrastructure, ecosystems</i> 	Rebuilding soil & ecosystems resilience: community cohesion: links to local economic devt
<i>MAPS / INDICATORS</i>		
ADAPTIVE GOVERNANCE	<ul style="list-style-type: none"> <i>Regulation / planning / fiscal policy: collaborative / deliberative / social learning governance</i> 	Local government finds land, connects to public services: self-organized community action. Many new forms of synergy between actors. Various splits & arguments under the surface.
<i>MAPS / INDICATORS</i>		
PRACTICAL ISSUES	<ul style="list-style-type: none"> <i>Program time, cost, location, people, outcomes etc.</i> 	Project started in 2007: now operating 3 strands, production, innovation, promotion: around 100 people actively involved: around 300 'incredible' sister projects around the world.

5.4.2 Practical questions on local case studies

There are also practical questions on local examples of adaptive / synergistic action (governance, pathways, policies, programs, projects etc): where, who, how much, etc. These in some cases can also use a similar template based on the synergistic model. A simple question such as 'how much did the project cost' may be a simple amount: or it may be a longer story of investments, collateral, partnerships, contingencies and so on. This can then be put in context with other contributions, social or ecological value, indirect benefits etc.

Figure xxx: practical questions for local case studies

PROJECT / POLICY OUTLINE	Causal model (Linear / Evolutionary effects)	Synergistic Model (Co-evolutionary effects)	LEADING QUESTIONS
			From KTH
Who is involved?			
Where: spatial area / relationships?			
How: methods of policy & delivery?		i	
When: time horizon & program?			
How much: cost / benefit / resource?			
What outputs / outcomes?			
Why: higher goals & implications?			

5.5 WP5: governance

For the complexity of the peri-urban-climate model we need to frame governance (adaptive / non or mal-adaptive), as a system of institutions / relations, not only as a specific project or policy. The 20 questions template then shows four sub-divisions of a wider & deeper governance system:

Formal government:

- Spatial planning, property institutions, green belt etc: / Housing policy / Infrastructure development

Collaborative / adaptive governance:

- Public sector / Private sector / Civic sector /Citizens etc

Informal governance: note this theme is still under debate and problematic in some ways: – see the D5-1 and other reports:

- Informal land-use, settlements / Corruption & nepotism / Social innovation & enterprise

System effects, resilience, collective intelligence

- Social learning & collaboration / Social co-creation & mobilization potential / System transformation potential

See the D5-1 for examples of how this works in practice.

5.5.1 Adaptive Governance template:

This template is an extension of the governance theme in the main 20 questions template. It includes for further definition of 'horizontal' / sectoral, and 'vertical' multi/ -level structures. It then includes for key words and concepts as defined by KTH, as part of D5-1.

The template puts the Causal Model and Synergistic Model results side by side: from experience, case study dialogue will include a combination of both.

Table xxx: governance theme & synergistic model analysis

	<i>Causal model (Linear / Evolutionary effects)</i>	<i>Synergistic Model (Co-evolutionary effects)</i>	LEADING QUESTIONS
		EMERGENT, TRANSFORMATIVE, SYNERGISTIC:	<i>Does the policy / project lead towards transformative action?</i>
FORMAL GOVERNANCE: 'Deeper' policy & agenda formation	<i>Linear problem-fixing, materialist, myopic.</i>	DELIBERATIVE / RESPONSIVE	<i>What types of expertise / knowledge are used? Is there integrative (cross-sectoral) multi-hazard approach?</i>
FORMAL GOVERNANCE: 'vertical' multi-level integration	<i>Command & control / power & conflict.</i>	MULTI-LEVEL	<i>top down VS bottom up: conflict or synergy? responsive to local needs & opportunities?</i>
ASSOCIATIVE / ADAPTIVE GOVERNANCE: 'horizontal' integration of stakeholders	<i>Command & control / power & conflict.</i>	ASSOCIATIVE / INCLUSIVE	<i>Stakeholder conflict management? Stakeholder synergies formed & maintained?</i>
ASSOCIATIVE GOVERNANCE: 'Further' integration of policy & services	<i>Fragmented & privatized services /infrastructure.</i>	CO-PRODUCTION, SOCIAL LEARNING	<i>Is the service responsive, innovative, learning? Risk management? Sharing of costs / benefits?</i>
'INFORMAL GOVERNANCE' dynamics of informality / formality	<i>Inequality, exploitation, corruption</i>	COLLABORATIVE / CREATIVE:	<i>How are informal claims on land & resources managed? negative informality / corruption? What positive kinds of informality can be seen?</i>

6 Annex

6.1 Synergistic Model: visual systems mapping

Visual systems mapping is possibly the best way to work with the synergistic model, as shown in the '12-step synergistic toolkit' in section 4. The guidance on such visual thinking follows a common format, where functional / evolutionary systems are shown on the left of the page, and synergistic / adaptive systems of collective intelligence are shown on the right (Ravetz 2020). Where space allows then the likely 'pathways' from one side to the other can be sketched, in terms of value-chains and cycles for typical combinations of actors, factors or sectors. Here we show examples for three of the four themes of the Framework:

- Peri-urban development: framed (on the left) as a typical system of disorder and transition – with pathways towards a synergistic model of inter-connection (on the right)
- Climate hazard and adaptation: framed (on the left) as a dysfunctional linear mindset – with pathways towards a synergistic model of joined up thinking (on the right)

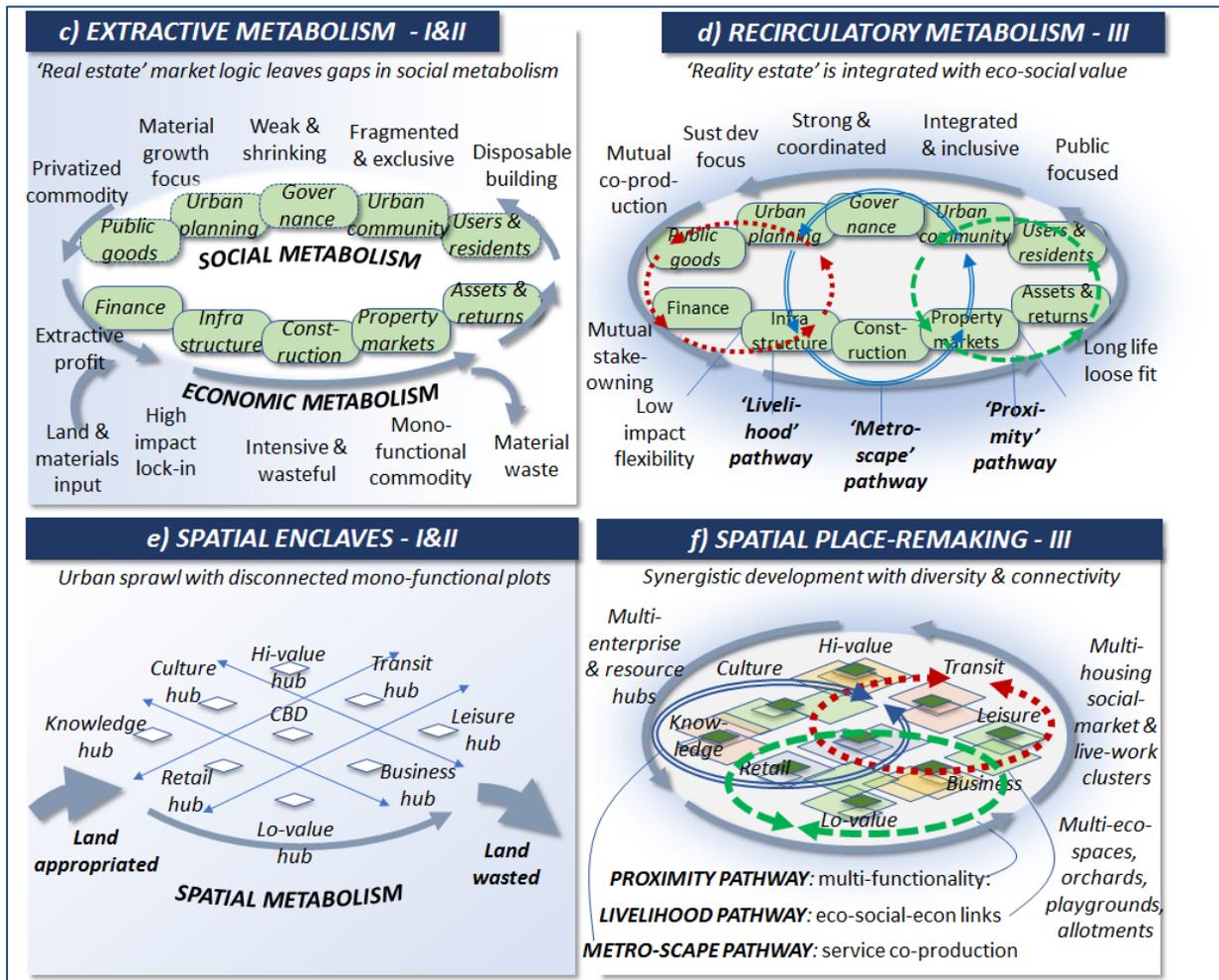
In both these examples, the Peri-cene Basic Model describes mainly the left-hand diagrams of linear / evolutionary systems, and their typical negative effects. The Synergistic Model describes the right hand diagram of more inclusive, intelligent systems: and the typical 'pathways' which lead from one model to the other.

6.1.1 Peri-urbanization: synergistic mapping

For example: a mapping of peri-urbanization in Figure xxx includes two layers, each illustrating from left to right, the pathways from urban sprawl to a sustainable city-region

- Upper diagrams show the 'metabolism' of land-use development, i.e. the process of metabolizing land, finance, materials etc, into finished real estate, with its many economic benefits and social / community impacts;
- The lower diagrams show a spatial system: on the left we see fragmented sprawl without structure or local synergies: and on the right, a structured system with many potential synergies of land-uses and livelihood.
- For the transformation from extractive / exclusive models, towards recirculatory / inclusive systems, there are a range of 'pathways'. Each pathway is a process of mutual learning between stakeholders, to co-create new value-synergies between multiple domains. For example the 'livelihoods pathway' looks for opportunities to combine economic growth and social well-being.

Figure 5: Synergistic visual systems mapping: peri-urban development

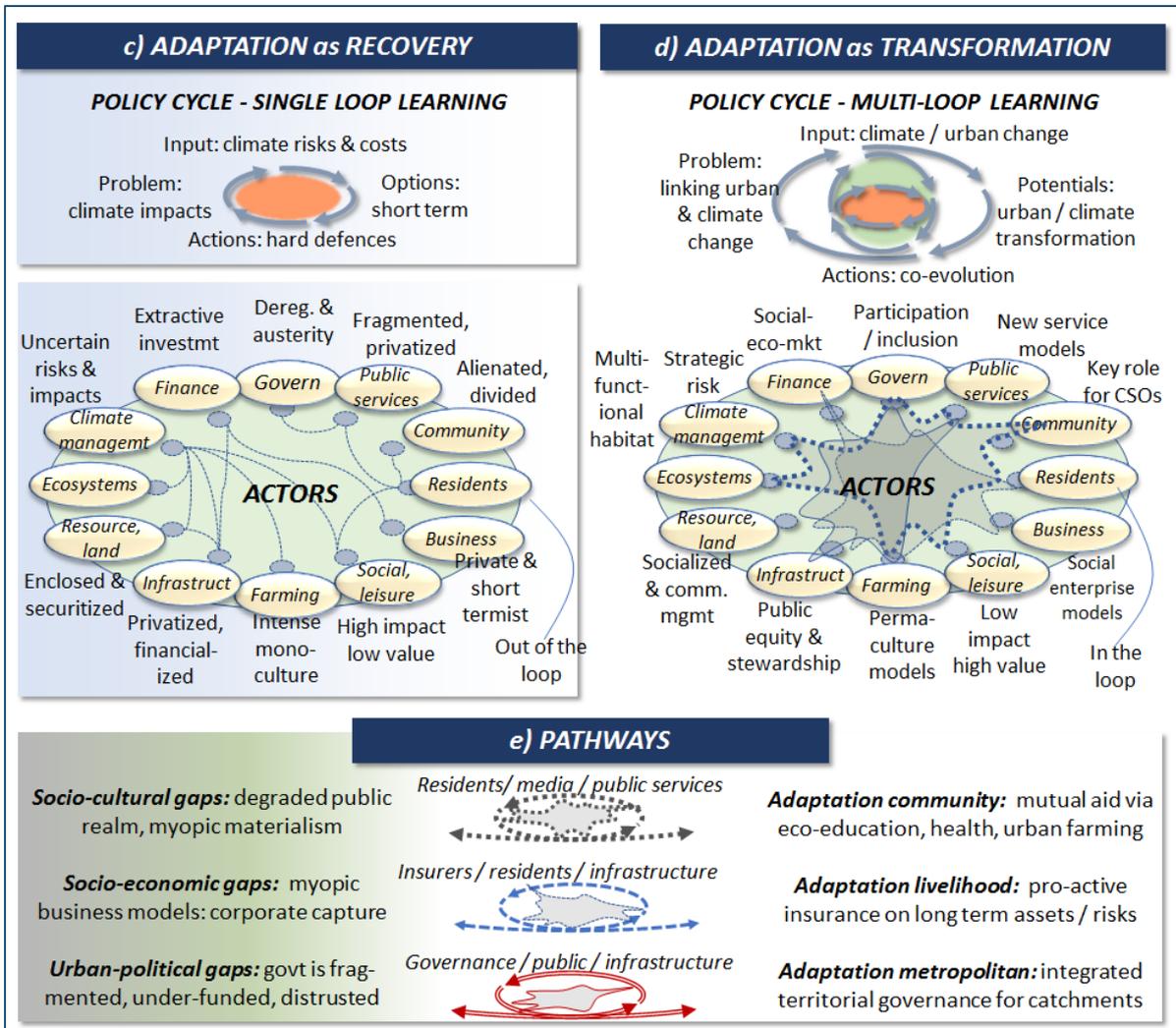


6.1.2 Climate adaptation: synergistic mapping

This example of climate adaptation mapping in figure xxx, includes:

- The upper diagrams show a policy 'cognitive cycle': i.e. how does policy learn about the problem and generate solutions
- The diagrams in the centre show a typical set of actors: on the left with dysfunctional relations and conflicts, and on the right, with new synergies and collaborations,
- The lower part shows the main pathway types, based on the main synergies of actors.

Figure 6: Synergistic visual systems mapping: climate adaptation learning & pathways



6.2 Peri-cene Framework '20 questions' template

This is shown in four main stages, based on the 'peri-urban-climate-risk' model above, with a fifth on the 'synergistic model'. Each part has 4 parts, for a total of '20 questions'.

Rows in blue show potential maps / indicators / images, which are supplied in the online version.

Each case city/region is divided into 'zones', i.e. distinct peri-urban types in climate/geographical or socio-economic profiles. A further template is a summary of the synergistic process, i.e. the four stage cycle of co-learning & co-creation described above. (note this links to the P-Path tool, see separate paper)

The example is the South Pennines area of uplands, in the north & east of the Manchester region.

THEMES	SCOPE & TOPICS	BASIC MODEL: PROBLEMS	SYNERGISTIC MODEL: RESPONSES & PATHWAYS
PERI-URBAN CHANGE:			
("drivers / stressors / exposures")	General overview:	Upland landscape with former industrial valley development	
Spatial peri-urban types & patterns:	<ul style="list-style-type: none"> Urban direct expansion Urban / rural fringe & gradient Counter-urbanization effect Urban agglomeration effect 	Geographical type: small-medium industrial towns in river valleys, scattered upland villages & small farm settlements	<i>Integrated city-region planning</i> <i>Integrated housing market</i>
MAPS / INDICATORS	<i>urban growth rate</i>		
Spatial peri-urban functional dynamics (growth / restructuring / transition).	<ul style="list-style-type: none"> Population growth & housing Technology & infrastructure Economy & employment Real estate & markets 	post-industrial economy in transition, to niche production, semi-retired livelihoods, hobby farming etc.	<i>Integrated transport / mobility / access system</i> <i>Real estate partnership & compacts</i>
MAPS / INDICATORS	<i>population growth rate</i>		
Other drivers (STEEP: social, technical, ecological, policy, culture etc)	<ul style="list-style-type: none"> Social demographics & lifestyle Environment & resources Policy & governance Culture & ethics 	Middle class in-migration & eco-gentrification: decline of family farming: enclaves of deprivation & post-industrial traumas	<i>Integrated social & anti-poverty policy</i>
MAPS / INDICATORS	<i>GDP / social change</i>		
Global-local dynamics & inter-dependencies	<ul style="list-style-type: none"> Internal structures external interactions power dynamics challenges & conflicts 	S.Pennines covers parts of 13 municipalities, provides headwaters & retention capacity: It provides visitor & ecosystem services for 3 city-regions. But, at the fringes of the policy agenda.	<i>Inward investment & FDI management</i>
MAPS / INDICATORS	<i>Tbc</i>		

THEMES	SCOPE & TOPICS	BASIC MODEL: PROBLEMS	SYNERGISTIC MODEL: RESPONSES & PATHWAYS
CLIMATE CHANGE			
("causes / hazards"):	<i>General overview:</i>	<i>Fluvial flood, wildfire, heat & drought, soil erosion, landscape</i>	
Climate change direct effects:	<ul style="list-style-type: none"> temperature, precipitation, storm etc coastal effects 	Summer drought & storm: winter precipitation & storm.	
MAPS / INDICATORS	<i>Climate change scenarios</i>		
Climate change direct hazards & impacts:	<ul style="list-style-type: none"> wildfire, heatwave, drought, flood, storm, cyclone landslide, sea incursion etc, 	fluvial & flash flooding, upland & valley soil erosion, summer wildfire: progressive landscape change	<i>Natural flood management Integrated water system management Integrated peri-urban wildfire interface</i>
MAPS / INDICATORS	<i>Climate change scenarios</i>		
Indirect hazards & nexus effects	<ul style="list-style-type: none"> water resources farming & forestry energy & resources ecosystems & microclimates critical infrastructure 	impacts on vulnerable landscape: ecosystems destruction, soil loss, air pollution, climate emissions. Upland farming is already marginal and may become more so.	<i>Adaptive farming / food transition policies Adaptive landscapes policies & partnerships</i>
MAPS / INDICATORS	<i>Environmental effects e.g. water, food / farming, forestry</i>		
Causal loops (impacts of peri-urban on climate change)	<ul style="list-style-type: none"> CO2 emissions from energy GHG emissions from land-use Land-use & forestry change Carbon storage 	Loss of peat bog carbon storage & vegetation: loss of (some) ancient woodlands. Transport CO2 is high due to location & geography	<i>Integrated LZC transport & transition planning</i>
MAPS / INDICATORS	<i>CO2 & GHG</i>		

THEMES	SCOPE & TOPICS	BASIC MODEL: PROBLEMS	SYNERGISTIC MODEL: RESPONSES & PATHWAYS
VULNERABILITY			
'sensitivity / adaptive capacity'	<i>General overview:</i>	<i>Landscape sensitivity & marginal livelihoods</i>	
Physical-ecological vulnerability-sensitivity	<ul style="list-style-type: none"> Soil & vegetation Topography & stability Settlement form & structure 	Upland peat bog with rapid run-off: upland semi-wild vegetation, thin & acidic soils. Most valley bottoms are in flood risk zone 3.	<i>Adaptive landscapes policies & partnerships (public / private / civic) Multi-functional eco-peri-urban settlement & livelihood systems</i>
MAPS / INDICATORS			

Functional-economic-infrastructure layers of vulnerability-sensitivity:	<ul style="list-style-type: none"> • technical & infrastructure • Markets & value effects • Employment & livelihoods 	privatized land management increases run-off & flood risk: much low cost housing remains in high risk areas	<i>Insurance & real estate sector partnerships. Housing market support for transition planning Eco-tourism & multi-function landuse</i>
<i>MAPS / INDICATORS</i>			
Eco-social-cultural layers of vulnerability-sensitivity:	<ul style="list-style-type: none"> • Affluence / deprivation • Education / communication • Cultural issues 	River valleys magnify flood risk: polarization of local residents vs incomers who tend to live on higher ground:	<i>Anti-poverty & social resilience strategy Security of tenure in land & housing</i>
<i>MAPS / INDICATORS</i>			
Adaptive governance capacity-vulnerability-sensitivity-	<ul style="list-style-type: none"> • Local government • Public services & infrastructure • Emergency services • Civil & community 	fragmented & shrinking local governance: community under change & stress. Privatized infrastructure, fragmented governance	<i>Local / regional government partnerships across boundaries & departments</i>

THEMES	SCOPE & TOPICS	BASIC MODEL: PROBLEMS	SYNERGISTIC MODEL: RESPONSES & PATHWAYS
GOVERNANCE FRAMEWORK			
<i>Adaptive action & governance</i>	<i>General overview:</i>	<i>Fragmentation of governance: self-help tradition & eco-social innovation</i>	
Formal government, (governance, regulation)	<ul style="list-style-type: none"> Spatial planning green belt etc Housing policy Infrastructure development 	Main regulation is for containment of urbanization under housing pressure: the area is on the fringe of 13 municipalities	<i>Integrated city-region planning / redistribution / cross-boundary investment: Housing transition finance policies: Restructure unequal land ownership / tenure patterns Environmental & ecosystems policies</i>
<i>MAPS / INDICATORS</i>			
Associative governance & institutions: (networks, coalitions, partnerships)	<ul style="list-style-type: none"> Public sector Private sector Civic sector Citizens etc 	From local history of cooperatives etc, many examples of networks, eco-innovations, partnerships etc. Big challenges in governance for in-between area on the fringes of 13 municipalities	<i>Mobilize social capital, reciprocity, mutual aid, community collateral</i>
<i>MAPS / INDICATORS</i>			
Informal governance, (corruption, development, community, livelihood,)	<ul style="list-style-type: none"> Informal land-use, settlements Corruption & nepotism Social innovation & enterprise 	Tradition of social enterprise, self-help, creative action. Landowning is centralized, majority are excluded, most farmers are tenants.	<i>Regularize encroachment & illegal development</i>
<i>MAPS / INDICATORS</i>			
System effects, resilience, collective intelligence	<ul style="list-style-type: none"> Social learning & collaboration Social co-creation & mobilization potential System transformation potential 	Enhanced social resilience with small town effect, with many synergistic enterprises / networks: however there are class & cultural divides.	<i>Mobilize - Social learning & collaboration : Social co-creation & mobilization potential</i>
<i>MAPS / INDICATORS</i>			

THEMES	SCOPE & TOPICS	BASIC MODEL: PROBLEMS	SYNERGISTIC MODEL: RESPONSES & PATHWAYS
SYNERGISTIC TOOLKIT PROCESS			
	General overview:	Growing pressure on fragile landscapes & settlements: potential for growing socio-eco-resilience	
Systems / syndromes / baselines (present)	Main cross-cutting issues: e.g. <ul style="list-style-type: none"> • Airport / port cities: • Rural livelihoods: • Informal development 	Private land management increases: flood risk increases in river valleys: Urban dependency increases:	
MAPS / INDICATORS			
Scenarios (future possibilities, wild cards & tipping points)	Critical themes: (STEEP): e.g. <ul style="list-style-type: none"> • Social cohesion declines • AI / IOT emerges • Climate change accelerates 	Climate change accelerates: collapse of upland ecosystems & farming: settlements in valleys become uninhabitable: social divides increase	
MAPS / INDICATORS			
Synergies (future vision & opportunities)	Potential ideas, connections, opportunities	Synergies of ecosystems & social systems: new semi-rural livelihoods: digital solution to fringe location. Possible new forms of collaborative 'co-governance' for in-between area	
MAPS / INDICATORS			
Strategies (present pathways for action)	Goals, objectives, targets for ways forward.	integrated adaptive upland landscapes: agro-forestry & eco-social innovation: innovative urban / building design for unstable & high risk locations. Prototype co-governance models	
MAPS / INDICATORS			

6.3 Interview template

For the case studies in WP3 and WP4, leading questions can be inserted for each of the 20 steps in the template. This can then be used in further analysis in WP5. From experience it is often more useful to take the case & the long story, and then to work back to the filling of the template. Questions can be asked on data sources / policies / academic papers, which can help to fill the details and indicators. Much data can be gathered more effectively in live workshop dialogues, where this template can help to structure the discussion.

PERI-URBAN THEMES: ("drivers / stressors / exposure")	
Spatial peri-urban types & patterns:	<ul style="list-style-type: none"> • <i>What is the main geographical type and structure here?</i>
Spatial peri-urban functional dynamics (growth / restructuring / transition).	<ul style="list-style-type: none"> • <i>How did it evolve / become like this?</i>
Other drivers (STEEP: social, technical, ecological, policy, culture etc)	<ul style="list-style-type: none"> • <i>What other drivers of change are in the picture?</i>
Global-local dynamics & inter-dependencies	<ul style="list-style-type: none"> • <i>Which are some key conflicts & challenges?</i>
CLIMATE CHANGE THEMES ("causes / hazards"):	
Climate change direct effects:	<ul style="list-style-type: none"> • <i>What are the main climate change projections for this area?</i>
Climate change direct hazards & impacts:	<ul style="list-style-type: none"> • <i>What are the expected hazards, impacts and risks?</i>
Indirect hazards & nexus effects	<ul style="list-style-type: none"> • <i>Which impacts are most critical for food, energy, water, infrastructure?</i>
Causal loops (peri-urbanization >> climate change)	<ul style="list-style-type: none"> • <i>Does the peri-urbanization cause or contribute to climate emissions or landuse change?</i>
VULNERABILITY THEMES sensitivity / capacity	
Physical-ecological vulnerability-sensitivity	<ul style="list-style-type: none"> • <i>How do physical systems and spatial structures work under pressure?</i>
Vulnerability-sensitivity: functional-economic layers	<ul style="list-style-type: none"> • <i>Ditto - the functional /economic systems?</i>
Vulnerability-sensitivity: eco-social-cultural layers	<ul style="list-style-type: none"> • <i>Are the underlying social/ cultural layers a major influence?</i>
Adaptive capacity in governance	<ul style="list-style-type: none"> • <i>How far are the governance systems fit for purpose?</i>
GOVERNANCE THEMES:	

<i>Adaptive action & governance</i>	
Formal government, (governance, regulation)	<ul style="list-style-type: none"> • <i>How does government work here & which kind of regulations & plans?</i>
Adaptive governance & institutions: (networks, coalitions, partnerships)	<ul style="list-style-type: none"> • <i>Are there networks, coalitions, partnerships etc, or emerging signs of these?</i>
Informal governance, (corruption, community, livelihood,)	<ul style="list-style-type: none"> • <i>How much corruption or other informal activity?</i>
System effects, resilience, collective intelligence	<ul style="list-style-type: none"> • <i>What is the overall resilience, or collective capacity for learning & thinking?</i>
<i>SYNERGISTIC TOOLKIT PROCESS:</i>	
Systems / baselines (present)	<ul style="list-style-type: none"> • <i>Which are the main cross-cutting issues & challenges so far?</i>
Scenarios (future possibilities)	<ul style="list-style-type: none"> • <i>Which are the most critical trends. Uncertainties, alternative futures?</i>
Synergies (future visions & opportunities)	<ul style="list-style-type: none"> • <i>What are the most visionary ideas, synergies, connections, collective intelligence opportunities?</i>
Strategies (present pathways for action)	<ul style="list-style-type: none"> • <i>Which are the most practical & future proof pathways, strategies and actions?</i>

6.4 Spatial maps & indicators template

As far as possible spatial maps will be assembled in the structure of the framework. These can be linked to the online templates of the Policy Lab.

Some are available at global level, and these would be in the 'starter pack' which can be applied in the P-CAT to any location in the world. Others are only available at the local level at higher resolution, as illustrated in the detailed case studies.

- Normal type shows indicators which we assume are available with relevant detail
- *Italic types shows indicators which may / may not exist at the resolution needed*

THEMES	LOCAL SPATIAL DATA	GLOBAL SPATIAL DATA
PERI-URBAN FRAMEWORK:		
Spatial patterns:		
<i>MAPS / INDICATORS</i>	Peri-urban areas: peri-urban area change: Land use & land cover:	Peri-urban areas: peri-urban area change: Land use & land cover:
Functional dynamics.		
<i>MAPS / INDICATORS</i>	population density & growth rate <i>real estate values??</i>	<i>population density & growth rate</i>
Socio-eco dynamics		
<i>MAPS / INDICATORS</i>	<i>GDP growth</i> <i>Demographic change (age, class etc)</i>	
Global-local dynamics		
<i>MAPS / INDICATORS</i>	<i>(Depends on the case)</i>	

THEMES	LOCAL SPATIAL DATA	GLOBAL SPATIAL DATA
CLIMATE FRAMEWORK		
Climate change direct effects	•	
<i>MAPS / INDICATORS</i>	Climate change projections / scenarios: (precipitation, heat, drought)	Climate change projections / scenarios: (precipitation, heat, drought)
Climate direct hazards & impacts	•	
<i>MAPS / INDICATORS</i>	Climate change projections / scenarios: flood, sea-level, cyclone, wildfire, saline, landslide, desertification etc	Climate change projections / scenarios: flood, sea-level, cyclone, wildfire, saline, landslide, desertification etc
Indirect hazards & nexus effects		
<i>MAPS / INDICATORS</i>	<i>Environmental effects e.g. water, food / farming, forestry</i>	
Peri-urban impacts on climate		
<i>MAPS / INDICATORS</i>	<i>CO2 & GHG emissions?</i> <i>Eco-footprint index?</i>	

THEMES	LOCAL SPATIAL DATA	GLOBAL SPATIAL DATA
VULNERABILITY FRAMEWORK		
Physical sensitivity & capacity	•	
<i>MAPS / INDICATORS</i>	Soil quality & soil loss: Air / water pollution index: Ecosystems & species loss:	
Techno-economic capacity	•	
<i>MAPS / INDICATORS</i>	Critical infrastructure (road, rail, port, airport etc) Public services (health, education etc)	Critical infrastructure (road, rail, port, airport etc)
Eco-social-cultural capacity	•	
<i>MAPS / INDICATORS</i>	Socio-economic income, education level, demographic profiles (age, job, health, housing etc)	
Governance adaptive capacity	•	
<i>MAPS / INDICATORS</i>	Democratic indicators: transparency, freedom of speech, tolerance etc	

THEMES	LOCAL SPATIAL DATA	GLOBAL SPATIAL DATA
GOVERNANCE FRAMEWORK		
Formal government & planning	•	
<i>MAPS / INDICATORS</i>	Strategic spatial plans Green belt & protected areas Public fiscal balance of government?	
Adaptive governance	•	
<i>MAPS / INDICATORS</i>	Third sector organizations?? Social cohesion index??	
Informal governance	•	
<i>MAPS / INDICATORS</i>	Crime & security map Informal livelihoods index??	
System resilience & intelligence	•	
<i>MAPS / INDICATORS</i>	Resilience index??	

6.5 Abbreviations

CO ₂	Carbon dioxide
CBD	Central Business District
CSR	Corporate Social Responsibility
EC	European Commission
EU	European Union
FUR	Functional Urban Region
GDP	Gross Domestic Product
ha	Hectare
hh	Household
HDI	Human Development Index
IOT	Internet of Things
IPCC	Inter-Governmental Panel for the Scientific Assessment of Climate Change
KIBS	Knowledge Intensive Business Services
LED	Local Economic Development
Manchester	(Shorthand for Greater Manchester and its wider hinterland / region)
MEA	Millennium Ecosystem Assessment
NGO	Non-governmental organization
OECD	Organization of Economic Cooperation and Development
pph	persons per hectare
RUI	Rural-urban interface
SDG	Sustainable Development Goals
STEEPC	Futures / foresight domains for analysis and debate ('socio-technical-economic-ecological-political-cultural'), with many variations
WEF	World Economic Forum
WHO	World Health Organization
UN, UNEP etc	United Nations, UN Environment Program etc

6.6 Citations

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